2nd International Conference on Ambulatory Monitoring of Physical Activity and Movement

24th - 27th May 2011,
Glasgow, Scotland

www.ICAMPAM2011.org

PROGRAMME AND ABSTRACTS
activPAL™
the single sensor solution for quantifying posture allocation and activity

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activator
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Dear ICAMPAM participant,

It is a great pleasure to welcome you all to the second International Conference on Ambulatory Monitoring of Physical Activity and Movement and also to welcome you to Scotland and more specifically to Glasgow. We feel this is indeed a unique occasion in a special location.

The first ICAMPAM conference was held in Rotterdam in May 2008 and attracted over 200 participants with an outstanding scientific and social programme. This conference was led by Hans Bussmann and his team who had the foresight to recognise the need for such a meeting and the courage to organise the first meeting of its kind. Since that meeting there has been a growth in activity in this area, with many more high quality research publications appearing and research groups emerging and expanding. This research activity has been spread widely over a number of different discipline areas and has featured at a multitude of disparate conferences. There seemed to be an even greater need to bring this research together under one broad banner where we could share knowledge and exchange ideas and develop meaningful collaborations. So welcome to ICAMPAM 2!

This conference has indeed grown and we will have well over 300 participants from around the world. The programme has 17 invited and keynote lectures, 67 oral presentations and over 170 posters. Our invited and keynote speakers are leaders in their field with established work programmes and research groups and the conference participants are representative of the broad spectrum of world class research activity from around the globe. We have a real international expertise and a true global research community.

I would like to thank the many people who have been involved in organising this conference. Firstly to the Organising Committee: Sebastien Chastin, Philippa Dall, Janet Finlayson, Margaret Grant, Karen Jack, Danny Rafferty, Cormac Ryan and Ben Stansfield. In particular I would like to thank Hans Bussmann who organised the first conference and who gave me the privilege of organising this, the second ICAMPAM. Thanks to Hans for allowing us to benefit from his experience through guidance in the initial stages of the planning for this meeting. I would also like to thank the Scientific Committee for their invaluable input in generating ideas for the programme and for reviewing over 250 abstracts that were submitted and I would also give special thanks to Philippa Dall and Ben Stansfield for collating all the input and for putting together the programme. I would also like to give a special welcome to our sponsors and exhibitors who have played a key role in allowing this conference to take place.

It has been clear from the response we have had when putting together this conference that there is indeed a future and this is something we should be thinking about and discussing during and after the conference. Where will we take this? Do we want to form a “society”? Where and when will the next ICAMPAM be held?

I hope that this conference will be an interesting one for every one of you and that you will not only find enjoyable but also inspirational. I hope this will help us, as a global community, to tackle the many challenges we have in developing this rapidly growing field and in collaborating effectively so that we can make a real and significant impact across the growing number of disciplines in which we are actively engaging.

Malcolm H Granat
Conference Chair
GENERAL INFORMATION

VENUE
The Glasgow Royal Concert Hall, 2 Sauchiehall Street, Glasgow, G2 3NY.

REGISTRATION DESK
The registration desk will be located in the North Entrance of the venue, which can be accessed from Killermont Street. Registration will be open at the following times:-

Tuesday 24 May 1500 hours – 1800 hours
Wednesday 25 May 0800 hours – 1800 hours
Thursday 26 May 0800 hours – 1800 hours
Friday 27 May 0800 hours – 1400 hours

The registration desk will remain open throughout the Conference for general queries.

SPEAKERS
Speakers are asked to submit their presentation to the audio-visual staff in the Speakers’ Preview Room no later than three hours before their talk. The Speakers’ Preview Room can be found at the end of the foyer near the Café Bar. Only PowerPoint presentations will be accepted. They should be provided on a CD or USB stick. Given the tight schedule, it will not be possible to use your own laptop computer.

POSTERS
Poster numbers on the boards relate to the poster numbers indicated in the abstract book. Velcro will be available to attach the posters to the boards. Presenters are asked to attend their posters during the following times: Mounted between 0800 and 0900 hours and removed between 1745 and 1800 hours.

Presenters should stand by their poster to discuss the content with delegates from 1100 to 1145 hours (coffee break), from 1315 to 1430 hours (lunch break) and again at the evening poster session from 1630 to 1745 hours.

Poster session 1 is on Wednesday 25 May, poster session 2 is on Thursday 26 May.

CME ACCREDITATION
The conference has applied for CME accreditation. In order to be eligible for accreditation participants must sign in and out for each day they attend the conference. A sign-in/out sheet will be available at the registration desk.

BADGES
Name badges will be issued to all registered delegates and, for security reasons, must be worn at all times to ensure admission to sessions and the Civic Reception.

DELEGATE LIST
You will find a list of delegates attending the conference in your delegate pack.

CONFERENCE LANGUAGE
The language of this conference is English.

CATERING
Tea, coffee and lunch will be served in the Exhibition Hall and foyer areas. Please see the programme for timings.

EXHIBITION
Stands will be located in the Exhibition Hall on the ground floor of the Concert Hall. Please refer to the exhibition section of the programme for further details.

INTERNET
Free WiFi internet access will be available throughout the Conference and is intended for general web browsing only. Delegates should refrain from downloading large files or watching HD videos which will slow the connection speed down considerably.

DOMESTIC ANNOUNCEMENTS
Important announcements will be made by Session Chairs at the start or end of sessions.

MESSAGES
Any messages received for delegates during the conference will be displayed on the notice board beside the registration desk. We advise all delegates to check this board regularly, as messages will not be relayed as announcements.

MOBILE PHONES
Out of courtesy to speakers and other delegates, mobile phones must be switched off or on silent mode before entering sessions.

SMOKING POLICY
It is against the law to smoke in any enclosed public area in Scotland.

GENERAL ASSISTANCE
Please go to the registration desk if you have any queries.

BANKS
Delegates needing to exchange currency may do so at banks, Post Offices or at currency exchange outlets (e.g. at Glasgow Central Station and at the major airports). Normal banking hours are 0900 – 1700 Monday to Friday. 24-hour cash points can be found throughout the city centre.

SHOPPING
City centre shops opening hours:
Monday to Saturday 0900 to 1700 hours
Late night shopping on Thursdays until 1930 or 2000 hours
Some shops are open on Sundays from 1200 to 1600 hours

SOCIAL EVENTS
Tuesday 24 May 2011
1930 – 2030 hours
Civic Reception
The conference will open with a civic-sponsored drinks reception at the Glasgow City Chambers.

Thursday 26 May 2011
1930 – 2400 hours
Gala Dinner
The Gala Dinner will be held in the famous Kelvingrove Art Gallery and Museum. Pre-dinner drinks will be followed by dinner and entertainment. Ticket required.

Kelvingrove Art Gallery and Museum is a short taxi ride from the city centre. Alternatively it is a 5 minute walk from Kelvinhall Subway Station. Please refer to the map on page 3.
ICAMPAM PROGRAMME

WEDNESDAY 25 MAY 2011:

08:30-08:40 – STRATHCLYDE SUITE
WELCOME

08:40-09:30 – STRATHCLYDE SUITE
K1 KEYNOTE SPEAKER: DAVID BASSETT
Recent Applications of Physical Activity Monitoring
Chairs: Malcolm Granat, Hans Bussmann

09:30-10:00 – STRATHCLYDE SUITE
I2 INVITED SPEAKER: STEPHEN REDMOND
Data fusion of triaxial accelerometry and barometric pressure sensing for falls detection and prevention.
Chair: Wiebren Zijlstra

10:00-11:00 – BUCHANAN SUITE
SESSION 2

DEVELOPMENT NOVEL DEVICES AND SENSORS 1
Chairs: Stephen Redmond, Wiebren Zijlstra

Oral Presentations:

02.1 ISAW: INSTRUMENTED STAND AND WALK TEST
Horak FP, Salarian A, Mancini M1, Carlson-Kuhta P1
1Department of Neurology, Oregon Health & Science University, Portland, USA

02.2 DESIGN OF A WEARABLE MULTI-SENSOR SYSTEM FOR PHYSICAL ACTIVITY ASSESSMENT
Liu S1, Gao R1, Freedson PS2
1University of Connecticut, Storrs, CT, USA; 2University of Massachusetts, Amherst, MA, USA

02.3 BREATHING FREQUENCY AND VOLUME ESTIMATIONS USING A MULTI-SENSOR INTEGRATED MEASUREMENT SYSTEM
John D1, Liu S1, Sasaki J1, Gao R1, Staudenmayer J1, Freedson P1
1Dept. of Kinesiology, University of Massachusetts, Amherst, MA; 2Dept. of Mechanical Engineering, University of Connecticut, Storrs, CT; 3Dept. of Mathematics and Statistics, University of Massachusetts, Amherst, MA

02.4 A PATTERN RECOGNITION TECHNIQUE TO ASSESS FREE-LIVING PHYSICAL ACTIVITY: THE SOJOURN METHOD
Lyden K1, Kozey Keadle S1, Staudenmayer J1, Freedson P1
1Department of Kinesiology and Math and Statistics1, University of Massachusetts, Amherst, MA, USA

11:45-12:15 – STRATHCLYDE SUITE
I3 INVITED SPEAKER: JORUNN L. HELBOSTAD
Activity monitoring in older adults with impaired functioning – challenges and possibilities.
Chair: Charles Matthews

09:30-10:00 – BUCHANAN SUITE

10:00-11:00 – BUCHANAN SUITE
SESSION 1

POPULATION & INTERVENTION ASSESSMENT CHILDREN
Chairs: Jo Salmon, Hans Bussmann

Oral Presentations:

01.1 CORRELATES OF SEASONAL OUTDOOR PHYSICAL ACTIVITY MEASURED USING ACCELEROMETERS AND GPS
Page AS, Cooper AR, Jago R, Macdonald Wallis K
Exerc Ice, Nutrition and Health Sciences, University of Bristol, Bristol, UK

01.2 EFFICACY OF PREBiotics AND PRObiotics FORTIFIED MILK FOR IMPROVING GROWTH AND PHYSICAL ACTIVITY IN CHILDREN 1-4 YEARS OF AGE – A COMMUNITY BASED, DOUBLE MASKED RANDOMIZED CONTROLLED TRIAL
Dhingra U1, Dutta A1, Dhingra P1, Black RE2, Menon VP1, Kumar J1, Sazawal S1,2
1Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore USA; 2Center for Micronutrient Research, Annamalai University, India

01.3 VOLUME, PATTERNS, AND TYPES OF SEDENTARY BEHAVIOR AND CARDIO-METABOLIC HEALTH IN CHILDREN AND ADOLESCENTS
Carse V1, Janssen I1,2
1School of Kinesiology and Health Studies, Queen’s University, Kingston, ON, Canada; 2Department of Community Health and Epidemiology, Queen’s University, Kingston, ON, Canada

01.4 CHILDREN’S PHYSICAL ACTIVITY LEVELS OVER A 5-YEAR PERIOD ASSESSED USING ACCELEROMETRY
Ridgers ND, Timperio A, Crawford D, Salmon J
Centre for Physical Activity and Nutrition Research, Deakin University, Australia
12:15-13:15 – STRATHCLYDE SUITE

SESSION 3

POPULATION & INTERVENTION ASSESSMENT OLDER ADULTS & FALLS

Chairs: Jorunn Helbostad, Charles Matthews

Oral Presentations:

03.1 AMBULATORY MEASUREMENT OF DUAL-TASKING BEHAVIOUR: METHOD AND PRELIMINARY EVALUATION IN OLDER ADULTS

Tune JY1,2, Roy EA3, Poupart P3
1Department of Kinesiology, University of Waterloo, Waterloo, Canada;
2David Cheriton School of Computing Science, University of Waterloo, Waterloo, Canada

03.2 USING ACCELEROMETERS TO ASSESS TEMPORAL CHANGES IN OLDER ADULTS’ SEDENTARY TIME FOLLOWING AN INTERVENTION

Gardiner PA1, Eakin EG2, Healy GN1,2, Owen N1,2
1The University of Queensland, Cancer Prevention Research Centre, School of Population Health, Brisbane, Australia; 2Baker IDI Heart and Diabetes Institute, Melbourne, Australia

03.3 ISWAY: A SENSITIVE, VALID AND RELIABLE TEST OF POSTURAL CONTROL

Mancini M1,2, Salari A1, Carlson-Kuhta P1, Zampieri C1, Chiari L1, Harak FB1
1Department of Neurology, OHSU, Portland, USA; 2Biomedical Engineering Unit, DEIS, Alma Mater Studiorum-Università di Bologna, Bologna, Italy

03.4 WALKING ON SUNSHINE: EFFECT OF WEATHER CONDITIONS ON PHYSICAL ACTIVITY IN OLDER PEOPLE

Klenk J1,2, Büchele B1, Rapp K1,2, Franke S1, Peter R1
1Institute of Epidemiology, Ulm University, Ulm, Germany; 2Clinic for Geriatric Rehabilitation, Robert-Bosch-Hospital, Stuttgart, Germany

14:30-15:15 – STRATHCLYDE SUITE

K2 KEYNOTE SPEAKER: YUKITOSHI Aoyagi

Habitual physical activity and health in the elderly: the Nakanojo Study

Chairs: Nick Wareham, Chris Baten

15:15-16:30 – STRATHCLYDE SUITE

SESSION 5

METHOD DEVELOPMENT

POSTURE & ACTIVITY CLASSIFICATION

Chairs: Chris Baten, Patty Freedson

Oral Presentations:

05.1 DURATION OF SIT-STAND-SIT TRANSFERS: A COMPARISON OF DETECTIONS BASED ON A SINGLE HYBRID-SENSOR UNIT VERSUS FORCE PLATES

Zijlstra A, Zijlstra W
Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands

05.2 QUANTIFYING PHASES OF THE SIT-TO-WALK MOVEMENT WITH ACCELEROMETERS

Kerr A1, Rafferty D1, Hall PM1, Muhaidat J1
1University of Strathclyde, Glasgow, Scotland; 2University of Strathclyde, Glasgow, UK

05.3 POSTURE AND POSTURE TRANSITIONS IN THE PRE-SCHOOL CHILD AND CATEGORIZATION BY THE ACTIVPAL

Davies G, Reilly JJ, Paton JY
University of Glasgow, Glasgow, United Kingdom
EVALUATING LABORATORY-TRAINED ACTIVITY CLASSIFICATION ALGORITHMS IN DAILY LIFE

Cuba Gyllensten 1, Bonomi AS 2
1Care and Health Applications, Philips Research laboratories, Eindhoven, Netherlands; 2Medical Signal Processing, Philips Research laboratories, Eindhoven, Netherlands.

AN OBJECTIVE METHOD FOR SLEEP DETECTION FROM CONTINUOUS MONITORING OF HEART RATE AND MOVEMENT IN FREE-LIVING INDIVIDUALS

Amin 1, Ekelund U, Skene S, Ridgway C, Wareham N, Brage S
1MRC Epidemiology Unit, Cambridge, UK; 2Birkbeck College, University of London, UK

AN OBJECTIVE METHOD FOR SLEEP DETECTION FROM CONTINUOUS MONITORING OF HEART RATE AND MOVEMENT IN FREE-LIVING INDIVIDUALS

Amin 1, Ekelund U, Skene S, Ridgway C, Wareham N, Brage S
1MRC Epidemiology Unit, Cambridge, UK; 2Birkbeck College, University of London, UK

ACCELEROMETRY-BASED ACTIVITY SPECTRUM IN PERSONS WITH CHRONIC PHYSICAL CONDITIONS

van den Berg-Emons RJ, Bussmann JB, Stam HJ
Department of Rehabilitation Medicine and Physical Therapy, Erasmus Medical Center, Rotterdam, The Netherlands

IMPACT OF EXERCISE TRAINING AND A SEDENTARY BEHAVIOR INTERVENTION ON TOTAL DAILY SITTING TIME

Kezey Keadle 1, Lyden K, Staudenmayer J, Freedson P
1Department of Kinesiology; 2Math and Statistics, University of Massachusetts, Amherst, MA, USA

WALKING PERFORMANCE IN DAILY LIFE IS RELATED TO THE O2 COST OF WALKING IN ADULTS WITH BILATERAL SPASTIC CEREBRAL PALSY

Slaman J, Bussmann JBJ, Stam HJ, van den Berg-Emons HJQ
1Department of Rehabilitation Medicine and Physical Therapy, Erasmus MC, University Medical Center, Rotterdam, the Netherlands

HOW DO COPD PATIENTS DISTRIBUTE THEIR DAILY ACTIVITIES?

1Roessingh Research and Development, the Netherlands; 2Telemedicine group, University of Twente, the Netherlands; 3Department of Pulmonary Medicine, Medisch Spectrum Twente, the Netherlands; 4Department of Research Methodology, Measurement and Data Analysis, University of Twente, the Netherlands; 5Medical School Twente, Medisch Spectrum Twente, the Netherlands

PATIENTS WITH END-STAGE HIP OSTEOARTHRITIS SHOW DISTINCTIVE PATTERNS OF TRUNK MOVEMENTS DURING GAIT – A BODY-FIXED-SENSOR BASED ANALYSIS

Reininga IH, Stevens M, Wagenmakers R, Bulstra SK, Groothoff JW, Zijlstra W
1Department of Orthopaedics; 2Department of Health Sciences; 3Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, the Netherlands; 4Department of Orthopaedics, Amphia Hospital Breda, the Netherlands

OBJECTIVELY MEASURED PHYSICAL ACTIVITY AND BONE HEALTH IN OLDER JAPANESE ADULTS: LONGITUDINAL DATA FROM THE NAKANOJO STUDY

Park H, Park S, Shepherd RJ, Aoyagi Y
1Exercise Sciences Research Group, Tokyo Metropolitan Institute of Gerontology, Itabashi, Tokyo, Japan; 2Faculty of Physical Education and Health, University of Toronto, Toronto, Ontario, Canada

PHYSICAL ACTIVITY LEVELS OF CANADIAN ADULTS: RESULTS FROM THE 2007-2009 CANADIAN HEALTH MEASURES SURVEY

Colley RC, Janssen I, Craig CL, Tremblay MS
1Healthy Active Living and Obesity RG, Children’s Hospital of Eastern Ontario RI, Ottawa, Canada; 2Health Analysis Division; 3Canadian Fitness and Lifestyle RI; 4Physical Health Measures Division, Statistics Canada, Ottawa, Canada; 5School of Kinesiology and Health Studies, Queen’s University, Kingston, Canada

PHYSICAL ACTIVITY LEVELS OF CANADIAN CHILDREN AND YOUTH: RESULTS FROM THE 2007-2009 CANADIAN HEALTH MEASURES SURVEY

Colley RC, Janssen I, Craig CL, Tremblay MS
1Healthy Active Living and Obesity RG, Children’s Hospital of Eastern Ontario RI, Ottawa, Canada; 2Health Analysis Division; 3Physical Health Measures Division, Statistics Canada, Ottawa; 4School of Kinesiology and Health Studies, Queen’s University, Kingston; 5Canadian Fitness and Lifestyle RI, Ottawa; all Canada.
07.4 USING ACCELEROMETRY DATA TO UNDERSTAND WHEN CANADIANS ARE MOST (AND LEAST) ACTIVE
Colley RC1,2, Garriguet D3
1Healthy Active Living and Obesity Research Group, Children’s Hospital of Eastern Ontario Research Institute, Ottawa, Ontario, Canada; 2Health Analysis Division, Statistics Canada, Ottawa, Ontario, Canada

09:30-10:00 – BUCHANAN SUITE

16 INVITED SPEAKER: KAMIA AMINIAN
Ambulatory monitoring in sports: performance evaluating in ski jump.
Chair: Malcolm Granat

10:00-11:00 – BUCHANAN SUITE
SESSION 8
METHOD DEVELOPMENT KINETICS AND KINEMATICS
Chairs: Kamiar Aminian, Malcolm Granat

Oral Presentations:

08.1 VALIDATION OF A PROTOCOL FOR FAST GAIT ASSESSMENT IN A CLINICAL ENVIRONMENT USING INERTIAL SENSORS
Morris RG1, Pearce MS2, Birrell F3, Lawson SEM1
1Bioengineering Research Group, School of Mechanical & Systems Engineering; 2Institute of Health and Society; 3Institute of Cellular Medicine, Musculoskeletal Research Group, Newcastle University, Newcastle upon Tyne, UK

08.2 EXTRAMURAL FALL RISK ASSESSMENT USING A WEARABLE INSOLE MOTION MEASUREMENT SYSTEM – A BASE FOR NEW AAL APPLICATIONS
Oberzaucher J1, Jagos H1, Zödl C1, Hlauscek W1, Zagler W1,2
1CEIT RALTEC, Central European Institute of Technologies, Schwechat, Austria; 2fortec – Research Group on Rehabilitation Technology, Vienna Univ. of Technology, Vienna, Austria

08.3 AMBULATORY MEASUREMENT OF PHYSICAL ACTIVITY BASED ON KNEE FLEXION/EXTENSION: PRELIMINARY EVALUATION OF A SMART KNEE BRACE
Bonroy B1, Gransier R1,2, Dunias P1, Meijer K1, Vanrumste B1,5
1MOBILAB, K.H. Kempen University College, Geel, Belgium; 2Dept. Human Movement Sciences; 3Dept. Orthopaedics, Maastricht University Medical Centre, Maastricht, The Netherlands; 4TNO Medical Devices, Eindhoven, The Netherlands; 5ESAT – SCB, Katholieke Universiteit Leuven, Heverlee, Belgium

11:45-12:15 – STRATHCLYDE SUITE

17 INVITED SPEAKER: NICKWareham
Objective measurement of physical activity in observational cohort studies: what have we learnt?
Chair: Soren Brage
12:15-13:15 – BUCHANAN SUITE

SESSION 10

DEVICE DEVELOPMENT

DEVICE VALIDATION & RELIABILITY

Chairs: Wiebren Zijlstra, Stephen Redmond

ORAL PRESENTATIONS:

010.1 HABITUAL PHYSICAL ACTIVITY ASSESSMENT WITH ACCELEROMETERS: NEW INSIGHTS AND VALIDATION STUDIES.
Plasqui G¹, Bonomi AG², Westerterp KR¹
¹Human Biology department, NUTRIM School for Nutrition, Toxicology and Metabolism, Maastricht University Medical Centre, Maastricht, The Netherlands; ²Medical Signal Processing, Philips research laboratories, Eindhoven, The Netherlands

010.2 VALIDITY AND RELIABILITY OF A SMARTPHONE ACCELEROMETER TO INSTRUMENT THE TIMED UP AND GO TEST
Melone S¹, Tacconi C¹, Chiari L¹
¹Biomedical Engineering Unit, Department of Electronics, Computer Science & Systems, University of Bologna, Italy

010.3 COMPARISON OF ACTIVPAL AND GT3X-PLUS IN DISTINGUISHING SITTING, STANDING AND WALKING IN TYPICAL OFFICE-BASED ACTIVITIES
Anuradha S¹, Adam O¹, Dunstan DW¹, Owen N², Healy GN²
¹The University of Queensland, School of Population Health, Brisbane, Australia; ²Baker IDI, Heart and Diabetes Institute, Melbourne, Australia

010.4 VALIDITY AND USER FRIENDLINESS OF THREE ACTIVITY MONITORS
Berendsen BA¹, Antemans J¹, Hendriks MRC¹, Schaper NC¹, Willems P¹, Plasqui G¹, Meijer K¹, Savelberg HHCM¹
¹Human Movement Science, NUTRIM, Maastricht University Medical Centre, Maastricht, the Netherlands; ²Internal Medicine, CAPHRI, Maastricht University Medical Centre, Maastricht, the Netherlands

14:30-15:15 – STRATHCLYDE SUITE

K4 KEYNOTE SPEAKER: NEVILLE OWEN

Ambulatory monitoring and sedentary behaviour: Evidence, distinctions and issues
Chairs: Catrine Tudor-Locke, Ulrich Ebner-Priemer

15:15-16:30 – STRATHCLYDE SUITE

SESSION 11

METHOD DEVELOPMENT

SEDENTARY BEHAVIOUR

Chairs: Neville Owen, Ulrich Ebner-Priemer

Oral Presentations:

011.1 METHODS FOR QUANTIFYING BEHAVIOUR IN THE STUDY OF INACTIVITY
Chastin S¹, Granat M¹
¹School of Health, Glasgow Caledonian University, Glasgow, UK

011.2 USING OBSERVATION TO COMPARE DIFFERENT ACCELEROMETER CUT POINTS FOR SEDENTARY BEHAVIOR IN CHILDREN
Chin A Paw M¹, Fischer C¹, Yildirim M¹, Salmon J²
¹EMGO-Institute and Department of Public and Occupational Health, VU University Medical Center, Amsterdam, The Netherlands; ²Centre for Physical Activity and Nutrition Research, School of Exercise and Nutrition Sciences, Deakin University, Melbourne, Australia

011.3 VALIDITY OF TWO SELF-REPORT MEASURES OF SITTING TIME
Clemes SA¹, David BM², Zhao Y¹, Han X¹, and Brown WJ²
¹School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, UK; ²School of Human Movement Studies, University of Queensland, Brisbane, Australia

011.4 MEASURING TOTAL SITTING TIME IN WORKING ADULTS
Bauman AE¹, Chau JY¹, van der Ploeg HP³, Dunn S⁴, Kurko J²
¹Prevention Research Collaboration, Sydney School of Public Health, University of Sydney, Australia; ²Heart Foundation New South Wales, Australia

15:15-16:30 – BUCHANAN SUITE

SESSION 12

METHOD DEVELOPMENT

PHYSICAL ACTIVITY PATTERNS

Chairs: Kamiar Aminian, Catrine Tudor-Locke

Oral Presentations:

012.1 REAL WORLD WALKING BEHAVIOR IN TYPICALLY DEVELOPING ADOLESCENTS: AN ACTIVITY PROFILE USING STEP AND BOUT DISTRIBUTIONS
Drenduff MS¹, Do V¹, Tulchin K²
¹Activity Monitoring and Outcome Services, Orthcare Innovations, Mountlake Terrace, WA, USA; ²Movement Science Laboratory, Texas Scottish Rite Hospital for Children, Dallas, TX, USA

012.2 PHYSICAL ACTIVITY AND SEDENTARY BEHAVIORS IMMEDIATELY BEFORE AND AFTER SCHOOL
Dowd KP², Harrington DM¹, Donnelly AE¹
¹Department of Physical Education and Sport Sciences, University of Limerick, Limerick, Ireland; ²Pennington Biomedical Research Unit, Baton Rouge, Louisiana, USA

012.3 THE RELATIONSHIP BETWEEN STANDING AND STEPPING TIME AS CONTRIBUTORS TO UPRIGHT TIME IN 11-13 YEAR OLD SCOTTISH SCHOOL CHILDREN ACROSS SEASONS
McCrorie P¹, Duncan E¹, Granat MH¹, Stansfield BW¹
¹School of Health; ²Department of Psychology, Glasgow Caledonian University, Glasgow, Scotland

012.4 RECOGNITION OF PHYSICAL ACTIVITY BY BIOMECHANICAL MOVEMENT ANALYSIS
Fradet L¹, Marin F
¹BMBI CNRS UMR6600, University of Technology of Compiègne, France
MODELLING OBESITY AS A FUNCTION OF WEEKLY PHYSICAL ACTIVITY PROFILES MEASURED BY ACITGRAPH ACCELEROMETERS

Augustine NH1, Matlock C1, Riddoch C1, Ness A1, Faraway J1
1Department of Mathematical Sciences; 2Department for Health, University of Bath, Bath, UK; 1Department of Oral and Dental Science, Bristol Dental Hospital, Bristol, UK.

16:30-17:45 – LOMOND AND CLYDE FOYERS

POSTER SESSION 2

See poster abstract section for details

FRIDAY 27 MAY 2011:

08:45-09:30 – STRATHCLYDE SUITE

K5 KEYNOTE SPEAKER: CATRINE TUDOR-LOCKE

Cadence: An Overlooked Opportunity to Measure and Motivate Ambulatory Intensity?

Chairs: Neville Owen, Jorunn Helbostad

09:30-10:00 – STRATHCLYDE SUITE

19 INVITED SPEAKER: MALCOLM GRANAT

What is important? Extracting relevant outcome measures from free-living behaviour.

Chair: Neville Owen

10:00-11:00 – STRATHCLYDE SUITE

SESSION 13

METHOD DEVELOPMENT WALKING PATTERNS

Chairs: Malcolm Granat, Neville Owen

Oral Presentations:

013.1 ESTIMATION OF HEEL & TOE CLEARANCE DURING GAIT USING FOOT-WORN SENSORS: APPLICATION TO DUAL-TASK STUDIES IN ELDERLY PERSONS

Mariani B1, Rochat S1, Moskovec C1, Bülly CJ1, Santos-Eggimann B1, Aminian K1
1Laboratory of Movement Analysis and Measurements, EPFL, Lausanne, Switzerland; 2Service of Geriatric Medicine and Geriatric Rehabilitation; 3Institute of Social and Preventive Medicine, CHUV, Lausanne Switzerland

013.2 AMBULATORY ACTIVITY PATTERNS IN CHILDREN WITH CEREBRAL PALSY USING THE STEPWATCH

Bjørnson KF1, Song KM1, Zhou C1, Coleman K1
1Seattle Children’s Research Institute; 2Orthopedic Surgery, Seattle Children’s Hospital; 3Orthocare Innovations, Seattle, USA

013.3 IDENTIFICATION OF CHILDREN’S ACTIVITY TYPE WITH ACCELEROMETER-BASED NEURAL NETWORKS

Galindo-Garre D de Vries SL, Engels M
TNO Quality of Life, Department of Health Promotion, Leiden, the Netherlands

013.4 METHODS FOR QUANTIFYING CHANGE IN AMBULATORY BEHAVIOUR

Chastin SF1, Baker K1, Jones D1, Burn DJ1, Rochester L1, Granat M1
1School of Health, Glasgow Caledonian University, Glasgow, UK; 2Northumbria University, Newcastle, UK; 1Institute for Ageing and Health, Newcastle University, Newcastle, UK

09:30-10:00 – BUCHANAN SUITE

110 INVITED SPEAKER: ULRICH EBNER-PRIEMER

Interaction ambulatory behaviour monitoring – an approach to optimise the sampling strategy.

Chair: Jorunn Helbostad

10:00-11:00 BUCHANAN SUITE

SESSION 14

POLICY DEVELOPMENT

PUBLIC HEALTH

Chairs: Ulrich Ebner-Priemer, Jorunn Helbostad

Oral Presentations:

014.1 COMBINING ACCELEROMETERS WITH GPS TO INVESTIGATE CHILDREN’S OUTDOOR PHYSICAL ACTIVITY

Cooper AR1, Page AS1, Macdonald Wallis K1, Wheeler B1
1Exercise, Nutrition and Health Sciences, University of Bristol, Bristol, UK; 2Peninsula College of Medicine & Dentistry, University of Exeter, Truro, Cornwall, UK

014.2 THE METABOLIC RESPONSE OF SHORT INTERVALS IN WALKING

Little JA1, Chastin SFM1, Rafferty D1
1School of Health, Glasgow Caledonian University, Glasgow, Scotland

014.3 THE VALIDITY OF THE INCIDENTAL AND PLANNED EXERCISE QUESTIONNAIRE (IPEQ) FOR SEDENTARY OLDER ADULTS

Meron D1, Voukelatos A1, Sherrington C1, Watson W1, Rissel C1, van der Ploeg HP1
1Cluster of Physical Activity and Health, School of Public Health, University of Sydney, Australia; 2Health Promotion Unit, Sydney South West Area Health Service, NSW Health, Australia; 3Musculoskeletal Division, The George Institute for Global Health, Australia; 4Injury and Risk Management Research Center, University of New South Wales, Australia

014.4 THE EFFECT OF PHYSICAL ACTIVITY IN EVERYDAY LIFE AND ITS CONTEXT ON DIFFERENT MOOD STATES

Kanning M1, Ebner-Priemer U1, Schlücht W1
1University of Stuttgart, Stuttgart, Germany; 2Karlsruhe Institute of Technology, Germany
11:45-12:15 – STRATHCLYDE SUITE

**INVITED SPEAKER:**

**HANS BUSSMAN**

To total amount of activity…. and beyond!
Chair: Jo Salmon

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12:15-13:15 – STRATHCLYDE SUITE

**SESSION 15**

**METHOD DEVELOPMENT**

**CLINICAL OUTCOME MEASURES**

Chairs: Hans Bussmann, Jo Salmon

**Oral Presentations:**

**015.1 A ROBUST METHOD FOR DETECTING STEPS IN THE FRAIL ELDERLY**

Carvajal P1, Vaaga S1, Stavdal Ø1, Helbostad J1

1Department of Engineering Cybernetics; 2Department of Neuroscience, NTNU, Trondheim, Norway

**015.2 SELECTION OF OUTCOME MEASURES FOR TIMED UP & GO TEST IN PARKINSON’S DISEASE**

Palmerini L1, Rocchi L1, Mellone S1, Valzania F1, Chiari L1

1Biomedical Engineering Unit, DEIS, University of Bologna, Italy; 2Department of Neuroscience, University of Modena and Reggio Emilia, Italy

**015.3 INERTIAL SENSOR MOTION ANALYSIS OF GAIT, SIT-STAND TRANSFERS AND STEP-UP TRANSFERS: DIFFERENTIATING KNEE PATIENTS FROM CONTROLS.**

Bolink SAAN1, van laarhoven SN1, Lipperts M1, Heyligers I C1, Grimm B1

1AMHORSE Foundation, Dept Orthopaedics, Atrium Medical Center Heerlen, the Netherlands

**015.4 AMBULATORY MONITORING IN PARKINSON’S DISEASE: A MODEL-BASED APPROACH**

La Calverzin P1, Rochcongar P1, Vérin M1

1URU 425 « Comportement & Noyaux Gris Centraux », Université de Rennes 1, Rennes, France; 2Unité de Biologie et Médecine du Sport, CHR de Rennes, Rennes, France

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11:45-12:15 – BUCHANAN SUITE

**INVITED SPEAKER:**

**CHRIS BATES**

Fusion – Bridging the gap between laboratory achievements and practical application through instant ambulatory 3D analysis of movement
Chair: Kamiar Aminian

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12:15-13:15 – BUCHANAN SUITE

**SESSION 16**

**DEVICE DEVELOPMENT**

**NOVEL DEVICES & SENSORS 2**

Chairs: Chris Baten, Kamiar Aminian

**Oral Presentations:**

**016.1 THE EFFECT OF SELF-DETERMINATION ON THE ASSOCIATION OF PHYSICAL ACTIVITY AND MOOD**

Kanning M1, Ebner-Priemer U1, Bossmann T1, Schlicht W1

1University of Stuttgart, Stuttgart, Germany; 2Karsruhe Institute of Technology, Germany

**016.2 A CONTEXT-AWARE ADAPTIVE FEEDBACK SYSTEM FOR ACTIVITY MONITORING**

op den Akker H1,2, Hermens HJ1,2, Jones VM2

1Monitoring and Diagnostics, Roessingh Research and Development, Enschede, The Netherlands; 2Remote Monitoring and Treatment Group, University of Twente, Enschede, The Netherlands

**016.3 ACCURACY OF WEARABLE ACCELEROMETERS IN DISTINGUISHING FALLS DUE TO INTERNAL VERSUS EXTERNAL PERTURBATIONS**

Aziz O1, Robinovitch SN1,2

1School of Engineering Science; 2Department of Biomedical Physiology and Kinesiology, Simon Fraser University, Burnaby, BC, Canada

**016.4 METHOD TO COMPARE NEW AND TRADITIONAL ACCELEROMETRY DATA IN PHYSICAL ACTIVITY MONITORING**

van Hees VT1, Brychta RJ1, Pias, M1, Taberian S1, Catt M1, Ekelund U1, Chen KY2, Brage S2

1MRC Epidemiology Unit, Institute of Metabolic Science, Cambridge, UK; 2Clinical Endocrinology Branch, NIDDK, National Institutes of Health, Bethesda, Maryland, USA; 3Computer Laboratory, University of Cambridge, Cambridge, UK; 4Institute for Ageing & Health, Newcastle University, Newcastle, UK

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13:15-13:45 – STRATHCLYDE SUITE

**CLOSING**
KEYNOTE SPEAKER ABSTRACTS
INVITED SPEAKER ABSTRACTS
KEYNOTE SPEAKER ABSTRACTS

K1  DAVID BASSETT
Director of the Applied Physiology Laboratory and Co-Director of the Obesity Research Center, Department of Exercise Science and Sport Management, The University of Tennessee, Knoxville, USA.

Recent Applications of Physical Activity Monitoring
Objective measurement of physical activity is important, given the role of this human behavior in physical and mental health. This presentation will cover the applications of objective physical activity monitoring, within the framework of the public health approach. Wearable monitors are currently being used to conduct surveillance; and to determine the extent and distribution of physical activity and sedentary behaviors in populations around the world. In some cases, time trends in physical activity are studied by using a series of snapshots, as is being done in Japan and Canada. A second group of studies are those in which wearable monitors are being used to clarify the dose-response relation between physical activity and health, both through cross-sectional association studies and prospective, longitudinal studies. In a third group of studies, wearable monitors have been used in longitudinal interventions, to motivate research participants to meet program goals and to assess their compliance in doing so. Recently, technologies have been developed that could document the effectiveness of community interventions designed to enhance opportunities for physical activity through changing the built environment. A future challenge for researchers is to develop new monitors and post-processing software that will enhance our ability to accurately assess physical activity energy expenditure in free-living individuals.

K2  YUKITOSHI AOYAGI
Head, Exercise Sciences Research Group, Tokyo Metropolitan Institute of Gerontology, Itabashi, Tokyo, Japan. With Roy J. Shephard, Faculty of Physical Education and Health, University of Toronto, Toronto, Ontario, Canada

Habitual physical activity and health in the elderly: the Nakanojo Study
We will: 1) examine associations between daily physical activity and the physical, psychosocial, mental and metabolic components of health; 2) explore possible interactions between step count and amount of moderately vigorous physical activity; 3) consider psychological and meteorological factors modulating physical activity patterns; and 4) offer a theoretical model to estimate the potential for a physical activity-related reduction in health care costs, based on data from the ongoing Nakanojo Study. Participants have included an entire community of approximately 5,000 free-living people aged 65 years, with one-tenth of the sample wearing a pedometer/accelerometer continuously, 24 hours per day, for >10 years.

K3  PATTY FREEDSON
Professor and Chair, Department of Kinesiology, University of Massachusetts, Amherst, MA, USA.

Using pattern recognition techniques to interpret wearable physical activity monitor output: Laboratory calibration studies
Objective monitoring of physical activity using wearable sensors has become widespread in the research community. Traditional methods for interpreting output from sensor signals use simple linear regression approaches. Specifically, sensor output signals are related to some measurable physiological response such as energy expenditure and simple linear regression models are built. Locomotion, lifestyle and sport activities are performed to build these models and energy expenditure metrics are predicted from the sensor signals. Recently our group has used pattern recognition methods such as Hidden Markov Models, artificial neural networks, and support vector machines to build models for predicting ventilation, energy expenditure and to identify activity type. This presentation will describe the evolution of these methods and the process used to develop and validate these models in a laboratory setting. Transformation of these lab tools for use in the field will be discussed.

K4  NEVILLE OWEN
Head, Behavioural Epidemiology Laboratory, Baker IDI Heart and Diabetes Institute, Melbourne, Professor of Health Behaviour, University of Queensland, Cancer Prevention Research Centre, School of Population Health, Brisbane, Australia.

Ambulatory monitoring and sedentary behaviour: Evidence, distinctions and issues
Primarily, ambulatory monitoring devices capture movement or posture. Research on physical activity and health aims to understand and influence behaviour: moderate-to-vigorous activity and sitting time. The three main settings for adults’ prolonged sitting time are: domestic environments (sitting for screen-based entertainment, computer and Internet use); workplaces (sitting at desks and/or in front of computer terminals); and, private transportation (sitting in automobiles). Sedentary behaviour research aims to characterize sitting time accurately, understand the relevant behavioural determinants, and develop effective interventions. Evidence to illustrate potentials and pitfalls of ambulatory monitoring in the context of a behavioural epidemiology research agenda will be considered.

K5  CATRINE TUDOR-LOCKE
Associate Professor, Director, Walking Behavior Laboratory, Pennington Biomedical Research Center, Baton Rouge, LA, USA.

Cadence: An Overlooked Opportunity to Measure and Motivate Ambulatory Intensity?
Cadence (steps/minute) is a gait parameter that has been traditionally measured using short laboratory or clinic-based walking tests. Since intensity is known to increase with speed of ambulation, and since cadence is correlated with speed, cadence is a logical surrogate of intensity. Indeed, at least four laboratory-based studies have documented increasing intensity with increasing cadence such that 100 steps/minute appears to be a reasonable indicator of walking at minimally moderate intensity (i.e., 3 METs). Therefore, the purpose of this keynote presentation is to explore the potential utility of studying minute-by-minute cadence to represent patterns of free-living ambulatory activity intensity.

KEYNOTE SPEAKER ABSTRACTS

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Comparison of sedentary and sitting time using the activPAL, GT3X Actigraph, and observation among children.

Data from several studies will compare the activPAL and Actigraph in terms of children’s sedentary/sitting time against observation. One aim is to examine appropriate cutpoints for sedentary time using the Actigraph (eg. <100, <200 counts per minute) compared to sitting time from the activPAL and observation. A second aim is to use observation to validate the activPAL in terms of sitting time, standing time, sustained bouts of sitting, and transitions from sitting to standing among children.

Activity monitoring in older adults with impaired functioning - Challenges and possibilities

Valid information on physical activity in older persons is important for designing exercise interventions aiming at improving physical functioning. Physical activity in old persons with impaired functioning is mostly performed as part of daily life activities, like getting out of bed or up from a chair, standing and walking. Reliable and valid measures of physical activity should therefore capture such aspects. During the talk feasibility of activity monitoring in older persons as well as accuracy and validity of different outcomes will be discussed.

Objective measurement of physical activity in observational cohort studies; what have we learnt?

Precise measurement of physical activity in epidemiological studies is needed to accurately assess dose-response associations between physical activity and health outcomes, to clarify which dimension of physical activity is most important for a specific health outcome, to monitor temporal trends in population levels of physical activity, and to assess the effect of interventions. The overall aim with the present talk is to discuss the importance of objective measurements of physical activity in epidemiological studies. Further, results from studies examining the associations between objectively measured physical activity and its sub-components with obesity and metabolic outcomes will be presented.

Objective measurement of physical activity in large epidemiologic studies: Strengths, Weaknesses, and Strategies to Reduce Measurement Error

Physical activity monitoring systems provide an opportunity to gather more precise estimates of active and sedentary behaviors in disease-association studies, but the strengths of this approach, its inherent weaknesses, and strategies to minimize measurement errors must be considered. The aim of this talk will be to examine the strengths of using physical activity monitors in association studies (e.g., more precise estimates of activity, greater statistical power), discuss the potential weaknesses of such measures (e.g., random and systematic errors), and outline strategies that can be employed to minimize certain types of measurement errors in an effort to provide a better estimate of the true behavior-disease association of interest.
MALCOLM GRANAT
School of Health, Glasgow Caledonian University, Glasgow, Scotland

What is important? Extracting relevant outcome measures from free-living behaviour.
The use of ambulatory monitoring devices to collect data on activity and inactivity is becoming widespread, and the data sets obtained are large and relatively complex. At present we are data rich - but we are still information poor. Recent research has started to investigate how we can extract meaningful relevant outcomes from this data. This presentation will explore how it is possible to develop outcome measures tailored to our research questions. Examples will be given from different populations showing how free-living activity data sets can be analysed to produce relevant, meaningful outcomes.

ULRICH EBNER-PRIEMER
Karlsruhe Institute of Technology, Karlsruhe, Germany

Interactive Ambulatory Behavior Monitoring - An approach to optimize the sampling strategy in real time
There is a positive relation between activity and mood. Unfortunately, most studies assessing this association relied on subjective ratings of activity and retrospective ratings of mood. Whereas activity can be monitored continuously with a high sampling frequency, mood can only be assessed in discrete intervals. To optimize the assessment of the relation between physical activity and mood, we developed an algorithm which continuously monitored physical activity. When predefined thresholds were surpassed an alarm triggered participants to answer mood questions. Interactive ambulatory behavior monitoring is a promising sampling strategy, especially when analyzing the relation between variables which cannot be measured continuously, like many psychological variables.

HANS BUSSMAN
Associate Professor, Dept. of Rehabilitation Medicine & Physical Therapy, Erasmus MC University Medical Center Rotterdam, The Netherlands

To total amount of activity... and beyond!
In many studies on physical activity the total amount of activity (e.g. number of activity counts) is the primary outcome measure. It can be questioned, however, whether this outcome is the most valid and sensitive one. Disorders and treatments may influence movement behaviour, but which is not reflected in the total amount of activity. In this presentation an overview will be provided of recent insights on the added value of aspects of movement behaviour that go beyond the total amount of activity.

CHRISS BATE
Roessingh Research and Development, Enschede, The Netherlands

Fusion - Bridging the gap between laboratory achievements and practical application through instant ambulatory 3D analysis of movement
Technology and methodology of ambulatory 3D analysis of movement based on body mounted sensing is maturing at a promising rate. Still, widespread clinical application has not emerged yet. For this to happen, the next level of combined accuracy, reliability, robustness, practical applicability and evidence supported instant clinical usefulness has to be achieved. The Fusion research consortium (before FreeMotion) of Dutch research institutes and innovative companies aims at facilitating and actively endorsing widespread instant clinical application. Presented are the FUSION approach, research achievements and ambition following an analysis of requirements and illustrated with a series of example studies in rehabilitation, sports and ergonomics.
ORAL ABSTRACTS 01.1 — 016.4
INTRODUCTION

In the recent years probiotics have emerged as a potential intervention with effects on morbidity and immune functions among children. These effects have however been varied by the preparation of probiotics. Additionally, most of the data has come from selective intervention in sick children with limited sample size. Large community based prospective studies evaluating effects of probiotics on morbidity and thus, direct and indirect impact on growth and activity are lacking. Therefore, in a randomized controlled trial, we evaluated the effect of milk fortified with Bifidobacterium lactis HN019 (DR10™) and prebiotic oligosaccharide on growth and physical activity levels of children aged 1-4 year.

METHODS

624 peri urban children of north India were enrolled and randomly allocated to receive either the milk fortified with 1.9x10⁷ c.f.u/day of Bifidobacterium lactis HN019 (DR10™) and 2.4 g/day of prebiotic oligosaccharide, daily in 3 feeds (PP, n=312) or control milk with no additional fortification (CO, n=312). Intervention continued for 1 year. For physical activity sub study, randomly selected 159 children (PP, n=77; CO, n= 82) were enrolled. Height and weight of the child was recorded at baseline and end study to measure the growth effects. Physical activity was assessed baseline and end study using actiwatch (Mini Mitter Co.Inc.). Two actiwatches, one on Leg (L) and the other on Arm (A) were tied at the child’s home, which recorded 24 hours activity with one-minute epochs. Effect of probiotics on growth and physical activity scores was evaluated and compared between the two groups.

RESULTS

Compliance to fortified milk was high (>90%) in both groups. Children consuming fortified milk had better weight gain [Baseline weight (kg), PP: 9.07±1.43 CO: 9.13±1.46; Diff of means at end study (95% CI): 0.13 (0.03, 0.23), p=0.02], improved weight-for-age z scores [Baseline WAZ, PP: -2.86±1.25 CO: 2.94±1.25, Diff of means at end study (95% CI): 0.02 (0.02, 0.41), p=0.03] and weight for height z scores [Baseline WHZ, PP: -1.78±1 CO: -1.82±1.00, Diff of means at end study (95% CI): 0.18 (-0.003, 0.36), p=0.05] compared to children consuming non-fortified milk. The mean activity scores per minute were comparable for leg (PP: 339.6±123.2; CO: 336.1 ± 159.5) and arm (PP: 239.1±165.4; CO: 198.3 ± 58.0) in both the groups at baseline. Compared to the control group, probiotic fortified group had a significant increase in the combined leg and arm activity score (PP: 748.6± 220.8; CO: 670.6±242.2; p= 0.03).

DISCUSSION AND CONCLUSION

Our data suggest that consumption of Bifidobacterium lactis HN019 (DR10™) and prebiotic oligosaccharide fortified milk enhances the growth of children especially gaining weight velocity and improves overall leg and arm activity levels among pre-school children. These findings, if confirmed in other settings will render probiotics in milk as an accepted vehicle for improving the growth and physical activity of children in developing countries who are at a risk of high morbidity.

VOLUME, PATTERNS, AND TYPES OF SEDENTARY BEHAVIOR AND CARDIO-METABOLIC HEALTH IN CHILDREN AND ADOLESCENTS

Carson, V.1 & Jansen, I.1,2

1 School of Kinesiology and Health Studies, Queen’s University, Kingston, ON, Canada
2 Department of Community Health and Epidemiology, Queen’s University, Kingston, ON, Canada

INTRODUCTION

Cardio-metabolic risk factors are becoming more prevalent in children and adolescents. A lack of moderate-to-vigorous intensity physical activity (MVPA) is an established determinant of cardio-metabolic risk factors in children and adolescents [1]. Less is known about the relationship between sedentary behavior and cardio-metabolic health. Therefore, the objective was to examine the independent associations between volume, patterns, and types of sedentary behavior with cardio-metabolic risk factors among children and adolescents.

METHODS

Results are based on 2527 American children and adolescents (6-19 years old) from the 2003/04 and 2005/06 National Health and Nutrition Examination Surveys (NHANES). A cardio-metabolic risk score (CRS) was calculated based on age- and sex-adjusted waist circumference, systolic blood pressure, non-high-density lipoprotein cholesterol, and C-reactive protein values. The total volume of sedentary behavior, the volume of sedentary behavior accumulated in bouts lasting ≥30 minutes, and the total volume of MVPA were measured using Actigraph AM-7124 accelerometers (Actigraph, Ft. Walton Beach, FL). These uniaxial accelerometers recorded average intensities in one minute intervals over 7 consecutive days. A cut-off point of <100 counts per minute was used to define sedentary behavior. A regression equation developed by Freedson and colleagues [2] was used to convert accelerometry...
counts into METS, and MVPA was defined as ≥ 4.0 METS. The volume for the two main types of sedentary behavior (TV, computer) were measured by questionnaire. A series of logistic regression models were used to examine associations.

RESULTS
MVPA predicted high (top quartile) CRS after adjusting for sedentary behavior measures and other confounders (P<0.05). However, the total volume of sedentary behavior and the volume of sedentary behavior accumulated in bouts lasting ≥30 minutes were not predictors of high CRS after adjusting for MVPA and other confounders (P>0.1). For types of sedentary behavior, TV use but not computer use was a predictor of high CRS after adjusting for MVPA and other confounders. Children and adolescents who watched ≥4 hours per day of TV were 2.53 (95% confidence interval: 1.45-4.42) times more likely to have high CRS than those who watched <1 hour per day. TV use was poorly correlated (r=0.08) with total volume of sedentary behavior assessed by accelerometry.

DISCUSSION AND CONCLUSION
Excessive TV use and low MVPA were independently associated with cardio-metabolic risk in this large and representative sample of children and adolescents. At this time, TV use and MVPA appear to be two separate behaviors that need to be targeted with different interventions and policies.

REFERENCES

01.4 CHILDREN’S PHYSICAL ACTIVITY LEVELS OVER A 5-YEAR PERIOD ASSESSED USING ACCELEROMETRY

Ridgers, N.D.1, Timperio, A.1, Crawford, D.1 & Salmon, J.1
1Centre for Physical Activity and Nutrition Research, Deakin University, Australia

INTRODUCTION
Understanding how patterns of activity change over time may help to tailor specific interventions within discrete periods of the day. Two discrete periods during the school day are recess and lunchtime, which provide daily opportunities to engage in physical activity. The aim of this study was to determine changes in recess and lunchtime physical activity over a 5-year period using accelerometry.

METHODS
Data were drawn from two longitudinal studies that were conducted over 5-years in metropolitan Melbourne, Australia. In each study, children in Grade Prep (5-6 years) and Grade 5-6 (11-12 years) were invited to participate. At baseline (T0), 2762 children received written informed parental consent to participate in baseline measures. Of these 2490 children had their physical activity measured in 1-minute epochs for eight consecutive days using hip-mounted uni-axial accelerometry. Subsequent measurements were taken at 2-years (T1; n=773) and 5-years (T2; n=634) follow-up. Physical activity intensities were derived using age-adjusted cut-points. Sedentary time was defined as 100 CPM. Wear time was derived using accelerometer wear time measures results in the best combined Mobility Score to rate severity of Parkinson’s disease [3]. Objective, automatic assessment of static and dynamic balance with iSWAY includes protocol control, automatic analysis algorithms, and graphs of results that make it practical for clinical settings.

RESULTS
Decreases in moderate (-6.1%, -1.4%) and vigorous (-5.9%, -5.3%) physical activity during recess were observed for younger boys and girls, respectively, between T0 and T1 (p<0.05). In the older cohort, boy’s and girls’ sedentary activity during recess (22.9%, 22.6%) and lunchtime (23.1%, 17.6%) increased between T0 and T1 (p<0.01). Decreases were also observed in older boys and girls’ moderate activity during recess (-4.2%, -7.9%) and lunchtime (-4.5%, 6.4%; p<0.001). Between T0 and T2, decreases in the younger boy’s and girls’ recess (-9.1%, -12.2%) and lunchtime (-9.1%, -11.1%) vigorous activity were recorded, respectively (p<0.001). For the older children, boy’s and girls’ moderate activity during recess (-10.4%, -12.4%) and lunchtime (-10.9%, -11.8%) decreased between T0 and T2 (p<0.001).

DISCUSSION AND CONCLUSION
Understanding patterns of physical activity in discrete time periods of the day provides an opportunity to inform future intervention development. In this study, physical activity levels during recess and lunch decreased in both cohorts over time. This is consistent with interventions that showed decreases in the control children’s activity levels in the short-term (2-3 months). Interventions are needed in both primary and secondary schools to promote physical activity levels during recess and lunch, particularly during the early years of secondary school.

REFERENCES

SESSION 2
DEVICE DEVELOPMENT
NOVEL DEVICES AND SENSORS 1

02.1 iSWAY: INSTRUMENTED STAND AND WALK TEST

Heras FK1, Salarian A1, Mancini M1, Carlson-Kuhta P1
1Department of Neurology, Oregon Health & Science University, Portland, USA

INTRODUCTION
Current clinical practice to assess mobility relies on clinical scales. The goal of our study was to develop an objective, yet short and easy to use, clinical test to assess important aspects of mobility including gait, balance and postural transitions. iSWAY is an evolution of previously developed methods by our group to assess the Timed Up and Go (iTUG) [1] and body sway (iSWAY) [2] with wireless, inertial sensors. These sensors are cost-effective and easy to use for clinical tests. The software interface includes protocol control, automatic analysis algorithms, and graphs of results that make it practical for clinical settings.

METHODS
iSWAY was performed on a straight, 7 m pathway in a hospital hallway. Subjects were instructed to start by standing quietly with arms at their sides. After 30 seconds, they walked toward the end of the pathway that was marked by a line on the ground. After crossing the line, they made a 180° turn and returned back to where they started. Subjects were instructed not to stop walking until the end of each trial. Each subject was measured on 3 occasions.

RESULTS
All subjects were able to finish the task with excellent compliance. gait and turning measures had excellent agreement between iTUG and iSWAY, the ICCs for Cadence, Stride-Velocity, Turning Duration from iTUG and Sway Area, Sway Amplitude and Sway Frequency from iSWAY. The same measures were extracted from iSWAW. The data was automatically analyzed and uploaded to a database.

To assess absolute agreement between the results of either iTUG or iSWAY with iSWAW, Intra-Class Correlation (ICC type A-1) was used.

REFERENCES
**02.2 DESIGN OF A WEARABLE MULTI-SENSOR SYSTEM FOR PHYSICAL ACTIVITY ASSESSMENT**

Liu S1, Gao R2, Freedson PS3

1University of Connecticut, Storrs, CT, USA
2University of Massachusetts, Amherst, MA, USA

**INTRODUCTION**
Motivated by the increasing need for advanced physical activity (PA) assessment in free-living environments, a wearable multi-sensor integrated measurement system (IMS) was designed, prototyped and experimentally evaluated. The IMS consists of two accelerometers, two ventilation sensors, and one ultraviolet sensor to capture human body motion, breathing frequency, ventilation volume and environmental context. Based on the data captured, the IMS estimates PA modes and associated energy expenditure to produce an accurate estimate of PA.

**METHODS**
Given that multiple parameters and constraints are present influencing the final outcome of the IMS design (e.g. degree of functionality to be integrated into the device affects the device's dimension, and the same circuit complexity can be satisfied using different form factors, which in turn affects the wearability), a concurrent design approach was taken by creating a need-metric matrix [1], which establishes a correlation between the global design needs and quantifiable design specifications to guide the concrete system design. Detailed analysis and simulation were performed for the parametric design of the IMS hardware and software, and energy efficiency. The performance of the IMS was evaluated through a preliminary study involving 50 test subjects (32.6±9.9 years) performing 14 free-living activities of broad range of intensity (sedentary, lifestyle, locomotion, sports).

**RESULTS**
The IMS is comprised of two wearable devices: with the dimension comparable to a cell phone and weighing about 47 and 23 grams, respectively. Sensor data is sampled at 30 Hz, and the maximum sampling rate available to the system is 15.6 kHz. An adaptive-scheduling algorithm was devised and embedded in the IMS software, enabling continued system operation of up to 48 hours. The IMS has shown to be able to correctly recognize 14 different types of activity for 78.6% of the time, 20% more than using hip accelerometer alone. It predicted the associated energy expenditure with a root mean square error of 0.54 METs, 28% less than using hip accelerometer alone.

**DISCUSSION AND CONCLUSION**
The wearable IMS contributes to advancing the state of art in PA monitoring in two ways: (1) the system's small footprint, low power consumption, and extended operation life makes it suitable for long-term large-scale PA studies; (2) it is more effective in PA assessment than traditional methods using accelerometers alone. Future research will involve a large-population testing for examining feasibility of long-term wear and overall IMS performance.

**REFERENCES**

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**02.3 BREATHING FREQUENCY AND VOLUME ESTIMATIONS USING A MULTI-SENSOR INTEGRATED MEASUREMENT SYSTEM**

John D1, Liu S1, Sasaki J1, Gao R4, Staudenmayer J1, Freedson P2

1Dept. of Kinesiology, University of Massachusetts, Amherst, MA; 
2Dept. of Mechanical Engineering, University of Connecticut, Storrs, CT; 
4Dept. of Mathematics and Statistics, University of Massachusetts, Amherst, MA

**INTRODUCTION**
The multi-sensor Integrated Measurement System (IMS) is an indigenous activity monitor developed with grant support from the NIH’s Exposure Biology Program, which is part of the NIH Genes and Environment Initiative. The IMS has two piezoelectric respiration sensors secured at the level of the chest and abdomen. Raw signals from these sensors are used to estimate respiration variables to quantify the internal exposure (inhalation) to environmental pollutants. The purpose of this study was to examine calibration analyses of the IMS respiration sensors for predicting breathing frequency (BF) and volume (BV).

**METHODS**
Fifty adults (32.6±9.9 yrs) wore the IMS and a criterion portable metabolic unit that measured actual breathing frequency and volume while performing one of two activity routines (7 activities each and 7 min/activity). These consisted of both ambulatory and simulated free-living activities. The raw signals from each sensor were ‘filtered’ to eliminate tissue artifact and spectral analyses were used to reconstruct the respiratory signals and estimate BF. These analyses allowed us to differentiate tissue artifact and background noise from the true respiratory signal (arising from chest wall and abdomi- nal expansion). The average of predicted BF from the two belts was used as the BF estimate. BV was estimated using multiple linear regression analyses with estimated BF and the 10th and the 90th percentiles of each sensor’s raw signal distribution as predictor variables.

**RESULTS**
The overall BF was consistently underestimated during all activities with a root mean square error of 7.0 and a bias of -4.5 (Limits of Agreement= -15.3 to 6.1) breaths/min, respectively. BV estimates had a mean absolute percent error, root mean square error, and bias of 8.8%, 7.2 L/min, and 0.36 (Limits of Agreement= -18.2 to 17.52 L/min). Mean BV estimates during most light and moderate activities were reasonably good (mean absolute differences= 0.1 to 5 L/min). However, during vigorous intensity activities, mean BV predictions were underestimated. These underestimations were marginally high with the mean absolute differences ranging between 9 and 16 L/min.

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**02.4 A PATTERN RECOGNITION TECHNIQUE TO ASSESS FREE-LIVING PHYSICAL ACTIVITY: THE SOJOURN METHOD**

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**INTRODUCTION**
Accelerometer sensors are popular devices to objectively measure physical activity. Staudenmayer et al. [1] recently developed a simple artificial neural network (ANN) to estimate energy expenditure (EE) from accelerometer output. In a laboratory setting the ANN improves EE estimates compared to traditional approaches (e.g. simple linear and non-linear regressions). However, like previous methods, the ANN produces estimates for a given time period (usually 1-minute). In a laboratory this is not problematic because subjects perform the same activity for a prescribed amount of time. To measure activity in a free-living setting, where behavior is sporadic and not specifically planned, we must first identify bouts of activities and then apply the ANN to produce estimates for these given activities. The Sojourn Method is a pattern recognition technique that uses simple parameters from the acceleration signal to identify bouts of activities. The ANN can then be applied to produce PA estimates. This study is a free-living validation of the ANN, and the Sojourn Method in combination with the ANN (ANN+soj).

**METHODS**
Twelve participants (3 men, 9 women) wore the ActiGraph GT3X accelerometer for 10-consecutive hours in their free-living environment. During this time, a trained researcher directly observed (DO) each participant and recorded subject behavior in a personal digital assistant (Noldus Information Technology, Netherlands). The DO program uses custom software to record activity mode, intensity and duration. Accelerometer counts were processed using the ANN and ANN+soj to estimate time spent in sedentary (<1.5 METs), light (1.5-2.99 METs), moderate (3.5-9.99 METs) and vigorous (≥ 6 METs) intensity activity categories and total MET-hours. Linear mixed effects models were used to assess the average differences in ANN and ANN+soj estimates compared to DO.

<table>
<thead>
<tr>
<th>Hours (mean ± SD)</th>
<th>ANN</th>
<th>ANN+soj</th>
<th>DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary</td>
<td>0.0 ± 0.0*</td>
<td>6.8 ± 2.1</td>
<td>6.4 ± 2.3</td>
</tr>
<tr>
<td>Light</td>
<td>8.1 ± 0.4*</td>
<td>1.7 ± 2.4</td>
<td>2.3 ± 2.6</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.5 ± 0.4*</td>
<td>1.0 ± 0.4</td>
<td>0.9 ± 0.3</td>
</tr>
<tr>
<td>Vigorous</td>
<td>0.2 ± 0.2</td>
<td>0.3 ± 0.3</td>
<td>0.2 ± 0.2</td>
</tr>
<tr>
<td>MET-Hours</td>
<td>24.6 ± 1.6*</td>
<td>17.4 ± 1.7</td>
<td>17.8 ± 1.6</td>
</tr>
</tbody>
</table>

*significantly different than DO
RESULTS
ANN estimates were significantly different than DO for all PA estimates except vigorous intensity activity. ANN+soj estimates were not different than DO for any intensity category or total MET-hours.

DISCUSSION AND CONCLUSIONS
The ANN+soj produces valid estimates of intensity specific free-living activity and total MET-hours. The ANN did not produce valid estimates, indicating identification of activity bouts is required to measure free-living activity. This new technique for recognizing bouts of activity will allow researchers to apply laboratory based activity monitor calibrations to the field setting.

REFERENCES

Funded by NIH RC1HL099557

SESSION 3
POPULATION & INTERVENTION ASSESSMENT
Older Adults & Falls

AMBULATORY MEASUREMENT OF DUAL-TASKING BEHAVIOUR: METHOD AND PRELIMINARY EVALUATION IN OLDER ADULTS

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INTRODUCTION
Along with amnesia, decline of attention control of executive functions is among the earliest symptoms of dementia. Task performance under conditions of divided attention, or dual-tasking, are sensitive indicators. In particular, there is mounting evidence of poor performance of walking and talking simultaneously in patients with Alzheimer’s disease [1]. While the laboratory evidence has been growing, there is a lack of translational research examining dual-task behaviour in everyday life. The objectives of this study are to: 1) develop an ambulatory technique of capturing dual-tasking behaviour and, 2) characterize the frequency of naturally occurring dual-tasking events in older adults.

METHODS
Ten community-dwelling older adults without mobility or cognitive impairment participated in the study. Ambulatory dual-tasking behaviour was assessed over a 3 daytime collection period (~24 hrs). Participants were: 1) 3-G accelerometers (X6-2 Mini, Gulf Coast Data Concepts, Inc.) on each ankle, and 2) a microphone attached to a smartphone (Nexus 1, Google, Inc.). For privacy, the audio recording system allowed the ability to be turned off and to remove previously recorded data.

Ankle acceleration data was high-pass filtered to remove gravity, followed by identification of bilateral limb activity using a cross-spectral approach. Time segments with bilateral leg activity were then inspected visually to confirm walking (~3 steps). Audio data corresponding to the gait periods were segmented from the full record, and a standard voice activity detection algorithm (G.729. [2]) was applied. Detected voice activity was confirmed manually by a researcher.

RESULTS
To date, data from 2 of 10 participants have been processed. Over the 3 day collection, the total number of gait segments observed was 1085 and 807 for participant 1 (P1) and 2 (P2), respectively, with mean durations of 11.3s (P1) and 7.1s (P2). Corresponding audio data was recorded for the majority of the gait segments (P1: 673/1085 (62%); P2: 696/807 (88%)). Verbal activity was detected in 297/673 (44%) and 252/807 (36%) of the gait segments for P1 and P2, respectively.

DISCUSSION AND CONCLUSION
The first objective of developing an ambulatory technique of capturing dual-tasking behaviour was achieved. Participants complied with wearing and using the equipment throughout the collection. Efforts to meet the second objective of characterizing dual-task activity are on-going. Surprisingly, initial data from 2 participants yielded occurrences of dual-tasking in greater than gait periods (with a corresponding audio record). On-going work is focused on analyzing the remainder of the collected data and examining the influence of dual-tasking on gait characteristics (e.g., cadence, step time variability). Future work will extend collection to examine ambulatory dual-task behaviour in cognitively-impaired populations.

REFERENCES

03.2 USING ACCELEROMETERS TO ASSESS TEMPORAL CHANGES IN OLDER ADULTS’ SEDENTARY TIME FOLLOWING AN INTERVENTION

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INTRODUCTION
Accelerometer data provide reliable, valid, and stable measures of physical activity, and also allow for the estimation of sedentary time. Furthermore, as data are date and time-stamped, the outcomes of interventions targeting these behaviors can be explored beyond simple average of change.

METHODS
Stand Up For Your Health [1] was a quasi-experimental (pre-post) study that assessed the feasibility of an intervention to reduce and break up sedentary time in older adults. Participants (n=59; 75% female; age range 60-92 years) wore a GT1M accelerometer for 14 days during waking hours to derive sedentary time (<100 counts per minute (cpm); expressed as minutes and percentage of wear time) and breaks in sedentary time (> 100cpm, for at least one minute). The intervention consisted of one face-to-face goal setting consultation (delivered after seven days of accelerometer wear) and one individually-tailored mailing providing feedback on accelerometer-derived sedentary time. Intervention outcomes (participants’ changes in total sedentary time and in breaks) were assessed in three ways: pre- to post-intervention changes (via paired t-tests); day-by-day changes (via linear mixed models); and, hour-by-hour changes (via Wicoxon signed rank tests).

RESULTS
From pre- to post-intervention there was a significant reduction (baseline level [SD], mean change [95%CI]) in sedentary time (71.1% [8.9], -3.2% [-4.18 to -2.14], p<0.001), and a significant increase in the number of breaks in sedentary time per day (67.8 [14.8], 4.0 [1.48 to 6.58], p<0.003). Compared to the day prior to the intervention, participants had lower sedentary time (-4.8% [-6.96 to -2.36]) and more breaks (8.3 [2.5 to 14.1]) on the day immediately following the intervention. While significantly greater reductions in sedentary time were made in a consistent pattern during each hour after 10am, participants mostly broke up their sedentary time between 7pm and 9pm.

DISCUSSION AND CONCLUSION
Examining the temporal patterns of the accelerometer data extended the understanding of the intervention effects beyond the pre-post mean change. These approaches have applicability to studies using other monitoring devices that capture time-stamped data.

REFERENCES
INTRODUCTION

Clinicians need a practical, objective test of postural control that is sensitive to mild neurological disease, shows experimental and clinical validity and has good test-retest reliability. Body worn accelerometers have been proposed for instrumented measures of postural sway (iSWAY) and offer a practical and low-cost alternative to force-plates. We recently showed that acceleration-based measures are able to distinguish sway during quiet stance between people with untreated Parkinson’s disease (PD) and age-matched control subjects (CTR).

This study has two aims: 1) To determine the sensitivity and concurrent validity of iSWAY compared to force-plate measures of body sway, and 2) To measure test-retest reliability and clinical validity of acceleration measurements.

METHODS

Study I: Thirteen subjects with early, untreated PD and 12 age-matched CTR were tested in the laboratory. All participants maintained a standing position on a force-plate (AMTI OR6-6), with a standardized foot position for 2 minutes. Subjects were a MTX Xsens sensor (49A33G15, Xsens) mounted on the posterior trunk at the level of L5, near the body center of mass. Data from the sensor and the force-plate were simultaneously recorded for 3 trials of sway with eyes open and eyes closed. Study II: A different set of 17 early-to-moderate, treated PD (tested ON medication), and 17 age-matched CTR were tested in the clinic. For reliability, after finishing the 3 sway trials, the sensor was removed, subjects rested for 30 min, and the protocol was repeated.

Thirteen measures (7 time-domain, 5 frequency-domain measures, and JERK) were computed from the 2D time series acceleration data. Differences between untreated PD and CTR were determined with a Paired t-test. Pearson product moment correlations were used to assess the relationship between center of pressure (COP) and acceleration (ACC) measures, and between ACC measures and clinical scores. Intra-Class Correlation (IC0.1,1) evaluated test-retest reliability.

RESULTS

Both COP and ACC measures differentiated sway between CTR and untreated PD. All but 2 ACC measures showed significant correlation with COP measures (r ranged from 0.41 to 0.89, 0.000001<p<0.05). JERK and time-domain measures showed the best reliability (JERK ICC is 0.86 in PD and 0.81 in CTR; time-domain measures ICC ranged from .55 to .84 in PD and from .53 to .85 in CTR), whereas the frequency measures showed worse test-retest reliability (ICC ranged from .35 to .65 in PD and from .24 to .61 in CTR). JERK, all but one time-domain measures, and one frequency measure were significantly correlated with the clinical postural stability score (r ranged from 0.50 to 0.63, 0.01<p<0.05).

DISCUSSION AND CONCLUSION

Based on presented results, we recommend a subset of the most sensitive, reliable, and valid iSWAY measures to characterize posture control in PD. We suggest including: 1) JERK, for its excellent reliability and sensitivity; 2) RMS amplitude, and mean velocity from the time-domain measures; and 3) centroidal frequency as the best frequency measure (sensitive, reliable, and correlated with COP CF).

ACKNOWLEDGEMENTS

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WALKING ON SUNSHINE: EFFECT OF WEATHER CONDITIONS ON PHYSICAL ACTIVITY IN OLDER PEOPLE

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INTRODUCTION

The motion-sensor-based measurement of physical activity in older people is affected by weather conditions [1,2]. However, it is unclear which weather parameters are most important and how they are linked among each other as well as their magnitude in terms of walking duration.

METHODS

Between March 2009 and April 2010 physical activity from 1,324 German community-dwelling older people (≥65 years, 56.4% men) was recorded over five days using a uni-axial accelerometer (activPAL™, PAL Technologies Ltd., Glasgow, UK). Multi-level linear regression analysis was used to estimate the effect of local daily weather parameters (daylight, maximum temperature, total global radiation, average precipitation, average wind speed, average humidity) on walking duration.

RESULTS

Mean daily walking duration was comparable for men and women with 104.4 ± 50.7 min and 102.9 ± 47.8 min, respectively. Global radiation, maximum temperature, and daylight were highly correlated among each other. A linear relationship with walking duration was observed for all considered weather parameters. The strongest effect was found for global radiation involving an increase in walking duration of 16.1 min in men and 19.2 min in women between an average winter day (with about 0.9 kWh m² radiation) and an average summer day (with about 6 kWh/m²). The patterns were similar for daily maximum temperature and daylight. Furthermore, physical activity decreased significantly with increasing wind speed, precipitation and humidity. After mutual adjustment the effects of all weather parameters were reduced but still significant with the exception of daylight.

DISCUSSION AND CONCLUSION

The presented results show strong associations between weather conditions and physical activity in older people. It is the first study quantifying the outcome measure in terms of objectively measured walking duration. The strongest relationships in terms of effect size were found for global radiation and maximum temperature. Daylight as a measure of season was only slightly associated with activity and after adjustment for other weather parameters did not remain significant.

The present results strongly suggest that studies on physical activity in community dwelling older people should account for specific daily weather conditions.

REFERENCES

RESULTS

For both speed and VO2, the TM vs. OG slope and intercept were significantly different from the LOI (p < .05). The regression slope and LOI converged at the 3 MET point. Bland-Altman plots revealed significant (p < .05; Cohen’s d = 0.12 and 0.30) fixed bias and significant (p < .05; r = -0.60 and -0.62) proportional bias. At higher cadences, speed and VO2 were progressively lower for OG walking than TM walking. Similarly, a combined scattergram of the cadence/VO2 relationship for TM and OG walking showed a steeper slope for TM (β = 0.175; CI95 = 0.143-0.207) than OG (β = 0.139; CI95 = 0.114-0.164).

DISCUSSION AND CONCLUSION

Comparison of TM and OG walking in the same sample indicates the relationships among speed, cadence and EE are dissimilar between the two modes. Because TM speeds were not self-selected, when walking OG (despite matching the cadence from the TM trial), participants may have adjusted their stride length to a self-preferred walking speed, especially at higher speeds/cadences. Interestingly, differences were minimal at the 3 MET point of the EE continuum, which could explain the current agreement among TM and OG studies, that walking at approximately 100 steps-min-1 elicits 3 METs. These results merit caution when using TM walking to investigate the cadence/EE relationship, until further evidence has been obtained on this potential inconsistency.

REFERENCES


04.3 PREDICTING PHYSICAL ACTIVITY INTENSITY DURING SWIMMING USING A WEARABLE WATER-PROOF ACCELEROMETER IN ELITE AND RECREATIONAL SWIMMERS

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2Philips DirectLife, Philips Lifestyle Incubator, Amsterdam, Netherlands.

INTRODUCTION

Recent advances in accelerometry-based prediction of energy expenditure suggest the need of activity-type specific estimations of physical activity intensity from measurements of body movement. Swimming represents a common type of physical activity which intensity needs to be accurately estimated for determining the related activity energy expenditure. The aim of this study was to test the ability of a water-proof accelerometer in assessing physical activity intensity during swimming by predicting movement speed in elite and recreational swimmers.

METHODS

Five elite (age: 19±2; BMI: 22.9±3.3 kg/m2) and five recreational (age: 48±14; BMI: 31.5±5.8 kg/m2) swimmers performed free-style, back stroke, breast stroke, and butterfly lane swimming at self selected speed. Physical activity intensity was determined by measuring average swimming speed from measurements of lap duration using a stopwatch. Body movement was registered during swimming using 3 water-proof accelerometers (TracmorD, Philips DirectLife, Philips Lifestyle Incubator, Amsterdam, Netherlands) placed at the upper arm, wrist and waist, respectively. The output of each TracmorD was defined as activity counts per minute (AC-upper-arm, AC-wrist, AC-waist). Subjects reported drag and obtrusiveness for each wearing position on a visual analog scale (0-10) questionnaire. Linear regression was used to develop prediction algorithms of swimming speed from TracmorD activity counts.

RESULTS

The measured swimming speed for free-style, back-stroke, breast-stroke, and butterfly was 4.2±1, 4.0±0.4, 3.8±0.9, 4.9±0.4 km/h for elite and 3.3±0.4, 2.4±0.2, 2.1±0.4, and 2.6±0.2 km/h, respectively, for recreational swimmers. The AC-waist showed the highest association with swimming speed (R2 = 62%; p<0.05) as compared to AC-wrist (R2 = 53%; p<0.05) and AC-upper-arm (R2 = 45%; p<0.05), independently of style and subjective skill level. The speed prediction model based on AC-waist may have a 0.61 km/h standard error of estimation. Subjects reported a significantly higher obtrusive level (4.4±1.6; p<0.05) and water drag (6.6±0.6; p<0.01) for the wrist wearing position as compared to upper arm and waist, which scores were not significantly different (P>0.05).

DISCUSSION

The TracmorD showed to accurately predict physical activity intensity during swimming independently of style in both elite and recreational swimmers. The waist wearing position gave the best compromise between high accuracy, low water drag and low obtrusiveness.

04.2 A NEW METHOD TO ESTIMATE ENERGY EXPENDITURE FROM ABDOMINAL AND RIB CAGE DISTANCES

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3ENS-Cachan Antenne de Bretagne, Bruz, France.

INTRODUCTION

The precise measurement of physical activity (PA) is important in characterizing the dose-response relationship between PA and health outcomes (Bouchard 2001). Therefore, a need for noninvasive, accurate and valid methods for the measurement of PA and predicting energy expenditure (EE) is justified when addressing important health issues.

Our first study has shown that VE is strongly correlated with VO2, which confirms the need to find VE in order to estimate EE (Gastinger et al., 2010b). Our second study (Gastinger et al., 2010a) aimed at validating a new device which would allow for the estimation of ventilation (VE) and oxygen uptake during different activities. The aim of this paper is to validate a new method of energy expenditure (EE) estimation stemming solely from the measurement of rib cage, abdominal and chest wall distances. We set out to prove that the variations of these distances, measured by two pairs of electromagnetic coils, lead to the estimation of the ventilation (VE) and hence, the EE is estimated from the individual relationship between VE and EE.

METHODS

Eleven subjects were recruited to take part in this study (27.6±5.4 years; 73.7±9.7 kg). Each subject participated in two tests. The objective of Test 1 was to determine the individual relationship between VE and EE during light to moderate activities while Test 2 compared the two pairs of electromagnetic coils with the indirect calorimetry so as to estimate EE in upright sitting and standing positions and during walking exercises at 4, 5 and 6 km/h.

RESULTS

During Test 2, where we compared EE measured by indirect calorimetry (EEind) and estimated by the two pairs of electromagnetic coils (EEmag), it was found that the mean values of EE measured versus estimated were 1.7±0.3 kcal·min⁻¹ vs 1.6±0.3 kcal·min⁻¹, 1.7±0.3 kcal·min⁻¹ vs 1.6±0.3 kcal·min⁻¹, 4.3±0.1 kcal·min⁻¹ vs 4.4±0.0 kcal·min⁻¹, 5.2±0.7 kcal·min⁻¹ vs 5.1±0.2 kcal·min⁻¹ and 6.8±0.1 kcal·min⁻¹ vs 6.8±0.1 kcal·min⁻¹ for upright sitting and standing positions and walking exercises at 4, 5 and 6 km/h, respectively. Therefore there is no significant difference between EEind and EEmag for each activity.

CONCLUSION

In conclusion, on the proven basis of this study we are able to validate this new method which allows for the estimation of EE from abdominal and rib cage distances.
ESTIMATION OF AEE WITH RAW ACCELEROMETER AT THE LOWER BACK DURING LEVEL GROUND WALKING, STAIR WALKING AND CYCLING

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INTRODUCTION
Accelerometers are commonly used for physical activity assessment. It has recently been shown that inference on the type of activity can help to improve the estimation accuracy of activity-related energy expenditure (AEE) as opposed to using a regression equation based on acceleration magnitude alone [1]. The original prediction model used type-specific equations within five activity categories; lying, sitting, standing, walking, and not classifiable, which was inferred from a raw (100Hz sampling rate) acceleration signal. The equation for walking was derived from treadmill walking which may not be suitable for over-ground walking. The aim of the current study is to derive an equation for walking on level ground and to investigate whether the model needs to be expanded to stair walking and cycling.

METHODS
All participants were fasted and fitted with a tri-axial accelerometer (DynaPort MiniMod, McRoberts B.V., The Netherlands) on their lower back (N = 175, age range: 8 – 81; 82% female). Oxygen consumption and carbon dioxide production were measured using a mobile oxygen analyzer (MetaMax 3b, Cortex Biophysik, Germany). A physical activity parcours was completed involving: rest test (30 min); walking on level ground at slow (8 min), normal (8 min) and fast speed (3 min); stair walking (3 min); and cycling (3 min). For each individual and activity, the average acceleration and average AEE (TEE – REE) were calculated. Mixed linear regression analysis was used for developing a walking regression equation, which was evaluated in cycling and stair walking.

RESULTS
Acceleration explained 74.7% of variation in AEE for walking (p < .001), the regression equation is: AEE [J min⁻¹ kg⁻¹] = 99.41 + 470.42 x Acc(g), the 95% confidence intervals for the slope are 405.5 and 535.4. AEE was underestimated in bicycling and stair walking.

DISCUSSION AND CONCLUSION
A regression equation developed from walking on level ground results in a significant underestimation of AEE in cycling and in stair walking. This may be explained by: an activity type specific relation between overall body acceleration and the acceleration of the lower back; differences in mechanical efficiency; and/or inappropriate correction for body composition. In conclusion, an expansion of the prediction model with cycling needs to be expanded to stair walking and cycling.

REFERENCES

SESSION 5
METHOD DEVELOPMENT POSTURE & ACTIVITY CLASSIFICATION

DURATION OF SIT-STAND-SIT TRANSFERS: A COMPARISON OF DETECTIONS BASED ON A SINGLE HYBRID-SENSOR UNIT VERSUS FORCE PLATES

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INTRODUCTION
A single sensor solution for quantifying the amount and quality of sit-stand transfers is a prerequisite of home-monitoring in optimizing interventions for supporting independent mobility in older adults. Insight into the relation of body-fixed-sensor based outcomes to those of existing laboratory-based methods is needed.

METHODS
Thirteen older adults (mean age 71.4 (59-85), 7 males) and 10 patients with Parkinson’s disease (PD) (mean age 70.0 (61-77), 7 males, mean Hoehn & Yahr stage 2.5 (2-3) performed sit-stand-sit movements from a chair in different conditions. A sensor unit containing accelerometers and gyroscopes (DynaPort Hybrid, McRoberts, NL) was attached with a waiststrap at the level of the lumbar vertebrae. The start of the flexion phase and the end of the extension phase of sit-stand and stand-sit were identified from the sine of the trunk angle in the sagittal plane. A positive peak followed by a negative peak in the vertical velocity signal identified standing up (SU) and sitting down (SD). The DynaPort data were send to the supplier for blinded analysis. Detections based on force plates is illustrated in figure 1.

RESULTS
Intraclass correlations (2,1) for the duration of standing up, for respectively the older adults and the patients with PD, were 0.76 (95%CI 0.64-0.84) (70 cases) and 0.69 (95%CI 0.53-0.81) (57 cases). For sitting down, correlations were 0.86 (95%CI 0.78-0.91) (73 cases) and 0.65 (95%CI 0.48-0.78) (59 cases).

<table>
<thead>
<tr>
<th></th>
<th>SU_plate</th>
<th>SU_hybrid</th>
<th>SD_plate</th>
<th>SD_hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older adults</td>
<td>1.86 (0.31)</td>
<td>1.79 (0.28)</td>
<td>1.98 (0.44)</td>
<td>2.14 (0.31)</td>
</tr>
<tr>
<td>Patients with PD</td>
<td>2.02 (0.32)</td>
<td>1.82 (0.24)</td>
<td>1.97 (0.31)</td>
<td>2.14 (0.25)</td>
</tr>
</tbody>
</table>

Mean duration (standard deviation) in seconds is indicated.

DISCUSSION AND CONCLUSION
The relationship between the two methods for assessing temporal aspects of sit-stand transfers is moderate to large. Although further fine-tuning of the detection methods is possible, the hybrid sensor-based method seems valid for evaluating sit-stand performance. Additional studies on the reliability and sensitivity-to-change are needed in specific target populations.
05.2 QUANTIFYING PHASES OF THE SIT-TO-WALK MOVEMENT WITH ACCELEROMETERS
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INTRODUCTION
Moving, uninterrupted, from sitting to walking (STW) is a regularly performed functional movement that is sufficiently demanding, from a mechanical and motor control perspective [1], to reveal mobility problems that may be masked when performing standard tests of mobility (e.g. sit to stand) [2]. Technology has so far limited observations to the laboratory, and this lack of ecological validity limits the development of the STW movement as a screening tool for early onset of mobility problems. Accelerometry may allow the STW movement to be continuously recorded in natural settings. The aim of this study was to test the concurrent validity of measuring the STW movement with accelerometers.

METHODS
Following local ethical approval, fifteen young, healthy subjects [nine male, mean age 34.8±7.1 years, weight 76.1kg±12.9kg and height 172.9±7.8cm] were recruited from a university population. Participants performed three STW movements at three self selected speeds; normal slow and fast. Concurrently, a seven camera motion analysis system tracked the 3D trajectory of reflective markers located on anatomical landmarks, and the acceleration signals of the trunk, pelvis and thighs were recorded by five triaxial accelerometers. Due to the degree of redundancy from the sensors and to enhance future clinical utility, only the two thigh-mounted accelerometers were used for analysis. Time events for the STW movement [seat-off, swing-off and swing-down] were identified from the motion analysis system [2]. Independent of this analysis, points of inflection in the acceleration signals, indicating a major change in body movement, were used to identify the same events. Agreement between the two measurement systems for these time points was assessed with ICCs (2,1).

RESULTS
Across all speeds there was an absolute difference of 0.084±0.05s for seat-off, 0.072±0.083s, for swing-off and 0.063±0.038s for swing-down. Agreement for the STW events was excellent with ICC values between 0.96 and 0.99. Agreement for the whole movement duration was also excellent [ICC=0.99].

DISCUSSION AND CONCLUSION
This study demonstrated high levels of agreement between a motion analysis system and thigh-mounted accelerometers for recording time events during the STW movement when performed by a healthy young sample. Although further work is required to automate and validate this measurement technique, these results mean that time events during the STW movement can be recorded in the community with the same level of accuracy as in the laboratory. These encouraging results reinforce the potential of using the STW movement as an early indicator of mobility problems.

REFERENCES

05.3 POSTURE AND POSTURE TRANSITIONS IN THE PRE-SCHOOL CHILD AND CATEGORISATION BY THE ACTIVPAL

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INTRODUCTION
We have recently reported the validity of the activPAL to detect posture in pre-school children [1]. In addition to agreement between direct observation and activPAL categories ‘sit’, ‘stand’ and ‘walk’, we were also interested in the detection of posture transitions. Single unit activity monitors such as the activPAL to detect posture in pre-school children because of their small size and weight. We have shown that posture transitions in the pre-school child do not always start with a typical ‘sit’ or ‘upright’ posture. So does it matter that limited activity monitor output categories will fail to capture and define the ‘non-standard’ postures? Given the low total proportion of time spent in such postures, it is probably not important if the aim is to determine total time spent sedentary or active. However, our data suggest that it may be an important consideration in the pre-school child if posture transitions are the outcome of interest.

REFERENCES

05.4 EVALUATING LABORATORY-TRAINED ACTIVITY CLASSIFICATION ALGORITHMS IN DAILY LIFE

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INTRODUCTION
Accurate identification of physical activity types has been achieved in laboratory conditions using single site accelerometers and classification algorithms. This methodology is, however, developed for being applied in free-living conditions to determine individuals’ activity behavior. The aim of this study was to analyze the accuracy of laboratory-trained classification algorithms in free-living subjects during daily life.

METHODS
Fifty-two subjects (29 males and 23 females; age: 29.2 ± 6.7 years; BMI: 23.6 ± 3.2 kg/m2) were recruited to perform a routine of 15 tasks in laboratory settings, including keeping postures, households, walking, running, and cycling activities. Physical activity was measured using a single triaxial accelerometer (Tracmor, Philips Research, Eindhoven, Netherlands) placed at the waist. The collected data was used to develop a Support vector machine (SVM), a feed-forward neural network (NN) and a decision tree (DT) algorithm to classify 6 general classes of activities: lying, sedentary, dynamic/transitions, walking, running, and cycling. The reproducibility of the classification performance in free-living conditions was tested on a new dataset collected in daily life. A population of 20 subjects was recruited (age: 30.6 ± 9.3 years; BMI: 23.0 ± 2.6 kg/m2) and habitual physical activity was recorded during a full day using a Tracmor, a multiple-site accelerometer (IDEEA, Minisun, Fresno, CA) and an activity diary for self-reporting cycling events. Leave-one-subject-out cross-validation on the training data was used to test the accuracy of the classification algorithms in laboratory conditions. The output of the three classification algorithms was then compared to the classification provided by the IDEEA and diary to determine the classification accuracy in daily life.

RESULTS
Leave-one-subject-out cross-validation on the training data showed accuracies of 95.1 ± 4.3%, 91.4 ± 6.7%, and 92.2 ± 6.6% for the SVM, NN, and DT, respectively. All algorithms showed a significantly decreased accuracy in daily life as compared to the reference truth represented by the IDEEA and diary classification (75.6 ± 10.4%, 74.8 ± 9.7%, and 72.2 ± 10.3%; p<0.001).

DISCUSSION
Cross-validation procedures on laboratory training data overestimate the accuracy of classification algorithms in daily life. Developing classification algorithms using free-living data can improve the daily life classification accuracy.
AN OBJECTIVE METHOD FOR SLEEP DETECTION FROM CONTINUOUS MONITORING OF HEART RATE AND MOVEMENT IN FREE-LIVING INDIVIDUALS

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INTRODUCTION
Measuring duration of sleep is a contemporary public health issue due to its association with a number of diseases such as Type 2 diabetes, obesity and cardiovascular diseases. Epidemiological studies have predominantly used self-reported sleep duration as the exposure measure. Although some recent epidemiological studies focused on measuring sleep duration, currently there is no standard method to objectively measure sleep duration in the free-living setting. The main aim of this work was to develop an objective method for sleep assessment using combined movement and heart rate sensing [1].

METHODS
A total of 200 volunteers (51% male, 49% female, age 9-65 years, BMI 14.5-35.5 kg m²) wore a combined sensor (Actiheart) and completed a sleep diary. In the present analysis, 105 participants were included with complete Actiheart or sleep diary data. The sleep diary was used as validation criteria for developing and evaluating the algorithm. Various signal features were extracted and explored graphically to investigate the relationship between sleep status and movement and heart rate, most importantly features capturing prolonged periods of little or no movement and low heart rate or change in heart rate. These features were used as input for a number of classification algorithms, including logistic regression, linear and quadratic discriminant analysis, decision trees, and neural networks. The logistic regression model was chosen for performance and simplicity. Model coefficients were established using a training set (n=84) and cross-validated in a hold-out sample (n=21).

RESULTS
The logistic model had a misclassification rate of about 10%, with approximately 80% sensitivity and 93% specificity. The mean (SD) difference between the objective (model-estimated) and the subjective measure of sleep was found to be 0.23 (0.179) hours. In general, adults under-reported sleep while children over-reported sleep.

DISCUSSION AND CONCLUSION
The developed algorithm may be used for objective assessment of sleep duration in epidemiological, psychological and clinical research. It has particular applicability in studies already employing combined sensing as a measure of physical activity. The algorithm is restricted to using only movement and heart rate data, rather than including participant-level information such as age, sex, and BMI. However, the differential bias by age implies the need for age-group specific algorithms. The main aim of this work was to develop an objective method for sleep assessment using combined movement and heart rate sensing [1].

REFERENCES
RESULTS
Table 1 shows the average %ST for each group at each time point. Relative to baseline, the EX group did not change ST, the EX-LIFE group reduced ST by 8%, and the LIFE participants decrease ST by 10% at week 12 (p<0.10).

DISCUSSION AND CONCLUSION
On average, EX participants’ ST did not change during the program; individuals both increased and decreased ST. Given the evidence that ST and exercise are independently associated with disease risk [2], this variability in behavior outside of exercise may explain why some individuals do not respond to exercise training programs. The changes in ST for the LIFE group were highly variable. The EX-LIFE group decreased total sedentary time by ~8%, suggesting it may be beneficial to simultaneously target ST and exercise. These preliminary data suggest non-exercise time should be objectively monitored during an exercise training program. Future research should examine a larger sample to adequately study the interactions between increases in exercise and changes in ST and their ensuing effects on metabolic risk factors.

REFERENCES

Funded by 1 RCI HL098557-01

06.4 HOW DO COPD PATIENTS DISTRIBUTE THEIR DAILY ACTIVITIES?
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INTRODUCTION
Patients with Chronic Obstructive Pulmonary Disease (COPD) need to remain physically active to prevent physical deconditioning. Increasing physical participation in everyday activities is therefore among the key goals of rehabilitation treatment in patients with COPD. Better insight in daily activity behaviour of COPD patients is needed as a first step to enable a tailoring of their treatment. The objective of this study was to measure the daily activity of COPD patients and to compare the daily activity distribution with asymptomatic controls, using triaxial accelerometry.

METHODS
Twenty-five COPD patients (66.0 years; FEV1%: 46.3%) and eighteen healthy controls (57.2 years) participated. Daily activity was assessed in the daily environment (in- and outdoors) by triaxial accelerometry (MTx-W sensor, Xsens) over four consecutive days, from waking until 20:00h. Daily activity was expressed as the amount of activity in counts per minute (cpm) [1]. Differences in daily activity between patients and controls and differences over day parts were investigated, as well as differences in activity levels: low (<1000 cpm), moderate (1000-3000 cpm) and high (>3000 cpm) [2].

RESULTS
COPD patients were significantly less active compared to controls during the day (863±244 cpm vs. 1189±320 cpm, p<0.001) and for each day part (p<0.05). Both groups were most active in the morning, but this decreased rapidly towards the afternoon and evening for the COPD patients (figure 1). Their mean activity in the evening was significantly lower compared to the morning (p<0.001). The activity of the controls lowered in the evening, but not statistically significant. Further analysis of the data showed a typical decline in activity around noon for the COPD group only. Furthermore, COPD patients spent less time in high-activity levels (3.1±2.6% vs 9.4±4.6%, p<0.001) compared to controls.
DISCUSSION AND CONCLUSION
Our study showed that COPD patients have a lower activity level that is less evenly distributed compared to asymptomatic controls. Our accelerometer data suggests that treatment should aim at improving the activity level and promoting a more uniform distribution of activities over the day. The next step could be to use ambulatory activity monitoring in COPD treatment: to change the activity behavior by providing feedback to the patient about his/her activity levels in daily life.

REFERENCES

06.5 PATIENTS WITH END-STAGE HIP OSTEARTHRITIS SHOW DISTINCTIVE PATTERNS OF TRUNK MOVEMENTS DURING GAIT – A BODY-FIXED SENSOR BASED ANALYSIS
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INTRODUCTION
Compensatory trunk movements during gait such as a Duchenne limp are observed frequently in patients with hip osteoarthritis (OA), yet angular trunk movements are seldom included in clinical gait assessments. Therefore, the aim of this study was to quantify compensatory movements of the trunk during gait in patients with end-stage hip OA by means of a body-fixed sensor (BFS) based approach. To this end, spatiotemporal parameters and frontal plane angular movements of the pelvis and thorax of patients who showed a Duchenne limp during gait were compared to healthy subjects and patients without a Duchenne limp.

METHODS
Sixty patients with end-stage hip OA and 30 healthy counterparts participated in the study. Ten patients showed a clearly visible Duchenne limp. Two hybrid triaxial BFS units, that contained gyroscopes and accelerometers, were attached on the spinal process just beneath the 7th cervical vertebrae and between the Posterior Superior Iliac spine of the pelvis. Data of the BFSs were transmitted in real-time to a PDA through a wireless connection. Subjects were instructed to repeatedly walk a distance of 25 m along a hospital corridor. Thus, walking on a self-selected low, preferred and high speed were measured. Walking speed, step length and cadence were calculated, and range of motion (ROM) of the thoracic and pelvic segments was determined by subtracting the maximum and minimum angle of the segments. The accuracy and reliability of this gait assessment protocol have been demonstrated in a preceding study.

RESULTS
Over a range of instructed walking speeds, patients walked at a significantly lower speed, along with a shorter step length and lower cadence, compared to healthy subjects. Patients with a Duchenne limp showed a significantly larger thoracic ROM during walking compared to healthy subjects and to patients without a Duchenne limp. In both groups of patients, pelvic ROM was lower than in healthy subjects. This difference however only reached significance in patients without a Duchenne limp.

Individual values: small symbols; mean values: large symbols. Healthy controls (+); patients with (ii) and without (ii) a Duchenne limp.

DISCUSSION AND CONCLUSION
Frontal plane angular movements of the thorax and pelvis provide valuable information on gait function of patients with hip OA. Distinctive patterns of trunk movements as well as spatiotemporal gait parameters could be determined with the BFS-based gait analysis approach. Since this BFS-based gait analysis approach is not confined to a laboratory and is user-friendly, it is highly applicable in real-life (non-laboratory) settings such as hospitals for monitoring (changes in) gait performance in patients with hip OA.

REFERENCES

07.1 OBJECTIVELY MEASURED PHYSICAL ACTIVITY AND BONE HEALTH IN OLDER JAPANESE ADULTS: LONGITUDINAL DATA FROM THE NAKANOJO STUDY
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INTRODUCTION
Cross-sectional study [1] shows significant associations between bone characteristics and yearlong physical activity in older adults, with better health in those taking >7,000 steps/day and/or spending >15 min/day at >3 metabolic equivalents (METs). The present study examines these relationships longitudinally.

METHODS
Subjects were free-living Japanese aged 65-84 years (196 men, 256 women). Daily step count and physical activity intensity were measured continuously by pedometer/accelerometer for 5 years. Osteosonic index (OSI, reflecting calcaneal bone stiffness) was determined by quantitative ultrasonography at baseline and each year end. Repeated measures analysis of variance assessed changes in month-averaged physical activity scores for each July. One-factor repeated measures analysis of covariance (ANCOVA) assessed yearly changes in OSI. ANCOVA at 2nd-6th measurements or Cox proportional hazards regression analysis assessed independent relationships between baseline physical activity and year-end value OSI or the estimated 5-year risk of fracture, respectively, after controlling for baseline OSI, age, body mass, years since menopause, calcium intake, smoking status and alcohol consumption.

RESULTS
Subjects maintained their physical activity over the 5 years. Year-end OSI values increased with increasing baseline physical activity scores in both sexes, the relationship being more marked for duration at ≥3 METs than for step count. However, when data were categorized into physical activity quartiles, final OSI values were not significantly greater in persons exceeding counts of around 6,800 and 6,900 steps/day and/or durations ≥3 METs of around 17 and 16 min/day in men and women, respectively. A multivariate-adjusted Cox proportional hazards model predicted that during the 5 years, individuals (especially women) who engaged in <6,900 steps/day and <16 min/day of activity at ≥3 METs were, respectively, 2.7-3.9 and 1.8-3.9 times more likely to sustain fractures than those participating in >8,900 steps/day and ≥25 min/day of activity ≥3 METs.

DISCUSSION AND CONCLUSION
This prospective study supports our cross-sectional observations [1]; after adjustment for potential confounders, the bone health of older people is associated with both the quantity (daily step count) and the quality (daily duration at an intensity ≥3 METs) of habitual physical activity. To conserve bone health, elderly people should be encouraged to take at least 7,000 steps/day and/or spend at least 15 min/day at ≥3 METs.

REFERENCES
INTRODUCTION

A quarter of Canadian adults are overweight or obese [1]. The reasons for increasing rates of obesity are complex and involve a myriad of biological, behavioural and environmental factors. Regular physical activity (PA) is associated with health benefits. To determine whether Canadians are sufficiently active to obtain health benefits, the 2007 to 2009 Canadian Health Measures Survey (CHMS) used accelerometers to collect the first time-sequence objective measures of physical activity for a nationally representative sample of Canadian adults.

METHODS

Data are from the 2007-2009 CHMS, the most comprehensive direct health measures survey ever conducted on a nationally-representative sample of Canadians (n = 2,632). PA was measured using the Actical accelerometer. The analysis includes respondents aged 20-79 years who returned the accelerometer with 4 or more valid days of data (87%). Average daily steps and time spent in sedentary, light, moderate and vigorous intensity movement are presented. Adherence to the new Canadian and World Health Organization PA recommendation - 150 minutes per week of moderate-to-vigorous PA - is also presented.

RESULTS

An estimated 15% of Canadian adults accumulate 150 minutes of moderate-to-vigorous PA per week; 5% accumulate 150 minutes per week as at least 30 minutes of MVPA on 5 or more days a week. Men are more active than women and MVPA declines with increasing age and adiposity. Canadian adults are sedentary for approximately 9.5 hours per day (69% of waking hours). Men accumulate an average of 9,544 steps per day and women, 8,677 steps per day. The 10,000 steps per day target is achieved by 35% of adults.

DISCUSSION AND CONCLUSION

Before the CHMS, objective measures of physical activity and sedentary behaviour were not available for a representative sample of Canadians. The findings of this study indicate that 85% of Canadian adults are not active enough to meet Canada’s new physical activity recommendation. Improvements in movement measurement techniques will lead to a more comprehensive understanding of both PA and sedentary behaviours and their relative contribution to the prevention and management of obesity and chronic disease. The broad range of health outcomes assessed in the CHMS will allow for researchers in Canada to study the impact PA and sedentary behaviour have on health in a way that is more robust and unbiased than has ever been possible.

REFERENCE


07.4 USING ACCELEROMETRY DATA TO UNDERSTAND WHEN CANADIANS ARE MOST (AND LEAST) ACTIVE

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INTRODUCTION

Population-level surveillance typically reports adherence to physical activity (PA) recommendations and time spent being moderately active and/or sedentary. Accelerometer data have the potential to provide more comprehensive profiles of PA behaviour. Such analyses would allow for greater insight to be gleaned about when PA is accumulated both within the day and across the week.

METHODS

The accelerometer data are from the 2007-2009 Canadian Health Measures Survey (CHMS), a nationally representative direct health survey on Canadians aged 6-79 years (n = 4,440). A simple intensity-based scoring protocol (e.g., sedentary = 1, light = 2 etc.) was applied to each minute of raw accelerometry data from valid days (defined as ≥ 10 hours per day of wear time) and scores were then summed over 5-min intervals. These intervals were then coded into quintiles ranging from most active (e.g., score of ≥ 20 in a 5-min period) to least active (e.g., score of < 5 in a 5-min period). The results were then presented graphically to show clusters of the most and least active times of the day.

RESULTS

The most active time of day for the average Canadian woman is 5-6pm on weekdays and noon-1pm on weekends. The most active times of day for the average Canadian man are after lunch and mid afternoon on both weekdays and weekend days. Children and youth are most likely to engage in MVPA during the noon hour and the after school period (e.g., 3-5 pm). Boys engage in some MVPA around 6 pm whereas girls are more likely to be sedentary at that time. Aside from the noon-hour activity, the school setting and period (e.g., 3-5 pm) is a likely setting for engagement in sedentary activities. Out of school hours, children and youth are most likely to engage in MVPA during the noon hour and the after school period (e.g., 3-5 pm). Boys engage in some MVPA around 6 pm whereas girls are more likely to be sedentary at that time.

DISCUSSION AND CONCLUSION

Scoring minutes of the day is a novel way of describing PA patterns at the population level. It is a more robust approach than looking at average counts per minute or occurrence of moderate-to-vigorous PA throughout the day because the scoring methodology accounts for all intensities of movement. This analytical approach may provide new information to improve the design of policy and programming efforts aimed at targeting critical periods of the day when PA is particularly low.
SESSION 8

METHOD DEVELOPMENT

KINETICS AND KINEMATICS

08.1 VALIDATION OF A PROTOCOL FOR FAST GAIT ASSESSMENT IN A CLINICAL ENVIRONMENT USING INERTIAL SENSORS

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INTRODUCTION

Inertial sensors have the potential for use in gait analysis in clinical, epidemiological and population studies, including those looking at osteoarthritis [1]. An inertial system has been selected for gait analysis of the Newcastle Thousand Families Study cohort (~400 members) [2]. A fast, accurate and portable protocol was required for use in a hospital environment, and the system and protocol required validation.

METHODS

An ambulatory protocol for large-scale gait analysis in a clinical setting was developed. Seven sensors (Xsens, Netherlands) were attached to participants on top of the foot, on the tibial plateau, on the lateral surface of the femur 10cm proximal to the lateral epicondyle, and over the sacrum. Attachment was by Velcro straps over the top of the hip, thigh and shank sensors, and with double-sided hypoallergenic tape on the foot. Four calibration movements were performed by following a walking trial of ten paces down a corridor at self-selected speed. Data was recorded wirelessly at 50Hz. The calibration movements and trials were repeated twice. Validation tests looked at the repeatability of sagittal plane joint motion for the hip, knee and ankle, and were compared against an opto-electronic system (Vicon, UK). Other influential parameters such as attachment position, material type underneath the straps, and simulated fatty tissue were also assessed. Each attachment scenario was repeated 5 times on a single subject. An F-test was used to test for statistical significance, with a significance level of 0.05 set for all tests.

RESULTS

Joint angle measurements were not significantly different between the two systems. For the inertial system, a maximum standard deviation of 1.3° was seen at the knee joint. Change in attachment position of the thigh sensor by moving it closer to the knee joint, significantly increased to 2.9°. Denim material under the sensor attachment straps had the greatest effect, significantly increasing maximum standard deviation to 2.0° at the hip joint. Simulated fatty tissue did not decrease repeatability.

DISCUSSION AND CONCLUSION

The inertial sensors were shown to have repeatability comparable to that of an optoelectronic system. Displacement of the thigh sensor towards the knee joint caused a decrease in repeatability, due to the movement artifact at the knee. Denim material had the greatest effect on repeatability of the materials tested due to its low elasticity, transferring tension directly to the sensor straps during flexion. Attention should be paid to sensor placement so as to minimise movement relative to the segment.

REFERENCES


08.2 EXTRAMURAL FALL RISK ASSESSMENT USING A WEARABLE INSOLE MOTION MEASUREMENT SYSTEM – A BASE FOR NEW AAL APPLICATIONS

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INTRODUCTION

Falls and fall related impacts are one of the major problems in geriatrics and gerontechnologies [3]. New ICT based ambulatory gait- and locomotion analysis systems and methods offer new chances for a better assessment and due to that better fall prevention and earlier intervention possibilities [1]. In this abstract an alternative approach to up-to-date, non-instrumented fall assessment methods is described, using a self-developed, wearable insole measurement system and automatic feature extraction in three domains (time, frequency and non-linear methods). The main aim was to identify well-known fall related parameters during the locomotion, as well as identifying new, extending features in the data. With the background of using the developed automated feature extraction algorithm in the AAL project vitaliSHOE (founded by the Austrian Research Promotion Agency – FFG).

METHODS

We conducted a first study together with older participants with normal fall-risk (n=15, age 59-76) and with an increased fall-risk (n=14, age 65-89). The data collection was performed extramural (with respect to a possible later use in AAL-surroundings) at a senior citizen home in Schwechat/Lower Austria as well as intramural at a social medical center in Vienna. During the data collection a predefined set of guided locomotions (Timed “Up and Go” (TUG), chair rising (STS5) and six meter straight walk) was performed by the participants and the locomotion data was recorded with the insole measurement system. The data was then appropriately preprocessed, features were extracted automatically and analyzed with statistical methods concerning their significance towards an increased fall-risk.

RESULTS

The results from the automated feature extraction and following significance testing showed promising results. On the one hand, clinical, fall-related [3] spatiotemporal locomotion parameters (n=9) (e.g. TUG duration, ankle joint angle range, etc.) could be extracted, on the other hand (n=37) additional features in other domains than time - better describing variances in gait and gait dynamics - could be automatically extracted, which also show a high significance in classifying the persons’ locomotion into a normal or increased fall-risk group.

DISCUSSION AND CONCLUSION

The results from the study showed, that significant fall-related parameters could be measured and extracted by the ambulatory system. In a next step we will focus on the most promising features – improving methodologies for extraction. This instrumented assessment, deploying the three guided locomotion tasks using the wearable system could be performed very fast (~5 minutes), extramural and with a minimum amount of interference with the surroundings. So this approach seems to be useful following a Pervasive Health approach [1] and aiming towards a later use in AAL-surroundings, as well as in medical-therapeutic systems. Parts of the results will be implemented in the framework of the project vitaliSHOE.

REFERENCES

AMBULATORY MEASUREMENT OF PHYSICAL ACTIVITY BASED ON KNEE FLEXION/EXTENSION: PRELIMINARY EVALUATION OF A SMART KNEE BRACE

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INTRODUCTION
Within the Biosensing project we developed a new generation of a smart knee brace (KB) to measure flexion/extension (F/E) of the knee joint during activities of daily living (ADL). This novel technology will enable tailoring treatment and rehabilitation strategies to the needs of the individual patient or to coach in individual training schemes for persons and sport athletes. The goal of this study was to classify and validate a limited set of physical activities on ten young healthy subjects based on knee F/E measured by the smart KB. Physical activities included in this study are walking, stairs descend, stairs climbing and running at different speeds.

METHODS
The smart KB, designed by TNO Medical Devices, includes 2 accelerometers and a coil. As we focus on physical activities, which implies a continue varying knee joint F/E angle, the coil is expected to provide adequate information on knee dynamics. This study included ten young and healthy subjects (6M and 4F, mean age 27.7 yrs ± 4.5 yrs). First, each subject was asked to put on the smart KB by themselves. Next, a predefined track was traversed twice, first a practice trial was performed followed by the actual measurement which was filmed to be able to label the activities. The track consisted of indoor (65%), outdoor (40%) paths and obstacles such as stairs (10%), slopes (2%), paved road (6%), grass and gravel (8%). The activity classification algorithm is based on peak detection in the knee F/E angle, measured by the coil. After smoothing the signal, we search for specific patterns in designating extreme minima and maxima to classify an activity.

RESULTS
Table 1 reports on the confusion matrix that summarizes the results, in terms of percentage of samples belonging to each activity as predicted by the algorithm. High values on the diagonal indicates that the algorithm can make a good distinction between the different activities.

<table>
<thead>
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<th>Labelled</th>
<th>Predicted</th>
<th>step</th>
<th>stair</th>
<th>climb</th>
<th>descend</th>
<th>run</th>
<th>no detection</th>
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<td>1.8</td>
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<tr>
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<td>0.3</td>
<td>93.3</td>
<td>6.1</td>
<td></td>
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</tr>
</tbody>
</table>

Table 1: Confusion matrix summarizes results, in terms of percentage, of samples belonging to each activity as predicted by the algorithm.

DISCUSSION AND CONCLUSION
As shown in the confusion matrix an acceptable distinction can be made between the aforementioned activities in healthy subjects traversing a predefined track based on the measured knee F/E angle by the smart KB. Stair descent has a lower percentage of correctly predicted events. This can be attributed to the fact that subjects whom are familiar with the stairs are going faster and in a more frolicking way downstairs. The correct prediction of events. This can be attributed to the fact that subjects whom are belonging to each activity as predicted by the algorithm.

OBJECTIVE MONITORING OF ENERGY BALANCE IN A WEIGHT LOSS PROGRAM

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INTRODUCTION
The SenseWear™ Armband is an objective monitor that provides valid estimates of total energy expenditure [1, 2]. This device allows individuals to obtain daily energy expenditure feedback. To our knowledge, no studies have evaluated whether weight loss can be promoted in overweight and obese adults through an intervention based on the armband.

METHODS
We recruited 197 sedentary overweight or obese adults (age, 46.8 ± 10.8 y; BMI, 33.3 ± 5.2 kg/m2; 81% women, 32% African-American) [3]. Participants were randomized into 1 of 4 groups that received a self-directed weight loss program via an evidence-based manual that focused on cognitive/behavioral strategies (Standard Care, n=50), a group-based behavioral weight loss program (GWL, n=49), the armband alone (SWA-alone, n=49), or the GWL plus the armband (GWL+SWA, n=49) during the 9 month intervention. Participants in the group-based programs received 14 (GWL) or 15 (GWL+SWA) one-hour counseling sessions over the first 4 months and 6 telephone counseling sessions during the final 5 months. Participants wearing the armband (SWA and GWL+SWA) wore the monitor daily to assess energy expenditure. The primary outcomes were body weight and waist circumference (WC). A mixed-model repeated-measures analysis compared change in the intervention groups to the control group on weight status after adjusting for age, sex, race, education, and recruitment wave.

RESULTS
Seventy percent of participants had body weight and WC assessed 4 months after randomization, and 62% completed the month 9 assessments. After controlling for confounders we observed significant weight loss in all 3 intervention groups (GWL, 5.46 kg, P=0.005; SWA-alone, 3.59 kg, P=0.01; GWL+SWA, 6.58 kg, P<0.0001) but not in the Standard Care group (0.91 kg, P=0.05). Only the GWL+SWA group achieved significant weight loss compared to the Standard Care group (P=0.02). Significant waist circumference reductions were achieved in all 4 groups (Standard Care, 3.53 cm, P=0.003; GWL, 2.42 cm, P=0.007; SWA-alone, 3.54 cm, P=0.01; GWL+SWA, 6.77 cm, P<0.0001), but no group had significantly reduced waist circumference compared to the Standard Care group.

DISCUSSION AND CONCLUSIONS
Objective monitoring of energy expenditure with the armband appeared to be a useful complement to a behavioral weight loss intervention. The value of accurate monitoring of energy expenditure is consistent with behavioral research on the use of self-monitoring, goal setting, and tracking in lifestyle change programs.

The armband is a useful tool to enhance lifestyle changes that promote weight loss in sedentary overweight or obese adults.

This study was supported by an unrestricted research grant from the BodyMedia Company.

REFERENCES
FEASIBILITY OF A PEDOMETER-BASED WALKING PROGRAMME FOR PEOPLE WITH CHRONIC LOW BACK PAIN: THE BACK 2 ACTIVITY TRIAL

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INTRODUCTION

Current guidelines advocate exercise as first line treatment for managing chronic low back pain (CLBP). Professional guidance, self-direction, on-going support, and promoting self-efficacy can encourage adults to be more active [1]. Pedometer-based walking incorporates these aspects [2]. Walking is ideal due to its relatively low impact and intensity, and low risk of musculoskeletal injury. However, it is unclear whether structured walking interventions are any more effective than simply giving advice to remain active. The aim of this study is to test the feasibility of using a pedometer-based walking programme as an adjunct to standard education and advice for people with CLBP.

METHODS

Fifty-seven adults with CLBP (Age [Mean (SEM)]: 49.2 years (2.42); Body Mass Index: 28.5 (0.93); Baseline Oswestry Disability Questionnaire (100): 30.6 (1.58)) were randomised to education and advice (E&A; group A), or E&A plus an eight week walking programme (group B) based on the 5A’s model of health behavior advice [3]. Participants were given daily step targets, based on actual step counts recorded in the previous week, with weekly phone calls to increase adherence, monitor and set goals. Targets and daily step counts were recorded in a diary and by the pedometer (Yamax Digiwalker CW-701, Yamax, Japan with 7-day memory).

RESULTS

Forty participants were allocated to group B. Four adverse effects were reported: skin reactions (n=2) due to the metal pedometer clip; minor musculoskeletal lower-limb complaints (n=2) which resolved within two weeks. Mean daily step targets increased from 5884 (±SD, 2068) to 7991 (±SD, 3043), an increase of 36%. Actual step counts increased from 5825 (±SD, 2427) to 8432 (±SD, 3165), or 45%. Actual step counts exceeded step targets by an average of 995 steps (±SD, 512) during each week of the intervention, with this margin reducing over time (13% difference at week 2 and 6% difference at week 8). Participants wore the pedometer an average of 6.3 days per week and met step goals 72% of the time over the monitored days.

DISCUSSION AND CONCLUSION

The walking programme resulted in few adverse effects and led to increases in step counts in excess of step targets during the eight-week intervention. Further analysis will examine the longer term effects of the intervention on relevant and condition-specific outcomes.

REFERENCES


OBJECTIVELY MEASURED SEDENTARY AND PHYSICAL ACTIVITY BEHAVIOR ACROSS THE LIFE SPAN

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INTRODUCTION

Recent research shows that too much sitting has negative effects on health and well-being independently of people meeting the current physical activity (PA) recommendations [1]. However sedentary behavior (SB) is still an understudied topic. The aim of this study was to objectively investigate the time spent in sedentary and PA behaviors in several cohorts of Belgian toddlers, children, adolescents and adults.

Further we wanted to examine if the amount of time spent in SB differed between these age groups (cohorts) and according to gender and BMI subgroups.

METHODS

To objectively assess SB and PA a total of 2083 Belgian preschoolers, primary and secondary schoolchildren, and adults (age range 3.64-75.96 years; 75.45% female; 75.96% normal weight, overweight or obese using age-specific BMI cut-offs) were assessed. Analyses of the accelerometer data showed that for the total sample participants spent 57% of their waking hours (7.8 hours/day) in SB, 38% in light intensity PA and 5% in MVPA. The amount of time spent in SB significantly differed between the cohorts according to gender, but not according to BMI subgroups. In women lower levels of SB were found in preschoolers (51%) and primary schoolgirls (53%), compared to adults (56%) and secondary schoolgirls (61%). In men, the older the cohort group, the more time they spent in SB, with a maximum amount of 59% in the adult group.

RESULTS

Analyses of the accelerometer data showed that for the total sample participants spent 57% of their waking hours sedentary (57%). Different levels were shown between cohort groups according to gender, with girls at secondary school being most sedentary (61%).

Large longitudinal studies using objective measurements are needed to investigate patterns of SB across the lifespan.

REFERENCES


USING THE ACTIBELT®-PLATFORM TO STUDY THE ROLE OF PHYSICAL ACTIVITY IN PATIENTS WITH DEPRESSIVE DISORDERS

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INTRODUCTION

Depressive disorders are globally showing an increasing incidence with more than 300 million people affected worldwide. Whilst pharmacological and psychotherapeutical methods are established for treatment [1], the relationship of physical activity (PA) and depression is still subject of current research. In this study the actibel®-platform was used to analyze cross-sectional and longitudinal associations between PA and depression severity in patients with depressive disorders.

METHODS

20 80 male, 12 female; mean age: 44.4±17.1 yrs) psychiatric inpatients with depressive disorders and 16 healthy controls (7 male, 9 female; mean age: 39.5±15.2 yrs) wore the actibel®-platform for four days. After 3 weeks of pharmacological and psychotherapeutical treatment follow-up measurements were performed with 12 patients and all controls. Parameters describing PA were automatically extracted from the raw accelerometry data, including “Step length” (SL), “Activity Temperature” (AT), “Coherence Length” (CL) and “Active Speed” (AS) [2]. Different aspects of disease status were analyzed by using the German versions of 7 questionnaires: BDI for subjective severity of depression, CGI for objective severity of depression and its changes whilst longitudinal measurements, IPQ (long version) for reporting of individual physical activity, ESI for excluding schizophrenic symptoms, STAI X1 & X2 for excluding significant anxiety symptoms and activity self-report for assessment of activity. Differences in PA between patients and controls were assessed by Wilcoxon-Rank test. Association between changes disease severity and PA was investigated using Fisher test.

RESULTS

Patients and controls showed significant differences in AT (2.7+/−1.0 vs. 4.7+/−0.2 AU, p<0.001) and CL (1.9+/−0.9 vs. 1.4+/−0.8 s, p=0.038). SL and AS were similar among the cohorts (SL: both 0.7 m; AS: both 1.2 m/s). A longitudinal evaluation revealed
HABITUAL PHYSICAL ACTIVITY ASSESSMENT WITH ACCELEROMETERS: NEW INSIGHTS AND VALIDATION STUDIES.

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INTRODUCTION
The field of application of accelerometer is diverse and ever expanding. One of the main purposes in health sciences is the assessment of physical activity in daily life. Since by definition all physical activity leads to energy expenditure (EE), the doubly labelled water (DLW) method is considered the “gold standard” to assess total energy expenditure. Since by definition all physical activity leads to energy expenditure (EE), the doubly labelled water (DLW) method as gold standard to assess total energy expenditure. The doubly labeled or labelled water in combination with accelerometer, accelerometry, and double labeled or labelled water method as gold standard to assess total energy expenditure. The doubly labelled water (DLW) method as gold standard to assess total energy expenditure. The doubly labeled water (DLW) method as gold standard to assess total energy expenditure.

METHODS
The PubMed Central database was searched using the following key words: doubly or labelled water (DLW) method as gold standard to assess total energy expenditure. The doubly labelled water (DLW) method as gold standard to assess total energy expenditure. The doubly labeled water (DLW) method as gold standard to assess total energy expenditure. The doubly labelled water (DLW) method as gold standard to assess total energy expenditure. The doubly labeled water (DLW) method as gold standard to assess total energy expenditure. Since by definition all physical activity leads to energy expenditure (EE), the doubly labelled water (DLW) method as gold standard to assess total energy expenditure.

RESULTS
Results are shown in Table. Several parameters have been shown to be associated with the ToA. No correlation was found with the ToA, as expected.

DISCUSSION AND CONCLUSION
There is evidence that in a near future SP may incorporate suitable solutions for quantitative movement analysis with a clear clinical value, providing a pervasive and low-cost support to eHealth.

REFERENCES
COMPARISON OF ACTIVPAL AND GT3X-PLUS IN DISTINGUISHING SITTING, STANDING AND WALKING IN TYPICAL OFFICE-BASED ACTIVITIES

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INTRODUCTION

Newer activity monitors that can provide an objective record of movement and posture, particularly incidental activity, are now available. However, little is known about the validity of these devices in assessing sedentary behaviour and light-intensity activity. We compared the accuracy of two commercially-available devices in measuring sedentary and light-intensity activity; the activPAL, a validated inclinometer; and, the ActiGraph GT3X-plus activity monitor, which includes an inclinometer as well as raw acceleration-data collection capabilities in three axes.

METHODS

Eighteen adults (5 men; age range 22-58 years; mean BMI 24.8kg.m-2 [SD 4.7]) were fitted with an activPAL and three GT3X-plus monitors, one each on their hip, dominant wrist and dominant ankle. They completed three office-based tasks (five minutes each of typing, listening to a presentation, talking on telephone) while sitting and while standing, and walked within the premises at their normal walking pace for five minutes. They were also required to sit still, stand still and walk on a treadmill at 3.2 and 5.4 kph (two minutes each). Agreement of the inclinometer function of the activPAL and GT3X-plus devices with the experimental protocol was calculated using the Kappa statistic (κ); 95% confidence intervals were obtained using cluster bootstrap method. Acceleration data were compared for sitting, standing and walking.

RESULTS

Agreement was very high for the activPAL for sitting (κ=0.99, 95% CI: 0.97, 1.00), standing (κ=0.98, 95% CI: 0.96, 1.00) and walking (κ=0.99, 95% CI: 0.99, 1.00). Agreement was modest for the GT3X-plus when worn on the hip, wrist, and ankle, for sitting (κ=0.30, 95% CI: 0.15, 0.45), κ=0.26, 95% CI: 0.20, 0.32; κ=0.48, 95% CI:0.32, 0.63) and for standing/walking (κ=0.37, 95% CI: 0.26, 0.49, κ=0.32, 95% CI: 0.27, 0.37; κ=0.48, 95% CI:0.32, 0.63). Counts in each axis and vector magnitude units (VMU) were all significantly higher (p<0.05) for walking than for sitting or standing. Significant differences (p<0.05) between sitting and standing were only noted for axis 1 and axis 2 (hip position) and for axis 2 and VMU (ankle position).

DISCUSSION AND CONCLUSION

The activPAL outperformed the GT3X-plus in distinguishing sitting from standing in typical office-based activities. The performance of the GT3X-plus varied with its position on the body. This important and novel information in the detection of key elements of posture and ambulation can inform choice on the most appropriate instrument(s) and position(s) to use in measurement, and particularly in interventions addressing sedentary behaviours.

VALIDITY AND USER FRIENDLINESS OF THREE ACTIVITY MONITORS

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INTRODUCTION

Health is associated with the amount of daily physical activity. The required amount, frequency and intensity of physical activity still is a matter of debate. Accelerometry can be used to assess human physical activity objectively. In measuring average daily activity it is important to discriminate between standing and sedentary time, because of the increased energy use associated with standing [1]. Recently, it has been suggested that the patterns of sedentary behaviour are strong predictors of future health outcome [2]. A validated and easy to use activity monitor is needed to investigate the relationship between sedentary and standing time and health. Therefore the aim is to compare the validity and user-friendliness of three commercially available activity monitors.

METHODS

User friendliness was evaluated in 14 participants who wore the accelerometers for at least 45 minutes up to 6 days with questions regarding wearing comfort and preference. Five participants performed a standardized protocol that consisted of sedentary (sitting and lying), standing and walking on the treadmill. Subjects wore three activity monitors simultaneously: 1) CAM (Maastricht Instruments) 2) ActiGraphGT3X and 3) ActiVPL3. The CAM and ActiGraphGT3X were worn in an elastic belt around the thigh and trunk respectively. The ActiVPL3 was taped to the skin at the thigh. Validity of the monitors is expressed as mean±SD percentage of correctly classified seconds. Correlations between accelerometer intensity and walking speed on the treadmill were assessed to determine how accurate monitors reflected subject’s movement intensity.

RESULTS

Sedentary and standing time was correctly classified in 99.7±0.5% and 96.0±5.5% of CAM-data; in 86.3±20.1% and 90.0±10.6% of ActiGraphGT3X-data; and in 100.0±0.0% and 100.0±0.0% of ActiVPL3-data. Correlations between the different intensity measures of the accelerometers and the walking speed on the treadmill were high (CAM: 0.979; ActiGraphGT3X: 0.910; ActiVPL3: 0.897 (all p<0.000)). Eight participants preferred the ActiGraphGT3X and six participants preferred the ActiVPL3. In four participants the CAM resulted in an adverse reaction (skin irritation).

DISCUSSION AND CONCLUSION

The CAM and ActiVPL3 are valid in discriminating sedentary behaviour and standing. Classification by the ActiGraphGT3X showed low agreement with the protocol, because sitting and standing were often confused. Additionally, a large amount of lying time was not classified by the ActiGraphGT3X and resulted in missing values.

The ActiVPL3 is preferable for classifying postures. If both acceleration intensity and posture classification are taken into account, the CAM is preferred. However, wearing comfort of the CAM is insufficient in measurements lasting several days.

REFERENCES

SESSION 11
METHOD DEVELOPMENT SEDENTARY BEHAVIOUR

011.1 METHODS FOR QUANTIFYING BEHAVIOUR IN THE STUDY OF INACTIVITY

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INTRODUCTION

Sedentary behaviour is an independent risk factors for all major chronic diseases, disability and frailty[1]. There has been increasing interest in objectively monitoring sedentary behaviour. Currently there is no definite definition of sedentary behaviour, but a consensus is slowly emerging that it could be defined as the time spent in a non-upright posture (either sitting or lying). Analysis of sedentary behaviour is often restricted to quantifying the total amount of time spent sedentary. We develop methods that enable robust quantification of actual behaviour and pattern sedentariness.

METHODS

We use data from activity monitors that use postural allocation (such as activPAL) to identify periods of time spent in a non-upright posture (sitting or lying). The distribution of the length of these periods is examined and we find the most simple statistical model for this distribution. Similarly the contribution of the different bout length to the total cumulative time spent sedentary is investigated. From these measures of pattern and accumulation of sedentary behaviour are derived.

RESULTS

The distribution of sedentary bouts is found to follow a power law \( p(t) \sim t^{-n} \) where \( t \) is the length of sedentary bouts. The accumulation pattern follows a Lorenz curve, which can be characterised by the area under this curve also called the GINI coefficient. Finally the pattern of accumulation can be defined by an index of fragmentation \( F_s \) defined as the time that characterise if an individual tends to be sedentary for long or short periods of time.

DISCUSSION AND CONCLUSION

The pattern of sedentary behaviour is characterised by a power law distribution of bouts. Consequently sedentary behaviour has infinite variability and cannot be represented by an average bout length. This implies that obtaining robust estimates of average time spent sedentary for an individual might be very difficult. However the exponent \( n \) of the distribution can be used as a sensitive measure of change in behaviour. The accumulation pattern of time spent sedentary can be quantified using the GINI index. How often an individual breaks their sedentary behaviour can be characterized by a fragmentation index which is the mathematical expression of the breaks of sedentary time reported by Healy et al [3]. These three indices are actual measures of behaviour and unable to understand how an individual spend time sedentary.

REFERENCES


011.2 USING OBSERVATION TO COMPARE DIFFERENT ACCELEROMETER CUT POINTS FOR SEDENTARY BEHAVIOUR IN CHILDREN

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INTRODUCTION

Accurate objective methods for the assessment of sedentary behaviour are crucial for population monitoring and evaluation of public health strategies for preventing childhood obesity. Actigraph accelerometers are a commonly used objective physical activity measurement tool. It is hypothesized that accelerometers may also provide a valid method for assessing children’s sedentary time. However, there is considerable variation in published accelerometer cut-off points for measuring sedentary time in children [1]. The objective of this study is therefore to compare different accelerometer cut points with observation of children performing specific sedentary behaviors in free-living conditions.

METHODS

A convenience sample of 29 apparently healthy children aged 5–to 11-years old (28% boys) were recruited. Direct observation and Actigraph uniaxial accelerometers were used to measure children’s activity intensity while playing computer games, non-electronic sedentary games, watching television and playing outdoors. The measurements took place in the child’s own houses. Direct observation was the criterion for assessing the validity of four different previously published sedentary cut-points: i.e., 100, 300, 800, and 1100 counts per minute (cpm). Data reduction from accelerometers (each of the four by 20 minute time periods) were performed manually with ActiLife software, and then transferred to SPSS. Figures were created to depict how different cut-points compared to the observed 25th, 50th and 75th percentiles for the cpm derived from each activity.

RESULTS

In total, 25 children (six boys and 19 girls) aged 5-11 years were included in the analysis. The median cpm were lowest for computer games (30 cpm), followed by television viewing (109 cpm) and non-electronic sedentary games (172 cpm) and highest for outdoor play (1452 cpm). The median counts during all sedentary behaviors were below the lowest cut-point of 100 cpm. The 75th percentile values for the sedentary behaviors were always below the cut-point of 300 cpm.

DISCUSSION AND CONCLUSION

The results suggest that estimated time spent in sedentary behavior would differ considerably using the various published cut-points available. It is important to be aware of the consequences of using different cut-points when assessing sedentary behavior in children. Based on our results, the Actigraph accelerometry cut-point of <100 cpm is the most appropriate, if not too high, for quantifying the time children spend sedentary.

REFERENCE


011.3 VALIDITY OF TWO SELF-REPORT MEASURES OF SITTING TIME

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INTRODUCTION

Evidence suggests that time spent in sedentary behaviours (usually defined as time spent sitting) is an independent risk factor for a number of adverse health outcomes [1] and there have been calls for the explicit measurement of sedentary behaviour in population surveillance studies [2]. To date, limited evidence exists on the validity of self-reported measures of sedentary behaviour. This study examined the criterion validity of two different self-report measures of sitting time.

METHODS

44 healthy volunteers (30% male, age = 41.5±12.8 years, BMI = 24.8±4.7 kg/m²) wore an ActiGraph accelerometer (the criterion measure) for seven consecutive days. Each day of monitoring, participants recorded their daily sitting time by responding to the single-item question “how long have you been sitting for today?” in a daily diary. Participants completed this specific-day question on a daily basis just before going to bed each night. After seven days, participants completed a new domain-specific sitting time questionnaire that requires participants to retrospectively report sitting times in different domains (i.e. time spent sitting whilst travelling to and from places, at work, watching TV, using a computer at home, and during leisure time), on a usual weekday and weekend-day [3]. Total sitting times recorded from the single-item question and from the domain-specific questionnaire were compared with mean accelerometer-determined sedentary time (minutes/day of <100 counts/minute) for weekdays and weekend-days.

RESULTS

Accelerometer-determined sedentary times (mean ± SD) for weekdays and weekend-days were 639.7±133.9 and 612.4±132.7 minutes respectively. Total sitting time calculated from the domain-specific questionnaire did not differ significantly from accelerometer-determined sedentary time on either weekdays (mean difference = -13.7 minutes [95% CI = -49.2 to 41.8]) or weekend-days (-4.2 minutes [95% CI = -9.1 to 17.9]). Total sitting time was significantly underestimated using the single-item specific-day question on weekdays (-173 minutes [95% CI = -207.5 to -138.5]) and weekend-days (-219 minutes [95% CI = -262.9 to -174.2]). From the domain-specific questionnaire, the greatest contributor to daily sitting time was sitting at work on average (91.7 to 83.4%).
DISCUSSION AND CONCLUSION
When assessed via self-report, the estimation of total sitting time is improved by summing sitting times reported across different domains. Estimates of sitting time are more precise for weekdays than for weekend-days. The continued improvement of self-report measures of sitting time, particularly for weekend-days, will be important if we are to further our understanding of the links between sedentary behaviour and health.

REFERENCES

011.4 MEASURING TOTAL SITTING TIME IN WORKING ADULTS
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INTRODUCTION
Much of the research about sitting measurement has focused on total sitting time [1] (Rosenberg et al) and leisure-time sedentary behaviours [2](Clark et al 2009), with less attention given to other domains in which sitting and sedentary behaviours occur. This study aimed to assess the measurement properties of a measure of total and domain-specific sitting based on work and non-workdays for use in working adults.

METHODS
A convenience sample (N=95, 63% female) was recruited from two workplaces and by word-of-mouth in Sydney, Australia. Participants completed a study questionnaire on two occasions, seven days apart, and reported their domain-specific sitting time (i.e., a) while travelling to and from places; b) while at work; c) while watching TV; d) while using a computer at home; and e) while doing other leisure activities) on work and non-workdays. Participants also wore an Actigraph accelerometer for the seven days in between the test and test, recording the times they wore the accelerometer, the days they worked, and their work times in a logbook. Analyses determined test-retest reliability with intraclass correlation coefficients (ICC) and assessed criterion validity against accelerometers using Spearman’s rho. Concurrent validity was assessed against the International Physical Activity Questionnaire (IPAQ) sitting measure.

RESULTS
Measuring total sitting based on a workday, non-workday and on average had fair to excellent test-retest reliability (ICC=0.46-0.90) and had sufficient criterion validity against accelerometry in women (r=0.22-0.46) and men (r=0.10-0.29). Measuring average total sitting time correlated well with average total sitting time assessed by IPAQ, indicating adequate concurrent validity in women (r=0.53) and men (0.69). Measuring domain-specific sitting at work on a workday was also reliable (ICC=0.63) and valid (r=0.45).

DISCUSSION AND CONCLUSION
Measuring total sitting by specific domains provides a detailed assessment of sitting in working adults. Many working adults spend large amounts of time sitting each day. Therefore, we recommend that this measure of total sitting time based on specific domains on work and non-workdays be used in research investigating the relationships between sitting time and health in working populations.

REFERENCES
SESSION 12

METHOD DEVELOPMENT

PHYSICAL ACTIVITY PATTERNS

012.1 REAL WORLD WALKING BEHAVIOR IN TYPICALLY DEVELOPING ADOLESCENTS: AN ACTIVITY PROFILE USING STEP AND BOUT DISTRIBUTIONS

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INTRODUCTION

Walking behavior involves a complex distribution of locomotor actions of different lengths to meet the mobility demand for functional community ambulation. Most walking for normal adults is made up of just a few steps in a row: forty percent of all walking is less than 12 steps in a row and 75% of all walking is less than 40 steps in a row. Adolescents may have a different profile of locomotor behavior as they transition from childhood play behavior to a more adult pattern of community mobility. The purpose of this experiment was to compare the number of steps at ten different bout lengths for typically developing eleven, twelve and thirteen year olds.

METHODS

Thirty adolescents participated in this study, 5 boys and 5 girls in each age group. Parents gave informed consent and participants gave assent. This study received ethical approval. Participants wore a StepWatch Activity Monitor for two weeks. The number of steps was counted and placed into 10 categories based on the number of steps in a row. A questionnaire determined participation in organized sports.

RESULTS

Thirteen year olds had ~2000 fewer average daily steps than twelve year olds, who had ~2000 fewer average daily steps than eleven year olds (p < 0.001). This decrease occurred primarily in long duration bouts that last approximately 500+, 1000+ and 2000+ steps in a row. Organization in sports was 20% for 11 year olds, 40% for 12 year olds and 65% for 13 year olds. Bouts less than 300+ steps occurred everyday for every participant, but longer bouts occurred less frequently. Bouts with 2000+ occurred every other day for 11 year olds, every third day for 12 year olds and every fifth day for 13 year olds. For each individual, the most active day was followed by their least active day.

DISCUSSION AND CONCLUSION

This method differentiates the locomotor behavior for transport during typical activities (<300+ steps in a row) and the longer duration activities that might be considered play or recreation (500-2000+ steps in a row). These longer duration activities may have substantial health related benefits by triggering the molecular signaling response to exercise and in maintaining appropriate caloric balance for adolescents as they transition to young adults.

REFERENCES


012.2 PHYSICAL ACTIVITY AND SEDENTARY BEHAVIORS IMMEDIATELY BEFORE AND AFTER SCHOOL

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INTRODUCTION

It is widely acknowledged that the consequences of physical inactivity are a major public health concern, particularly in children and adolescents [1]. Unfortunately, the contribution of commuting to and from school and extracurricular physical activity before and after school and is often overlooked when examining levels of daily PA [2, 3]. The purpose of this abstract is to examine the contribution of objectively measured PA to total daily PA in a group of adolescent females during the hour before school (8-9am) and the hour after school (3-4pm). This abstract also describes the objectively measured sedentary pattern of this group of adolescent during this time period.

METHODS

Participants were randomly selected from 6 schools across the mid-western region of Ireland (N=51). Four to six days of PA was recorded using accelerometry (ActivPAL, PAL technologies Ltd, Glasgow, Scotland). Data obtained on school days was examined from 8-9am and from 3-4pm. Data was examined for sedentary, light and moderate to vigorous PA (MVPA). Data was also examined for duration of sedentary bouts using a MATLAB computer program (version 7.0.1, Mathworks Inc, Natick, MA, USA).

RESULTS

The results reported in this abstract are based on a subsample of 20 participants. Participants accumulated 28% of their daily recommended MVPA between 8-9am and between 3-4pm (all means ± SD’s: 14.6 ± 8.6 mins). No significant differences existed between levels of MVPA achieved between 8-9am (8.25 ± 7.1) and 3-4pm (7.26 ± 6.88; p > .05). The analysis also showed that parents spent 43.3 (±13.4) mins in light activity, while 62.1 (±15.6) mins were spent in sedentary activities. Significantly more sedentary time was accumulated in the hour after school (34.05 ± 13.6 mins) than the hour before school (25.4 ± 14.5 mins; p<.001, Wilcoxon Sign). Significantly more sedentary bouts less than 10 minutes in duration were also identified in the hour before school (p=.009, Wilcoxon Sign).

DISCUSSION AND CONCLUSION

It is indicated that participants achieved 28% of their daily MVPA immediately before and after school. However, it is also highlighted that considerable periods of time were also spent sedentary, with more time being spent in sedentary activities after school than before school. The time period immediately before and after school provides students with the opportunity to be involved in active transport or in extracurricular PA, in particular, after school activities have the potential to significantly contribute to daily MVPA [3].

REFERENCES


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**012.3 THE RELATIONSHIP BETWEEN STANDING AND STEPPING TIME AS CONTRIBUTORS TO UPRIGHT TIME IN 11-13 YEAR OLD SCOTTISH SCHOOL CHILDREN ACROSS SEASONS**

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**INTRODUCTION**
The term ‘sedentary’ is often used to describe all activity that is not stepping [1]. The distinction between quiet standing time and sitting/lying is seldom made. This may occur due to monitoring protocol limitations. It might be reasonable to assume that quiet standing time contributes little to health if it were not a significant component of peoples’ activity, yet there is little evidence of the prevalence of this state. This study examines the proportions of upright time that are spent in the two states ‘standing’ and ‘stepping’ and thus provides evidence of the relative importance of quiet standing as a contributor to overall physical activity (PA) in Scottish school children across seasons.

**METHODS**
The PA of thirty three participants (baseline mean age = 12.2 years, 54% female) was measured using a PA monitor (activPAL®) in November/December 2009 (TP1) and May/June 2010 (TP2). Mean upright time, standing time and stepping time were calculated for four complete school days.

**RESULTS**

Table 1 Time spent in upright, stepping and standing

<table>
<thead>
<tr>
<th>Time (mins/day) or ratio</th>
<th>All day average total</th>
<th>9am-4pm School day</th>
<th>4pm-10pm Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upright</strong></td>
<td>227</td>
<td>324</td>
<td>162.2*</td>
</tr>
<tr>
<td><strong>Standing</strong></td>
<td>195*</td>
<td>171*</td>
<td>94.2*</td>
</tr>
<tr>
<td><strong>Stepping</strong></td>
<td>131*</td>
<td>68.0</td>
<td>43.0*</td>
</tr>
<tr>
<td><strong>Standing/stepping</strong></td>
<td>0.6</td>
<td>0.53</td>
<td>0.58</td>
</tr>
</tbody>
</table>

*p<0.01

**DISCUSSION AND CONCLUSION**

No difference in average daily ‘upright time’ between time-points was seen. However, when upright was examined as standing and stepping times, differences were evident: Average daily ‘standing time’ was significantly higher at TP1 than TP2 and ‘stepping time’ was significantly lower at TP1 than TP2. For ‘standing time’ this result was associated with school time activity changes, whereas the differences in ‘stepping time’ occurred in the evening.

‘Standing time’ accounted for a greater proportion of overall daily ‘upright time’ than ‘stepping time’ at both TP1 and TP2. However, examining data by daily average showed an apparent increase in ‘standing time’ at both TP1 and TP2. However, examining data by daily average showed an apparent increase in ‘standing time’ at both TP1 and TP2. Moreover, differences in ‘standing time’ were evident: during the day ‘standing time’ was significantly lower at TP1 than TP2, whereas the differences in ‘stepping time’ were not significant. For ‘standing time’ this result was associated with school time activity changes, whereas the differences in ‘stepping time’ occurred in the evening.

In this population, changes in PA cannot be fully characterised by measures of either ‘stepping time’ or ‘upright time’ alone, but must also take into account the ‘standing time’. Although the importance of ‘standing time’ in relation to health is not clear it is a significant component of 11-13 year olds’ daily physical activity.

**REFERENCES**


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**012.4 RECOGNITION OF PHYSICAL ACTIVITY BY BIOMECHANICAL MOVEMENT ANALYSIS**

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**INTRODUCTION**

New systems based on inertial sensors for ambulatory movement analysis are currently under development. This technique promising for rehabilitation purpose requires the development of algorithms for the recognition of the physical activities recommended by the clinical staff. The algorithms currently proposed are mainly consisting in decisional trees and neural networks having as inputs diverse acceleration frequency parameters defined by analyzing data of specific groups of subjects [1,2]. The aim of the present study is to propose a method using biomechanical analysis of the activities to classify to perform activity recognition, whatever the subject characteristics are.

**METHODS**

For the European project Physical Activity Monitoring of Elderly People (www.pamap.org), the postures sitting/standing/lying are to be classified as well as the endurance activities walking/running/cycling. 16 subjects of different age and physical condition took part in this study. They had to take the different postures during period of 6’5”s, to walk/run/cycle 6 times through a 10m-pathway at 3 different paces (slow/normal/fast) and they had to perform 2 daily activities also at 3 different paces. The motion capture was performed using an optoelectronical system (Vicon System). Markers were placed to track not only the body segments but also potential inertial sensor locations. To complete the analysis, walking and running from children having gait disorders were integrated to the study. Since the ambulatory systems are currently based on inertial sensors, the signals analysed to determine the “universal” characteristics of each activity were the accelerations deduced from the marker trajectories. Local body segment coordinate was also computed.

**RESULTS**

Each body posture could easily be recognized based on the acceleration of the markers placed at the pelvis and at least one placed on the thigh. For the different activities, the markers placed at the pelvis and those placed at the both thighs were needed. The biomechanical analysis of the different activities enabled indeed the detection of typical pattern of coordination of thigh acceleration, whatever the subjects as illustrated on the figure hereafter.

**DISCUSSION AND CONCLUSION**

The results of this study confirmed that the biomechanical approach enables the recognition of different physical activities. This approach has to be now implemented on ambulatory systems with inertial sensors.

**Acknowledgments:** this project was supported by the European program AAL-2008-1.

**REFERENCES**


Illustration of gait (A) and running (B) typical thigh acceleration pattern.
MODELLING OBESITY AS A FUNCTION OF WEEKLY PHYSICAL ACTIVITY PROFILES MEASURED BY ACTIGRAPH ACCELEROMETERS

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INTRODUCTION
Epidemiological studies for investigating physical activity as a predictor for a health outcome such as obesity often use average daily moderate to vigorous physical activity (MVPA) as a summary of the highly dimensional actigraph measurements. The problem with using a single summary statistic such as MVPA is that it ignores the pattern of the physical activity measurements. In addition, it relies on setting cut-points for moderate and vigorous activity with the cut-points being arbitrary or based on expensive calibration studies. Also, cut-points may change with age. Our objective is develop a statistical tool for exploring the relationship between physical activity and fat mass which allows to take the whole range and pattern of physical activity into account.

METHODS
The data is from the The Avon Longitudinal Study of Parents and Children (ALSPAC). Fat mass, the outcome, was derived using a Lunar Prodigy DEXA scanner. Physical activity, the predictor, is a time series of 10080 minute by minute accelerometer measurements of counts per minute over 7 days available at three time points (ages 12, 14 and 16). We summarised these profiles by a histogram, this makes the profiles comparable between individuals and reduces the dimension of data, while still being easy to interpret. Then we fitted a generalised version of a regression model with fat mass as the outcome and the profile histogram as one of the predictors. The model is a generalisation of a regression model, allowing the use of functions of high dimensional predictors rather than just univariate predictors.

RESULTS
The histogram is a useful summary for exploring characteristics of highly dimensional physical activity profiles aiding in classifying individuals into groups with similar profile characteristics. Our preliminary model results back up the cut-point used for MVPA at 3600 counts per minute set by a calibration study [1] and confirm that moderate and vigorous activity has a negative effect on fat mass. In addition, we find that light physical activity ranging around 500 counts per minute has a significant positive effect on fat mass.

REFERENCES

SESSION 13
METHOD DEVELOPMENT WALKING PATTERNS

ESTIMATION OF HEEL & TOE CLEARANCE DURING GAIT USING FOOT-WORN SENSORS: APPLICATION TO DUAL-TASK STUDIES IN ELDERLY PERSONS

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INTRODUCTION
During walking, insufficient or fluctuations in toe clearance could lead directly to tripping, a major cause of fall in older people. Few studies investigated so far the toe clearance pattern but only with laboratory settings [1]. Moreover, dual-task paradigm (i.e. walking with an additional cognitive or motor task) is of particular interest because a strong relationship exists between dual-task related gait changes and the risk for falling in older adults [2]. The aim of this study is to introduce a new method to assess both heel and toe clearance patterns using wearable sensors on foot and to investigate their changes with dual-task condition in a representative sample of elderly people.

METHODS
605 Elderly subjects were asked to perform a 20m gait trial at self-selected speed in the following conditions: single task walking (ST), walking while counting backward (DTc), walking while carrying a glass of water (DTm) and walking while carrying a glass of water and counting backward (DTcm). Foot angular velocities and accelerations during each trials were recorded using a miniature wireless inertial module (Physilog®) attached on foot. Data from a convenience subsample (N=34) of participants were analyzed for this study. The trajectory of the sensor and the stride velocity (SV) were obtained [3]. Then the instantaneous position of the Toe and Heel during gait was derived using a kinematic model. Finally, Minimal Toe Clearance (MTC) was extracted at each gait cycle.

RESULTS
The typical heel and toe clearance patterns obtained are shown in fig. a. They are consistent with literature [1]. Fig. b shows the results for the 34 subjects (N=2720 gait cycles) where the differences between ST and DT conditions are illustrated. Dual-task seems to similarly affect SV and MTC by decreasing average amplitude (mean) and by increasing variability (std). A similar trend was observed between MTC and SV; namely a bigger cost resulting from cognitive dual task compared to motor dual task.

DISCUSSION AND CONCLUSION
The method seems suitable to ambulatory assess heel and toe clearance and show equivalent face validity for analyzing single and dual task conditions compared to stride velocity. Further analyses including all 605 subjects will be performed to determine whether these preliminary results are confirmed. Furthermore, technical validation of the method in terms of accuracy and precision against gold standard system is in progress.

REFERENCES
013.2 AMBULATORY ACTIVITY PATTERNS IN CHILDREN WITH CEREBRAL PALSY USING THE STEPWATCH

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INTRODUCTION
This study compares the walking activity patterns of youth with cerebral palsy (CP) to a cohort of typically developing youth (TDY) with walking stride rate trajectory curves derived from the StepWatch (SW) and describes a longitudinal clinical case with the derived stride rate curves.

METHODS
Participants wore the SW at the lateral ankle for 7 days with stride rate trajectory curves developed from the average minutes per day spent at each stride rate for 5 days. A comparison cohort design examined 121 TDY (49% female, 12.0 [1.2] years), to 81 children with CP (Gross Motor Function Levels, GMFCS I-III, 68% spastic, 54% diplegia, 46% female, 11.8 [1.3] years).

RESULTS
On average youth with CP walk significantly less each day than TDY (p<0.001). The level I group had similar patterns (p=0.09) as TDY, while level II and III demonstrated lower mean group stride trajectories (p<0.001). Children at level III had significantly lower peak stride rates (p=0.001). Patterns of stride rate trajectories for youth with CP have greater variability. Pre-post intervention changes in walking activity, peak rates and trajectory curves were documented.

DISCUSSION AND CONCLUSION
Youth with CP at levels II and III demonstrated significantly lower mean group trajectories of stride rates. Stride activity curves have potential to capture the average daily walking inactivity level, peak stride rates and patterns of stride rate trajectory within a single visual format for potential research and/or clinical applications.

013.3 IDENTIFICATION OF CHILDREN’S ACTIVITY TYPE WITH ACCELEROMETER-BASED NEURAL NETWORKS

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INTRODUCTION
Children’s physical activity has traditionally been measured with self-reports. Self-reports are easily administered, low-cost measurements. However, they do not capture the sporadic short-burst nature of children’s physical activity very well. Accelerometers have therefore, in recent times, become the method of choice in physical activity research. These devices provide objective information about the frequency, intensity, and duration of physical activity. However, they do not provide information about the type of physical activity children engage in. Pattern-recognition-based approaches have shown to be successful in classifying a number of controlled physical activities among adults and elderly. To our knowledge, studies applying these approaches to accelerometer data from children are currently lacking. The physical activity pattern of children is very different from that of adults. Children’s physical activity pattern is characterized by frequent spasmodic bursts of short duration. They participate in intermittent and unstructured activities and the type of activities children engage in changes as they develop, going from informal active play during early childhood to activities that begin to mirror those of adults during adolescence. Because of these differences, it remains to be seen whether activity classification based on accelerometer data is just as successful in children as in adults and elderly.

The purpose of this study was to identify types of physical activity among school-aged children using artificial neural network models based on three-axial accelerometer data from the hip or the ankle. Secondarily, it was examined whether the accuracy of the developed ANN models improved by including more information about the intensity of activities measured by heart rate data or by adding information about the velocity of activities from global positioning systems (GPS).

METHODS
Fifty-eight children (31 boys; 27 girls; age range: 9-12 years) performed the following activities in a field setting: sitting, standing, walking, running, rope skipping, playing soccer, and cycling. All children wore a three-axial Actigraph accelerometer on both the hip and the ankle, a QStarz Travel Recorder GPS device, and a Polar heart rate device. ANN models were developed using the following accelerometer signal characteristics: 110th, 25th, 75th, and 90th percentiles, absolute deviation, coefficient of variability, and lag-one autocorrelation, and the mean of the heart frequency and the mean speed computed for 10 seconds intervals. The accuracy of the models was evaluated by leave-one-subject-out cross-validation.

013.4 METHODS FOR QUANTIFYING CHANGE IN AMBULATORY BEHAVIOUR

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INTRODUCTION
Objective measures of ambulation are increasingly being used to assess the impact of public health or rehabilitation intervention. These instruments enable long-term, free-living recording of walking behaviour. This offers a unique opportunity to assess changes in behaviour. However analysis of objective data is often restricted to quantifying the volume of walking (e.g. time spent walking, number of steps, distance), which due to intra and inter subject variability does not enable to quantify change in behaviour with much sensitivity. We have developed methods that quantify the diversity, complexity and variability of walking behaviour that can be used to assess subtle changes in behaviour.

METHODS
17 participants with advanced Parkinson Disease (UPDRS III 29.1±5.5; disease duration 12.5±4.3 years) took part in this longitudinal study. Ambulatory activity was measured objectively over a 7 day period using an activPAM™. Data were collected 6 weeks before surgery and 6 weeks, 3, 6 and 12 months after surgery. We examine the distribution of length and cadences of walking bouts in free-living conditions and how fragmented walking bouts are [2]. Based on these statistics we compute the probability P(l,c) to find a walking bouts of length l and cadence c. Using Hill’s numbers D = exp(1/ln2)σlσc - 11 we derive measures of the diversity, complexity and variability of walking bouts used by an individual. These numbers are normalised and expressed as al number of walking bouts.

RESULTS
The distribution of walking bouts follows a log-normal distribution and can be characterised standard log-normal statistics. Cadence is distributed normally. The possible combination of length and cadence pairs can therefore be represented by partition of the log of bout length and linear cadences centered around the mean cadence. Mixed model analysis shows that volume of walking is unaffected by brain stimulation surgery. However the walking behaviour has changed with more less fragmented more variable and diverse ambulatory periods.

DISCUSSION AND CONCLUSION
The results hint that showing that brain stimulation enabled Parkinson Disease patients to regain more flexibility and adaptability in their walking, allowing for longer more diverse ambulatory periods. Methods developed to quantify ambulatory behavior have the potential to inform intervention and their outcomes. Diversity of ambulation has also been shown to be an important factor to be considered along side the volume of walking in the assessment of physical activity in older adults[3].

REFERENCES
**INTRODUCTION**
With increasing interest in how the physical environment may influence physical activity, methods are needed that can be used to investigate the environmental context of activity. The aim of this study is to use combined accelerometer and GPS data to describe the level and location of children's physical activity outdoors.

**METHODS**
Data were collected in the PEACH project, a longitudinal study of 1300 children measured in their final year of primary school and 1 year later in the first year of secondary school. Children wore an accelerometer (Actigraph GT1M) for 7 days and a GPS (Garmin Foretrex 201) for 3 days after school and on one weekend day. Both instruments recorded at 10 second intervals. Accelerometer and GPS data were matched based upon the accelerometer time stamp. Any GPS data matched to an accelerometer record were considered to be outdoors. A Geographical Information System (ARCGIS 9.3) was used to identify the proportion of combined GPS and accelerometer points falling inside/outside of greenspace.

**RESULTS**
Primary school children (n=1010) spent 41.7 ± 46.1 minutes (approx. 13% of total time) outdoors each day between 3.30 and 8.30pm. Time outdoors did not differ between the sexes and was lower in the winter than the summer. Physical activity levels outdoors were > 2.5 times higher than indoors [1]. Time spent in greenspace after school accounted for only 2.4% of total time, but was more likely to be spent in activity of moderate to vigorous intensity than outdoors elsewhere [2]. In secondary school, time outdoors after school was lower (35.1 ± 39.5 minutes; n=466) but showed very similar associations with gender, season and physical activity. Preliminary analyses indicate that more time is spent outdoors in greenspace at weekends than during the week and that greater time in greenspace may be associated with active travel to school.

**DISCUSSION AND CONCLUSION**
Combining accelerometer and GPS data provides a method for objectively measuring time outdoors and segmenting physical activity into that occurring indoors or outdoors, and with GIS allows the level and location of outdoor physical activity to be described. This study shows that physical activity is substantially higher outdoors, and with GIS allows the level and location of outdoor physical activity to be described. This study was used to examine the effect of short interruptions in walking on metabolic response to establish if 10 minutes of walking with short interruptions can still be considered continuous.

**METHODS**
Healthy volunteers (N = 15) walked on a treadmill with walking interruptions of 10 seconds (s), 50s and 100s, where the speed, duration and total walking time were constant throughout their test. Oxygen consumption per Kg was measured using the K4b2 gas analysis system. The relative difference in oxygen consumption was defined at each of the interval times and as part of a larger section of walking, where the data was normalized to account for differences in the actual interval times. An ANOVA was used to analyze the data was used to test the equality of the mean for the direct interval effect and the effect during a longer section of time. Where a significant difference was found Tukey Post Hoc tests were employed.

**RESULTS**
As the length of the interval increased, the metabolic response for the period dropped. Significant difference in oxygen consumption was found as a result of the interval, at 50s (P = 0.00) and 100s (P = 0.00). A 10s interval had no significant effect (P = 0.17). The model explains 66.8% of the variance. The interval of 100s caused an average drop in oxygen consumption by 45% and the 50 second drop caused an average drop of 34%.

When considered within a period of walking the 100 s interval still has a significant effect when compared to a period of uninterrupted walking (P = 0.01) The 50s and 10s intervals had no significant effect (P = 0.18, P = 0.78, respectively). The model explains 90.3% of the variance. The 100s interval produced an average drop in oxygen consumption by 18% within a period of walking of approximately 10 minutes.

**DISCUSSION AND CONCLUSION**
Interruption of brisk walking bouts by stationary periods of under 50s could still be considered continuous physical activity. The conclusions of this study have a bearing on the way physical activity data are analysed.

**REFERENCES**

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**THE VALIDITY OF THE INCIDENTAL AND PLANNED EXERCISE QUESTIONNAIRE (IPEQ) FOR SEDENTARY OLDER ADULTS**

**INTRODUCTION**
The Incidental and Planned Activity Questionnaire (IPAQ), renamed to be IPEQ, is a self-report short questionnaire that was developed for use in ageing research. The questionnaire asks about an average week frequency and duration (closed categories) of planned exercise, walking for exercise, walking to places and chores inside and outside the home. It has shown excellent test-retest reliability, ICC=0.87 [1]. This study assessed the criterion validity of IPEQ for inactive elderly who were recruited to the "walking and Fall “ randomized control trial.
METHODS
Community dwelling older adults (≥65 years) were recruited to the trial through advertisements. Participants were not eligible if they engaged in any exercise, including walking, ≥3 times and/or ≥60 minutes per week. At baseline a 20-minute telephone interview, including IPEQ, was conducted with all eligible participants and of those about half were also randomized to undertake a 7-day accelerometer (Actigraph GT1M) data recording. A day was deemed as valid if total wear time was ≥10 hours. Participants were included in the analysis if they had at least 4 valid days of accelerometer data. We examined two suggested cut-off points to differentiate between light and moderate intensity physical activity: Low value of 760 ct min⁻¹ [2] and a medium value of 1041 [3].

RESULTS
The IPEQ and accelerometer measurements were available for 50 older people, of those 48 (96%) had ≥4 valid days. The Spearman coefficient between mean counts per day and total IPEQ score in the low and medium cut-offs were 0.16 and 0.18, respectively. The average minutes per day of at least moderate to vigorous physical activity (MVPA) were 71 and 47 minutes for the low and medium cut-off points, respectively. The impact of the momentary context (e.g. being at work, having leisure-time) and its interaction with physical activity in everyday life on three different mood states. But until today, there are only few studies analyzing within-subject relations of physical activity and mood, we aggregated the preceding 10 minutes of physical activity before each palm-assessment. Within-person effects were analyzed with hierarchical modeling (HLM6.0). Multilevel analyses show that preceding physical activity as well as the momentary context affect the different mood states significantly. The impact of physical activity on mood is well established in cross-sectional studies. But until today, there are only few studies analyzing within-subject relations of physical activity and mood.

DISCUSSION AND CONCLUSION
IPEQ walking questions showed moderate correlates with steps per day. The correlation with total IPEQ score and minutes spent in MVPA or counts per day were less good, which might have been influenced by lack of differentiation in physical activity levels in the sampled population. Coefficients were slightly better for the medium cut-off. The criterion validity of IPEQ should be tested on a larger representative sample with a range of activity levels.

REFERENCES

THE EFFECT OF PHYSICAL ACTIVITY IN EVERYDAY LIFE AND ITS CONTEXT ON DIFFERENT MOOD STATES
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INTRODUCTION
The positive effect of physical activity on mood is well established in cross-sectional studies. But until today, there are only few studies analyzing within-subject relations between mood and physical activity in everyday life [1]. Our study extended the existing research by using an ambulatory assessment. Secondly, we look for the impact of the momentary context (e.g. being at work, having leisure-time) and its interaction with physical activity in everyday life on three different mood states. Analyzing the interaction the provides answers to the optimal context of physical activity for individuals’ mood regulation.

METHODS
47 females and 40 males (Age: $M = 24.6$; $SD = 3.2$) participated in the study. Physical activity was measured continuously using a 3-way accelerometer for 24 hours. Ratings of mood and context were assessed via electronic diaries. A palmprompted subjects randomly every 45 minutes during a 16 hour daytime period. A 6-item mood scale [2] was used to measure mood. The instrument’s subscales valence, energetic arousal and calmness are optimized for assessing mood in every day life repeatedly. To define the context in which participants are situated during palm-assessment, the sample chooses one out of the four following categories: work, transport, chores or leisure time. In order to analyze lagged within subject relations of physical activity and mood, we aggregated the preceding 10 minutes of physical activity before each palm-assessment. Within-person effects were analyzed with hierarchical modeling (HLM6.0).

RESULTS
We achieved only a sufficient number of episodes for work (53%) and for leisure time (23%). For this, we created a dummy-coded indicator variable named Leisure/Work. Multilevel analyses show that preceding physical activity as well as the momentary context affect the different mood states significantly. The impact of physical activity was positive for valence ($t_{(69)} = 4.7$, $p < .001$; $r = .39$) and energetic arousal ($t_{(68)} = 8.6$, $p < .001$; $r = .54$) and negative for calmness ($t_{(68)} = -3.6$, $p < .001$; $r = .38$). The impact of Leisure/Work was positive for valence ($t_{(68)} = 1.9$, $p = .35$; $r = .17$) and negative for energetic arousal ($t_{(69)} = -3.0$, $p = .003$; $r = .19$). The assumed interaction between PA and LW is not significant in any mood state.

DISCUSSION AND CONCLUSION
The more our subjects are physically active, the more they feel good and full of energy. Surprisingly, they feel agitated and tense, too. Comprised to working episodes, the sample feels better and calmer and they show less energy during leisure time. An interesting point to discuss is that the interaction does not significantly affect any mood state. Hence, it does not seem to be relevant whether physical activity takes place during occupational activities or during leisure time.

REFERENCES

A ROBUST METHOD FOR DETECTING STEPS IN THE FRAIL ELDERLY
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INTRODUCTION
Physical activity (PA) is strongly related to a person’s quality of life and health, and hence there is a great interest in activity monitoring. Accelerometers are being increasingly used in studies of PA among older adults, however when used on elderly with an abnormal gait the interpretation of the data becomes difficult. The gait of frail older adults and individuals with neurological disorders can be characterized by being slow, shuffling and cautious. As a consequence the signal amplitude of the acceleration data and the gait pattern will differ from healthy individuals. From earlier studies examining the validity of commercially available accelerometer-based body worn sensors it is revealed that the software that follows the system exhibits inadequate validity in step recognition on short walking distances and at slow walking pace [1]. The aim for the study was to enhance the sensitivity of the system to detect steps in the frail elderly.

METHOD
A method to detect steps has been developed that is independent of the amplitude of the signal and that utilizes the cosine similarity transform to find a specific signal element in a measured signal. The similarity between the measured signal and that of a typical step is expressed as a similarity value that indicates whether there is a step. A cross sectional comparative study in 36 older persons (stroke patients, hip fracture patients and geriatric in-patients) was conducted to examine the accuracy of step count utilizing the new method.

RESULTS
The results were compared to the commercial system and revealed a decline in the error rate from 45 % to 3% when walking 5 meters at preferred gait speed. An overall sensitivity of 0.85 was detected.
INTRODUCTION

Timed Up and Go (TUG) is a clinical test to assess mobility and fall risk in older adults and Parkinson’s disease (PD). Its traditional outcome is total duration. Since this measure cannot provide insight on subtle differences in test performance (especially in early stages of the disease [1]), we considered an instrumented TUG (iTUG). The aim was to find the best set of quantitative measures that would allow an objective evaluation of locomotor function in PD.

METHODS

We examined 20 early-mild PD subjects OFF medication (62±7 yrs, 12 males) and 20 healthy controls (64±6 yrs, 7 males). Subjects wore a tri-axial accelerometer (McRoberts® Dynaport Micromod, sample rate: 100 Hz, range: ±2g) on the lower back. They performed 3 TUG trials (single task, ST) and 3 iTUG trials with a concurrent cognitive task (dual task, DT). iTUG test consisted of rising from a chair, walking 7m, turning around, returning and sitting down. Several temporal, coordination and smoothness measures were extracted from the acceleration signals in different sections of the TUG. To select the measures with the best discriminative ability, a feature selection was implemented [2] based on linear discriminant analysis.

RESULTS

In the figure the three best measures for discrimination between PD and CTRL are reported: they allow a misclassification rate of 7.5%. The measures are related to three different sections of TUG: Sit-to-Stand, Gait, Stand-to-Sit, and include both ST and DT measures. Interestingly iTUG duration was not selected.

DISCUSSION AND CONCLUSION

We found disease-specific measures from TUG in a case (early-mild PD) where traditional outcome measures would not be sensitive enough. This result may pave the way towards novel recommendations on which measures should be used in clinical practice. Because of the portability of the measurement system this protocol could be also used to evaluate the locomotor function as a personal health system, outside practice. Because of the portability of the measurement system this protocol could be also used to evaluate the locomotor function as a personal health system, outside practice.

REFERENCES


INERTIAL SENSOR MOTION ANALYSIS OF GAIT, SIT-STAND TRANSFERS AND STEP-UP TRANSFERS: DIFFERENTIATING KNEE PATIENTS FROM CONTROLS.

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INTRODUCTION

Recent advances in miniaturization and cost of sensors have made ambulatory motion analysis available for everyday clinical practice. As classic clinical outcome measures (i.e. self-report questionnaires) fail to objectively document functional improvements in response to therapeutic interventions [1], we investigated whether a single inertial sensor based motion analysis can feasibly differentiate the functional capacity between healthy subjects and patients undergoing total knee replacement (TKR) during activities of daily life.

MATERIALS AND METHODS

A 3D inertial sensor (41x63x24mm, f=100Hz) containing gyroscopes (±300°/s) and accelerometers (±5g) was attached onto the sacrum. Healthy subjects (n=30; m/f=18/12; age=61.0yrs±5.6) and patients scheduled for TKR (n=20, m/f=7/13; age=67.4yrs±7.7) performed 3 tasks at their preferred speed: 1) gait (20m), 2) sit-stand transfer, 3) stepping onto a block (20cm). Motion parameters were derived using peak detection algorithms (Matlab) after manually selecting the start and finish of the task. For gait, the first and last 20% of steps were excluded for analysis. In sit-stand and step-up transfers, parameters represent the average of 3 repetitions. Patients and controls were compared (t-test, *p<0.001, **p<0.05) and the diagnostic power of parameters to distinguish patients from controls was calculated using the receiver operating characteristic (ROC) curve, where the area under the curve (AUC) summarizes the tradeoff between sensitivity and specificity (best score is 1.0).

RESULTS

Time to task-achievement was longer for patients than for controls (gait=24.4s±4.8 vs. 15.8s±2.4, sit-stand=3.2s±1.1 vs. 2.0s±0.4, step-up=4.3s±1.3 vs. 2.4s±0.5, respectively). During sit-stand transfers, patients showed more left/right sway (6.5°±2.9 vs. 4.4°±2.3). During step-up transfers, patients showed more front/back sway (20.8°±5.8 vs. 14.1°±3.2). During gait, range of motion of pelvic obliquity was lower for patients (5.0°±1.9 vs. 7.8°±2.9) while pelvic tilt was higher (5.4°±1.6 vs. 3.9°±1.2). Other spatiotemporal gait parameters in healthy subjects were similar to those reported in literature (table 1) [2]. AUC values were highest for parameters of gait (speed=0.97, step length=0.95, pelvic obliquity=0.83), followed by step-up transfers (time=0.95, sway front/back=0.88) and sit-stand transfers (time=0.89, sway left/right=0.74).

Table 1: Gait

<table>
<thead>
<tr>
<th>Measure</th>
<th>Control n=30</th>
<th>Patients n=20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (m/s)</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>1.29</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>0.85*</td>
<td>0.16</td>
</tr>
<tr>
<td>Cadence (steps/min)</td>
<td>112.0</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td>98.1*</td>
<td>9.8</td>
</tr>
<tr>
<td>Steplength (m)</td>
<td>0.89</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>0.52*</td>
<td>0.07</td>
</tr>
<tr>
<td>Stepirregularity (cv %)</td>
<td>4.0</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>6.1**</td>
<td>3.3</td>
</tr>
</tbody>
</table>

DISCUSSION

Using a single inertial sensor, we were able to score functional capacity during tasks of daily life and differentiate knee patients from healthy subjects. Time to task-achievement seems a diagnostically powerful measure; however it is unable to show possible task and disease specific compensation mechanisms. Parameters of true motion (e.g. sway, pelvic obliquity) on the other hand have this ability and showed almost equally good diagnostic power. We suggest to combine temporal parameters with motion parameters to compose a functional outcome score.

REFERENCES

015.4 AMBULATORY MONITORING IN PARKINSON’S DISEASE: A MODEL-BASED APPROACH

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INTRODUCTION
Ambulatory monitoring is a promising approach for evaluation of movement in the daily living, enabling for Parkinson’s disease (PD) in the early 90’s. The platforms developed generally used multiple sensor designs and complex classification procedures [1,2] which restrained routine clinical applications. This study exposes how a device and a classification algorithm based on theoretical modeling of movement is able to simplify such classification procedures.

METHODS
In 23 parkinsonian patients, 48 h ambulatory recordings at home were performed using a wrist worn device (bi axial digital accelerometer - ADXL 202, microcontroller - ATMEGA 64L, memory cards - 3 x 8 Mbits and Li-ion battery). The general design of acceleration capture and processing was based on the schema theory of movement, allowing single sensor use, as the structure of movement is considered to be independent of the placement of the sensor on the body.

During the study, patients self-assessed their motor symptoms (tremor, bradykinesia, dyskinesia) every 30 min, using a four grades severity scale. The main clinical symptom was identified as the symptom the most often quoted on 48 h diaries, and was compared to the amount of each symptom calculated on accelerometric recordings (root mean square).

RESULTS
From the data obtained, 17 series were complete. In these, 14 (82 %) were in coherence, considering patient’s self evaluation and accelerometric recordings. Quality of accelerometric data processing further allowed to display time variation of motor symptoms in PD and to compare with estimated pharmacokinetics of dopaminergic medications (figure).

DISCUSSION AND CONCLUSION
This study underlines how referring to a physiological model of movement may facilitate ambulatory identification of motor symptoms in PD [3]. Further developments should focus on data collection for drug therapy optimization.

REFERENCES

SESSION 16

DEVICE DEVELOPMENT
NOVEL DEVICES & SENSORS 2

016.1 THE EFFECT OF SELF-DETERMINATION ON THE ASSOCIATION OF PHYSICAL ACTIVITY AND MOOD

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INTRODUCTION
Several studies show that physical activity positively affects mood. Potential moderators of that association have hardly been analyzed so far. This study aims at closing this gap by using an ambulatory assessment of mood and physical activity in every day life, and linking it with the construct of self-concordance [1]. Our hypothesis is that mood is affected by an interaction between self-concordance and physical activity. The more physical activity is self-determined, the greater mood will be positively affected.

METHODS
44 undergraduate students (Age: M = 26.2; SD = 3.2) participated in the study. Physical activity was measured continuously using 3-way accelerometer for 24 hours. Ratings of mood and self-concordance were assessed via electronic diaries. A palmtop prompted subjects randomly every 45 minutes during a 16 hour daytime period. A 6-item mood scale [2] was used to measure mood. The instrument’s subscales valence, energetic arousal and calmness are optimized for assessing mood in every day life repeatedly. Self-concordance was assessed with four questions [3]. In order to analyze lagged within subject relations of physical activity and mood, we aggregated the preceding 10 minutes of physical activity before each palm-assessment. Within-person effects were analyzed with hierarchical modeling (HLM6.0).

RESULTS
Physical activity positively affects valence (t(43) = 2.0, p = .04, r = .18) and energetic arousal (t(43) = 5.6, p < .001; r = .38) and negatively affects calmness (t(43) = -2.5, p = .02; r = .21). The impact of self-concordance was significant and positive for valence (t(43) = 4.0, p < .001; r = .35) and calmness (t(43) = 6.4, p < .001; r = .48). The assumed interaction between physical activity and self-concordance is significant for energetic arousal (t(43) = -2.31, p = .03; r = .16) and calmness (t(43) = 2.6, p = .01; r = .18), not for valence (p = .817).

DISCUSSION AND CONCLUSION
Physical activity did show a positive effect on different mood states. Hence, the more our subjects are physically active, the more they feel good and full of energy. Surprisingly, they feel agitated and tense, too. As expected, higher levels of self-concordance lead to improved mood. The interaction shows that the more physical activity is self-determined, the more participants feel full of energy and calm (but not better and more satisfied).

REFERENCES
A CONTEXT-AWARE ADAPTIVE FEEDBACK SYSTEM FOR ACTIVITY MONITORING

op den Akker H1,2, Hermens HJ1,2, Jones VM1
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INTRODUCTION
An active lifestyle is an important factor in the prevention of deconditioning and many negative secondary effects in chronic diseases (e.g. COPD). A number of studies have been conducted with the aim of gaining insight into the daily activity patterns of these patients [1]. Current research is focussing on motivating patients to stay physically active and balancing their activity patterns by using an activity sensor combined with remote monitoring and smart, personalised feedback.

METHODS
The feedback system consists of a wireless 3D-accelerometer for measuring activity and a PDA to provide feedback to the patient. Research has demonstrated the effectiveness of feedback in terms of improving activity balance and overall activity levels in different patient populations, but the feedback mechanisms are still quite rudimentary. In the past, feedback was given at fixed times using a randomly chosen text message (e.g. “Please go for a walk.”). However we are now able to predict better timing for the messages based on the context of the patient’s environment and usage of the system [2]. We are developing a system which incorporates a self-learning, adaptive feedback component that provides the right feedback at relevant timings for the individual patient. The aim is to improve patients’ compliance to treatment and reduce obtrusiveness. The figure shows the design of the system that is currently being implemented. The Feedback Control Module polls the Feedback Learner regularly, receiving input from the IMA Calculator node and two modules providing the patient’s contextual data. It then uses a rule-based machine learning scheme described in [2] to return the best feedback message and an indication of likely compliance by the patient.

RESULTS
Using the old system, patient compliance to individual feedback messages is low (57%). Analysing the data off-line, we are able to predict the compliance to individual feedback messages on average 64% better than using a baseline method. Currently the system is undergoing testing and patient evaluations are planned [3].

DISCUSSION AND CONCLUSION
The patient evaluations are expected to determine the effectiveness of the proposed adaptive feedback system. The theoretical work done on predicting patient compliance supports our view that a self-learning system can cater to individual patient preferences and improve treatment compliance.

REFERENCES

ACCUACY OF WEARABLE ACCELEROMETERS IN DISTINGUISHING FALLS DUE TO INTERNAL VERSUS EXTERNAL PERTURBATIONS

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INTRODUCTION
Falls are the number one cause of unintentional injury among older adults. Recently, there has been a rapid growth in research on wearable sensor systems to automatically detect falls, and alert care providers about these events [1, 2]. However, the application of wearable sensors may extend beyond fall detection, to providing information on the mechanisms (causes and activities) associated with falls, to guide strategies for fall prevention and risk assessment. In the current study, we examined whether the number and location of accelerometers influences the accuracy of data classification scheme in distinguishing between falls due to “external” and “internal” perturbations.

METHODS
12 healthy individuals, ranging in age from 20 to 35 years, participated in experimental trials involving falls onto a firm mattress. For external perturbations, the participants were subjected to slips (n=6) and trips (n=6). For internal perturbations, five different falling scenarios were randomly presented: fainting (n=3), and imbalance following reaching (n=3), turning (n=3), sitting down (n=3), and rising (n=3). In each trial, we acquired acceleration data from triaxial accelerometers mounted at the sternum, waist, and feet at 120 Hz. The means and variances of the X, Y and Z accelerations from each sensor, calculated over a 1500 ms time interval prior to impact, were input to a linear discriminant analysis (LDA) model for fall type classification.

RESULTS
A system consisting of four accelerometers (at the sternum, waist and feet) was at least 94% sensitive in distinguishing between slips, trips, and falls due to imbalance during reaching and turning (Table 1). However, this system was considerably less sensitive (and no better than a single sensor at the sternum) in classifying falls due to faints (39%), and imbalance while sitting down (81%) and rising (72%).

Table 1. Sensitivity of 3D accelerometer arrays in distinguishing classes of falls.

<table>
<thead>
<tr>
<th>Accelerometer combination</th>
<th>External events</th>
<th>Internal events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity (percent)</td>
<td>Sensitivity (percent)</td>
</tr>
<tr>
<td>Sternum</td>
<td>64</td>
<td>30</td>
</tr>
<tr>
<td>Waist</td>
<td>67</td>
<td>89</td>
</tr>
<tr>
<td>L.Foot + R.Foot</td>
<td>55</td>
<td>41</td>
</tr>
<tr>
<td>L.Foot + R.Foot + Sternum</td>
<td>61</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.Foot + R.Foot + Waist</td>
<td>49</td>
<td>78</td>
</tr>
<tr>
<td>L.Foot + R.Foot + Waist + Sternum</td>
<td>72</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>94</td>
<td>94</td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSION
We showed that an LDA data classification routine, based on data from accelerometers at the feet, waist and sternum, was at least 94% sensitive in distinguishing between slips, trips, and falls due to imbalance while sitting down (81%) and rising (72%).

REFERENCES
METHOD TO COMPARE NEW AND TRADITIONAL ACCELEROMETRY DATA IN PHYSICAL ACTIVITY MONITORING

van Hees, VT; Brychta, RJ; Pias, M; Taherian, S; Catt, M; Ekelund, U; Chen, KY; Brage, S

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3Computer Laboratory, University of Cambridge, Cambridge, UK
4Institute for Ageing & Health, Newcastle University, Newcastle, UK

INTRODUCTION
The accelerometer devices as traditionally used in the epidemiological field for physical activity monitoring (e.g. Actigraph, Actical, and RT3) provide manufacturer-dependent output values called counts that are computed by obscure signal processing techniques. The lack of transparency poses a challenge for comparison of historical accelerometer data in counts with data collected using raw accelerometry in S.I. units – m/s². The purpose of this study was to develop a method that facilitates the compatibility through conversion of raw accelerometer data into Actigraph counts. Our initial attempt has been described elsewhere [1], the current work represents an update on progress.

METHODS
The basics of the conversion algorithm were captured from the technical specifications of the Actigraph GT3X and GT1M. Fine-tuning of the algorithm was achieved empirically under controlled conditions using a mechanical shaker device. Five Actigraph GT3X devices and tri-axial raw accelerometers (GENEA, Unilever Discover, UK) were tested at twenty-three frequencies and three radius settings. Next, eighteen participants (aged: 23 – 58yr, BMI: 23.4 ± 2.6 kg m⁻², sex: 9♂/9♀) wore both devices tightly taped together on each hip for 48 hrs in their daily life.

RESULTS
Under mechanical shaker conditions, a second order Butterworth frequency filter with \(\omega_0 = 0.35 - 1.80\) Hz applied to the raw acceleration was found to result in the best correlation between devices. An interaction was observed between magnitude of acceleration \(Acc\) and filter response (see figure). This was addressed by deriving two prediction equations to predict counts sec⁻¹: \(Acc (g) x 465.41 - 10.41\) for \(Acc < 0.467g\) and \(Acc (g) x 512.14 - 32.20\) for \(Acc > 0.467g\). In free-living conditions, the metric explained 98% variation in mean AG counts between participants (85% excl. zero counts) with mean bias 14.0 cnts min⁻¹ (t = -3.0, p < .01). Accuracy \([\text{Estimate} - \text{True}] / \text{True}\) of time spent in the various intensity levels based on 5sec epochs was -3.7%, 23.6%, 5.4%, and 2.8%, respectively, for sedentary, low, moderate, and vigorous physical activity (thresholds: 100, 2000, and 4000 cnts min⁻¹).

DISCUSSION AND CONCLUSION
Perfect conversion was not achieved. Results indicate that a more complex algorithm is required that models the apparent interaction between magnitude of acceleration and filter response.

REFERENCES
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#### Device Development

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1 Northern Illinois University, DeKalb, USA; 2 Auckland University of Technology, Auckland, New Zealand; 3 Minnesota State University, Mankato, USA. |
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1 Department of Circulation and Medical Imaging; 2 Department of Cancer Research and Molecular Medicine; 3 Department of Neuroscience, Norwegian University of Science and Technology & St. Olav University Hospital, Trondheim, Norway. |
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¹Shriners Hospitals for Children Northern California, Sacramento, CA, USA
²Department of Electrical & Electronic Engineering, California State University, Sacramento, CA USA

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¹Sylvia Lawry Centre - The Human Motion Institute, Munich, Germany; ²Lith Lion GmbH, Munich, Germany; ³Spinor GmbH, Munich, Germany; ⁴Trium Analysis Online GmbH, Munich, Germany

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¹Department of Veterinary Clinical Sciences, The Royal Veterinary College, University of London

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¹Dept. of Physiotherapy, University of Limerick, Limerick, Ireland; ²Dept. of Rheumatology, Mid-Western Regional Hospital, Limerick, Ireland; ³Digital Health Group, Intel Ireland, Leixlip, Ireland

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Vanheist J¹,², Béghin L¹,², Bergman P¹, Sjöström M¹, Gottrand F¹
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¹Physical Therapy Dept, Clarkson University, Potsdam, USA; ²Electrical and Computer Engineering Dept, University of Alabama, USA

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¹Department of Electrical and Computer Engineering, the University of Alabama, Tuscaloosa, AL, USA; ²Department of Health and Exercise Science, Colorado State University, Fort Collins, CO, USA

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¹Institute for Experimental Musculoskeletal Medicine; ²Department for General and Tumor Orthopaedics, University Hospital, Münster, Germany

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¹MIRA Institute, University of Twente, Enschede, The Netherlands; ²Roessingh Research and Development, Enschede, The Netherlands

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¹Roessingh Research and Development, Enschede, The Netherlands; ²Faculty of Electrical Engineering, Mathematics & Informatics, University of Twente, Enschede, the Netherlands

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¹Centre for Musculoskeletal Research, University of Göteborg, Sweden

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¹Centre Hospitalo-Universitaire de Saint Etienne, France; ²Laboratoire de Physiologie de l’Exercice, Université de Lyon-Saint Etienne, France; ³CEA, LETI, MINATEC, Grenoble, France
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Hague, The Netherlands; 3Robert-Bosch-Hospital, Stuttgart, Germany; 4Centre
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1Department of Sport and Exercise Sciences, Northumbria University, Newcastle
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Maastricht University, Maastricht, The Netherlands

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Staudenmayer J, Lyden K, Freedson PS
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**P1-01** VIDEO RECORDING ERROR QUANTIFICATION (OR WHAT ERROR CAN YOU LIVE WITH?)

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**INTRODUCTION**

The purpose of this study was to quantify measurement errors due to camera placement while recording across a 10.5 meter walkway. Errors associated with a) panning and b) camera positioning were assessed every 2m with camera to wall distances of 2 (CW1) to 20m (CW10).

**METHODS**

A “gaitway” was set up with each 0.5 meter carefully marked with tape crossing a horizontal line on the wall. The middle 0.5m space was considered the goal (G) linear scale.

The numbers are distances (meters) the marker is distal to G. The video camera was positioned on a line perpendicular to the wall set back from the middle of the goal area (shown ). Video data were analyzed using Dartfish software with G width used as the linear scale (G=0.5 m) to convert measured video distances to meters. Example: If the G width is scaled, then any two points (e.g. the 3 and 4 marks) are identified and 3 to 4 distance is calculated in meters. If the 3 to 4 calculated distance is 1.0 there is no error, however if it is 0.95 this indicates a 5% error. a) Panning error. The camera was placed 2m back from the G area (CW1), with a focal length allowing a 2 meter view spanning the G area. The camera was then panned in each direction until the 5m markers were seen. This was repeated at each CW position. Each successive 0.5m distance was then calculated from the video; b) 3.5m accuracy. At each CW position the focal length was set to view only the middle 3.5m distance and all visible 0.5m distances were calculated.

**RESULTS**

a) No camera position allowed panning with < 5% error across the gaitway. At CW1 all measurements had <10% error; however with closer CW and wider panning angle the error increased in a systematic way. b) CW10 enabled the full 3.5m distance to be accurately measured but closer CW distances introduced error for the more distant positions (CW15), or the widest view was too narrow to see the full 3.5m width (CW20).

**DISCUSSION AND CONCLUSION**

Gaitway measurement errors are minimized if the camera is placed far back from the walkway, the focal length is as long as possible, and there is no panning. The greatest sources of error are found from close up when panning, and when measuring distances that are wide of the viewing center.  

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**P1-02** A NOVEL METHOD TO PREDICT ACTIVITY TYPE AND INTENSITY USING A MULTI-SENSOR DEVICE

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**INTRODUCTION**

The Integrated Measurement System (IMS) is a novel physical activity (PA) monitor that integrates measures of movement and ventilation. It has hip and wrist acceleration sensors and piezoelectric sensors to estimate abdominal (AB) and rib cage (RC) expansion. The development of this device was funded through the Exposure Biology Program in the NIH Genes, Environment and Health Initiative. The purpose of this study was to calibrate the IMS to predict PA type and intensity category from the combination of accelerometer and ventilation signals from the IMS.

**METHODS**

Fifty participants (32.6±9.9 yr) performed one of two routines consisting of 7 activities each (sedentary, locomotion, and lifestyle) while wearing a portable metabolic system (criterion) and the IMS. Triaxial accelerometer data (milliG) from the hip and wrist, and estimated breathing frequency (EBF) obtained using the AB and RC piezoelectric sensors were used to develop three models to predict PA type and PA intensity category. The models were developed using Support Vector Machines (SVM) with different input features: 1) M1 – mean and SD of hip acceleration from each axis (x, y, and z); 2) M2 – mean and SD of hip acceleration from each axis and EBF; 3) M3 – mean and SD of hip and wrist acceleration from each axis, and EBF. Model validity was tested using ‘leave-one-out’ cross-validation.

**RESULTS**

The accuracy (mean ± SD) of M1, M2, and M3 in classifying activity intensity as sedentary, light, and moderate vigorous, was 60 ± 19%, 66 ± 16% and 74 ± 13%, respectively. Similarly, M3 produced the best results in recognizing activity type with an overall accuracy of 71 ± 15% compared to 67 ± 14% and 63 ± 19%, from M2 and M1, respectively. When examining the accuracy of M3 to identify individual activities, a recognition probability of 80% or greater (range: 80.6 – 93.2%) was achieved for 6 activities. However, the model performed poorly for 3 activities where recognition probabilities were lower than 50% (range: 47.6 – 49.0%).

**DISCUSSION AND CONCLUSION**

The multi-sensor IMS yields reasonably accurate predictions of PA intensity category and activity type. Our findings suggest that multi-sensor monitors like the IMS may produce more accurate predictions of activity type and intensity compared to devices that only contain hip acceleration sensors. Our next goal is to reduce participant burden and improve IMS feasibility by developing prediction models that only use the AB respiration sensor belt to estimate breathing frequency.

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**P1-03** DAY TO DAY VARIABILITY IN PHYSICAL ACTIVITY

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**INTRODUCTION**

Objective measurement of physical activity (PA) is highly warranted. Body worn accelerometers, like the single axis accelerometer ActivPAL, are suitable for monitoring physical activity (PA) over days. ActivPAL has been found to be a reliable and valid measure of positions, transitions and walking in healthy adults [1]. The aim of this study was to determine the number of days of ActivPAL-monitored needed to obtain reliable measurements of PA over a week in cancer patients with different diagnoses referred to comprehensive inpatient rehabilitation.

**METHODS**

Cancer patients aged 18-67 years with Karnofsky performance status ≥70 (able to manage personal care) were eligible for inclusion. The ActivPAL professional PA monitor version 5.6.3.3 was used to measure PA during 24 hours over 7 days before arrival to the rehabilitation stay. Three outcomes from the ActivPAL were used; energy consumption [Metabolic Equivalent of Task (METs)], number of steps, and time in upright position (time during standing and stepping). Data were summarised in 24 hours periods. Intraclass correlation coefficient (ICC 1,1) was used to assess agreement of measurements between days. Acceptable reliability was set to ICC of ≥0.80 on all three outcomes [2].

**RESULTS**

Twenty three patients with mean age of 54 years, 78% females and 57% with breast cancer were included. Mean (SD) of outcomes of the ActivPAL were; METs per day; 33.7 (1.1), number of steps; 7720 (2753), time in upright; 5.9 (1.3) hours per day. For all three outcomes the trend was an underestimation of weekend days and a modest overestimation of weekdays and the weekend. ICC ≥0.80 on all three outcomes [2].

**DISCUSSION**

This study examined how many days of ActivPAL-monitoring were necessary to achieve reliable and valid estimates of seven days with registration. The more days of ActivPAL-monitoring the more reliable estimates were obtained. The analysis showed that to achieve an ICC of ≥0.80 on all three mean outcomes of ActivPAL, 3 or more days (week-end days excluded) were necessary.
CONCLUSION

3 or more days (weekend days excluded) were claimable to achieve acceptable reliability on all three outcomes when using ActivPAL data in monitoring PA in patients with different cancer diagnoses referred to a cancer-rehabilitation program.

REFERENCES


A METHOD TO DETERMINE VALIDITY AND RELIABILITY OF ACTIVITY SENSORS

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INTRODUCTION

Accelerometry-based activity sensors are nowadays widely deployed in ambulatory monitoring of physical activity. Field experiments are characterized by very little control over usage of the sensor [1]. A malfunctioning sensor, giving output within the range of normal physical activity, will not be noticed based on just the sensor output. A quick and reliable calibration procedure is required [2], focused on determining the relation between that accelerometer output and physical activity across a range of activity levels. The purpose of this study was to design an easy spot-check to monitor the validity and reliability of activity sensors.

METHODS

In this study, four sensors were securely fastened to a mechanical oscillator (Vibration Exciter, type 4809, Bruel & Kjær) and moved at various frequencies (6.67Hz; 13.45Hz; 19.88Hz) within the range of human physical activity. For each of the three sensor axes, the sensors were simultaneously moved for five minutes per defined frequency. The acceleration of each movement was expressed by its RMS value (RMSinput). Raw sensor output (sample frequency 200 Hz) was converted to IMA values per minute (counts per minute, in units of gravitational force (g), according to Bouten et al. (1997) [3]. Linear regression analysis was used to examine the relationship between the RMS and IMA. Factors taken into account were the four sensors and the three axes. The device tested in this study was the ProMove2 (Inertia Technology), containing the 3D MEMS inertial sensor (type: LIS3LV02DL, ST Microsystems).

RESULTS

The RMS output of the sensors was within 6% of the RMSinput at each frequency, indicating a high accuracy of the sensors. There were no significant differences between the sensors in IMA values. Small differences (<2%) were found in IMA values at the different axes, but these differences were not significant when added to the regression model. The resulting regression model is: IMA [g] = 3.9 + 25.8*RMS [ms^-2] (R²=0.998), indicating that only RMSinput is significant for the output of the sensors.

DISCUSSION AND CONCLUSION

The developed method provides an easy to perform procedure to test an individual activity sensor as well as to determine the inter-variability of a set of activity sensors. This is especially useful when multiple sensors are used in a field experiment. The tested activity sensors showed to be reliable in the frequency range of human movement with negligible inter-sensor variability, and are therefore feasible for use in field trials.

REFERENCES


The accelerometers were set to record acceleration at 1-s epochs. Six accelerometers were tested 3 times at 3 different frequencies: 3 Hz, 2 Hz and 1 Hz. Each test lasted 5 minutes. To test for validity 3 accelerometers of each model were tested simultaneously at each frequency.

Data were imported to SPSS (version 17.0) for analysis. To determine the intra-unit variability the standard error of measurement (SEM) and the coefficient of variation (CV) were calculated. To determine the inter-unit variability a intraclass correlation coefficient (ICC) was calculated. Pearson’s correlation and the mean difference with 95% limits of agreement (LOA) were calculated to determine the concurrent validity between models.

RESULTS
The mean intra-instrument CV for the GT1M was 0.66% while the MTI was 8.28%. The mean SEM for the GT1M was 0.82 and 2.42 for the MTI. The ICC for the GT1M was 0.91 while the MTI was 0.98. Pearson’s correlation was 0.84 (p<0.01) and the mean difference between models was 3.19 counts per second (cps) (95% LOA : 0.16-6.22 cps).

DISCUSSION AND CONCLUSION
The results suggest that both models had high inter-unit reliability with an ICC value >0.8 [2]. The CV and SEM of the MTI accelerometer were larger than the GT1M suggesting it had lower intra-unit reliability. While there was a significant correlation between accelerometer models, there was a mean difference of 3.19 cps. This difference of 191.4 counts per minute may not be biologically meaningful when considering applying cut-points to data i.e. 3,200 counts per minute for moderate to vigorous activity in children [3].

REFERENCES

P1-07 ACCURACY AND RELIABILITY OF VARIOUS AMBULATORY DEVICES IN ESTIMATING ENERGY EXPENDITURE
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INTRODUCTION
The ability to accurately estimate energy expenditure in a free living setting is important in further understanding the role of physical activity in various settings. Numerous devices are commercially available and are designed to measure energy expenditure. However the accuracy of these measurements is, in most cases, not known. The aim of this study was to determine the accuracy and validity of the Actheart (combined accelerometer and heart rate monitor), the Kitt Armband and the Yamax pedometer while measuring energy expenditure in a laboratory setting having indirect calorimetry as the gold standard measurement.

METHODS
Lab-based energy expenditure was measured in 35 young, healthy adults (21 men, 24.11 ± 1.82 years and 14 women, 24.31±3.30 years) during 5-minute bouts of different activities. We focused our attention on a standard activity–walking (at 3mph and 4mph). We also considered some activities that are energetically demanding and performed regularly in developing nations but not perceived as “physical activity” such as water carrying tasks, the Actiheart showed mean errors of 18-38% over the range of activities while the pedometers were more inaccurate with little agreement shown, in particular during the fruit picking task.

RESULTS
Throughout the activities the mean error was lowest in measurements taken by the Armband device (4-36%) with lowest error being shown in the corn crushing and water carrying tasks, the Actiheart showed mean errors of 18-38% over the range of activities while the pedometers were more inaccurate with little agreement shown, in particular during the fruit picking task.

DISCUSSION AND CONCLUSION
The results of the study indicate the Armband is the most accurate device for the measurement of energy expenditure; the Actiheart was found to also provide acceptable measures of activity while the activity levels measured by the pedometers were very inaccurate, however, more research is needed in each device before recommendation as an ideal free-living measurement tool of energy.

P1-08 STEP LENGTH ESTIMATE IN WALKING USING A SINGLE INERTIAL MEASUREMENT UNIT
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INTRODUCTION
Step length (SL) is a key gait spatial parameter for evaluating gait asymmetry and can be estimated by double integrating the linear acceleration between contra-lateral heel strike and ipsi-lateral heel strike instances measured with inertial measurement units (IMUs). Unfortunately, the drift in the linear acceleration signals affects the resulting displacement estimation. Various studies which employed a single IMU attached to the foot have been proposed to determine the SL of the relevant limb. However, to the authors’ knowledge, no study estimated right and left SL using a single wearable IMU. The aim of this preliminary study was to estimate SL during walking using a single IMU attached to the waist and advanced integration techniques for drift correction.

METHODS
Four healthy subjects were acquired using an IMU (FreeSense, SensoriS®) featuring a tri-axial accelerometer and gyroscope. The IMU was mounted on the right side of the body at the waist level. Acquisitions were sampled at 100 Hz. Two different datasets were acquired. Dataset A: subjects were walked along a closed loop track of 25 m varying their speed for 11 times. For validation purposes, trajectories of two markers, placed on each shoe, were recorded using a BTS® SMART-D statophotogrammetric system. Dataset B: subjects were asked to walk straight for 75 m and to increase their speed every 25 m. Heel strike and toe off events were estimated using a wavelet based technique. To obtain linear velocity time series along the direction of progression $v_y(t)$, two different integration techniques were used: Optimally Filtered Integration (OFI) and Optimally Filtered Direct and Reverse Integration (OFDRI) [2]. The OFDRI can be applied only when both initial and final values of the integral are known. Given an arbitrary gait cycle $j$, let be $v_i(t_j)$ the velocity at the initial heel strike which is supposed to be known. The velocity at the final heel strike $v_f(t_F)$ is first computed by integrating the acceleration $a_y (t)$ in the direction of progression using the OFI. Then, if the $v_i(t_F)$, $v_f(t_F)$ is lower than a selected threshold, the OFDRI technique is used to compute $v_f(t_F)$ otherwise $v_f(t_F)$ is estimated using OFI and $v_f(t_F)=v_i(t_F)$. SL values were computed by integrating $v_y(t)$ using the OFI technique.

RESULTS
Table A – Mean differences and standard deviations between SL values estimated with the IMU and with statophotogrammetric system. Dataset B – Differences between the actual displacement (75 m) and the estimates (Table 1).

DISCUSSION AND CONCLUSION
The proposed method allowed for estimating SL values during gait, for both right and left sides, using a single IMU with errors about 4% on average. Due to the asymmetric location of the IMU, the SL values were consistently underestimated for the right side and overestimated for the left side. However, the errors affecting the total displacement, which is calculated as the sum of left and right SL (Dataset B, resulted, on average, lower than 1% of the total distance.

REFERENCES
**P1-09 GLOBAL POSITIONING SYSTEM (GPS) TO LOCATE PHYSICAL ACTIVITY OF INDIVIDUALS**

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**INTRODUCTION**

Recently the relationship between the built environment and physical activity has become a promising topic. Therefore, the information where people are physically active is of major interest. Instead of using questionnaires to collect information about the environment of physically active people the global positioning system (GPS) identifies where individuals are located at any point in time. GPS data provide a variety of physical activity parameters such as position, distance, speed and time.

The aim of the study was to examine the use of GPS in terms of accuracy and applicability in order to locate people’s physical activity for transport in urban areas.

**METHODS**

The study took place in Graz, Austria. Seventy voluntary participants (Age: 16-60) were asked to wear a GPS device for four days. The small GPS-data logger (WBT-202) had limited external functions to provide simple handling. Participants were informed about the usage of the GPS personally and in addition, they got a study-folder with important advices to remember. In order to get information about the mode of transport people were asked to complete a structured activity diary. The amount of data loss was checked manually by comparing the activity diary (reference) with the GPS recordings using the geographic information system (GIS) ArcMap 9.2.

**RESULTS**

The results of the ongoing data analysis consist of a sub-sample of 40 participants, i.e. 161 study days collected with GPS. A data loss of ten percent was calculated. Most of the missing GPS data occurred because participants forgot to wear the device. Some data loss was during the initialization period of GPS when leaving a building. We had no problems with signal drop outs but accuracy was worse close to tall buildings and under dense vegetation. Only one person felt uncomfortable with wearing the device.

**DISCUSSION AND CONCLUSION**

GPS seems to be a promising method to improve our knowledge about the locations where individuals are physically active in urban areas. Due to detailed information we provided the study participants about the properties of the GPS system and the use of up-to-date GPS-devices the data loss was very small. In comparable studies applying GPS in daily life during four days at least 30% of data loss was reported [1]. Additional benefit for measuring PA behaviour with GPS is the combination with digital maps in GIS to study the relationship between environmental parameters and PA.

**REFERENCES**


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**P1-10 VALIDITY OF THE ACTIHEART ACTIVITY MONITOR FOR ACTIVITY ENERGY EXPENDITURE MEASUREMENT IN PATIENTS WITH COPD**

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**INTRODUCTION**

Assessment of physical activity energy expenditure (PAEE) outside the standardised laboratory is complex. Thompson et al.1 showed that motion sensors do not provide valid information about the environment of physically active people the global positioning system (GPS) identifies where individuals are located at any point in time. GPS data provide a variety of physical activity parameters such as position, distance, speed and time.

**METHODS**

27 patients with COPD (FEV1/FVC <70%, age 58 ± 7 years) were selected for the study. Patients were asked to perform five simulated Activities of Daily Living (ADL) (Walking, Watering plants, Walking with a load, Stocking laundry and Cycling) for 8 minutes each. Two patients with a clearly visible Duchenne limp and one patient without a Duchenne limp participated in a study aiming to evaluate accuracy. Triaxial accelerations and angular velocities of the upper thorax and pelvis were measured with 2 BFS units, attached on the upper thorax and between the Posterior Superior Iliac Spines of the pelvis. Angular movements of sensors attached to thorax and pelvis were compared with results based on an optical motion analysis system (OMAS). Range of motion (ROM) of the thoracic and pelvic segments was determined by subtracting the maximum and minimum angle of the segments. Per patient, the mean (D) and standard deviation (SD) of differences between the ROM of pelvis and thorax obtained by the BFS system and those obtained by OMAS were calculated.

To evaluate reproducibility, 15 patients performed the BFS-based gait assessment twice. ROM of the pelvis and thorax, walking speed, step length and step duration were measured. Test-retest reliability was determined with Intraclass Correlation Coefficients (ICCs). Reproducibility was assessed by calculating the mean difference between test and retest sessions with a 95% confidence interval (CI).

**RESULTS**

PAEE measured with Cosmed was in a very small range (13.3 vs 16.3 kJ/min) and most activities did not differ significantly from each other in energy expenditure. Using the algorithms valid in healthy subjects, the Actiheart was not able to correctly estimate PAEE in the individual tasks (p < 0.001) and the protocol as a whole (p < 0.001).

**DISCUSSION**

Actiheart was not able to calculate PAEE in patients with COPD using the algorithms validated for healthy adults. The HR-range (HR max symptom limited – HRrest) in which patients performed their activities was very small. Therefore, the PAEE range was also small. COPD patients are symptom limited due to shortness of breath and the use of medication (e.g. beta blockers). As a result, all activities were performed at an intensity between Flex- and Transition heart rate. This may limit the use of branched algorithms in COPD.

**REFERENCES**


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**P1-11 ACCURACY AND REPRODUCIBILITY OF A BODY-FIXED-SENSOR BASED ASSESSMENT OF COMPENSATORY TRUNK MOVEMENTS AND SPATIOTEMPORAL GAIT PARAMETERS IN PATIENTS WITH HIP OSTEARTHRITIS**

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**INTRODUCTION**

Compensatory trunk movements during gait such as a Duchenne limp are observed frequently in patients with hip osteoarthritis (OA), yet angular trunk movements are seldom included in clinical gait assessments. This study examined accuracy and reproducibility of a body-fixed-sensor (BFS) based gait assessment for quantifying spatiotemporal gait parameters and frontal plane angular movements of the upper thorax and pelvis at different walking speeds of patients with hip osteoarthritis (OA).

**METHODS**

Two patients with a clearly visible Duchenne limp and one patient without a Duchenne limp participated in a study aiming to evaluate accuracy. Triaxial accelerations and angular velocities of the upper thorax and pelvis were measured with 2 BFS units, attached on the upper thorax and between the Posterior Superior Iliac Spines of the pelvis. Angular movements of sensors attached to thorax and pelvis were compared with results based on an optical motion analysis system (OMAS). Range of motion (ROM) of the thoracic and pelvic segments was determined by subtracting the maximum and minimum angle of the segments. Per patient, the mean (D) and standard deviation (SD) of differences between the ROM of pelvis and thorax obtained by the BFS system and those obtained by OMAS were calculated.

To evaluate reproducibility, 15 patients performed the BFS-based gait assessment twice. ROM of the pelvis and thorax, walking speed, step length and step duration were measured. Test-retest reliability was determined with Intraclass Correlation Coefficients (ICCs). Reproducibility was assessed by calculating the mean difference between test and retest sessions with a 95% confidence interval (CI).

**RESULTS**

Accuracy was high, with small D (0.07°) and SD (0.13°) between OMAS and BFS data. Test-retest reliability was high (ICCs ranged from 0.77 to 0.97) and the mean differences of all test parts between the test and retest sessions were small with the 95% CI containing zero, indicating good reproducibility.

**DISCUSSION AND CONCLUSION**

This BFS-based gait assessment is an accurate and reproducible method for quantifying compensatory trunk movements and gait parameters in patients with hip OA. Because of the use of BFS units, this gait analysis protocol is not confined to a laboratory setting and there is little to no interference with gait. This makes the
gait analysis protocol highly applicable in real-life (non-laboratory) settings such as hospitals for monitoring changes in gait performance due to (surgical) interventions in patients with hip OA.

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**P1-12** THE RELATIONSHIP BETWEEN THE RAW ACCELERATION SIGNAL FROM A COMMERCIALLY AVAILABLE ACCELEROMETER AND GROUND REACTION FORCE

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**INTRODUCTION**

Accelerometers are increasingly employed to assess relationships between physical activity and health. Output is in proprietary counts, hindering between model comparisons, and translated into time spent at activity intensities based on energy expenditure [1]. Bone mineral density (BMD) is improved by mechanical overload. Thus, in order to use accelerometers to assess activity beneficial to bone, accelerometer output needs to be calibrated against mechanical loading, e.g. ground reaction force (GRF). The purpose of this study was to examine the relationship between the raw acceleration signal (vertical and resultant over three axes) from a new commercially available accelerometer and mechanical loading.

**METHODS**

Ten participants (age: 29.4±8.2 y; mass: 74.3±10.3 kg) wore a triaxial GENEA accelerometer (80 Hz, ActiWear Ltd, UK) on the hip. A force plate set flush within the floor (960 Hz, Advanced Mechanical Technology Inc., Massachusetts) was used to collect GRF data. Each participant performed eight trials of slow walking, brisk walking, jogging and running with GRF data collected for one step per trial. Low jumps and higher jumps (one per second) were each performed for 20 s on the force plate. Finally participants dropped from a 20 cm high box onto the force plate eight times. Force plate and accelerometer data were analysed for one step from each trial and eight jumps of each type with the mean of eight steps/jumps used for all analyses.

**RESULTS**

Mean vertical accelerations (g, acceleration of gravity (1g) subtracted) measured by the GENEA for each activity (slow walking: 0.76±0.20; brisk walking 1.34±0.39; jogging 4.69±0.72; fast running 4.76±0.69; low jumps 3.45±1.06; high jumps 4.32±1.01; box jumps 4.01±0.79) compared well to previous research [2]. Resultant and vertical accelerations correlated similarly with force plate outputs. Peak accelerations were positively correlated with resultant force (r>0.74, p<0.01), peak active force (r>0.65, p<0.01) and peak impact force (r>0.58, p<0.01). Slopes from the acceleration curves were positively correlated with loading rates (peak loading rate and peak slope: r>0.55, p<0.01; average loading rate and average slope r>0.68, p<0.01).

**DISCUSSION AND CONCLUSION**

The acceleration level of activities and slope of the acceleration curve, as measured by the GENEA, are related to GRF. This data can be used to identify acceleration thresholds that relate to levels of loading beneficial to bone.

The GENEA is a small, commercially available accelerometer that provides raw acceleration data. Accelerations associated with physical activity reflect mechanical loading and appear promising for assessment of activity beneficial to bone.

**REFERENCES**


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**P1-13** RELIABILITY OF ACCELEROMETER-BASED SIT-TO-STAND ASSESSMENT IN GERIATRIC INPATIENTS

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**INTRODUCTION**

Accelerometer-based body fixed sensors are increasingly used to assess mobility function such as sit-to-stand (STS) movement. Analysis of the kinematics of the trunk during STS allows documentation of relevant phases of task execution [1]. However, reliability of accelerometer-based STS assessment has not been yet tested in geriatric inpatients. The aim of the present study was to obtain the test-retest reliability of STS assessment by an accelerometer (DynaPort®) in geriatric inpatients.

**METHODS**

Forty geriatric inpatients were consecutively recruited during ward rehabilitation. Two sets of 4 repeated STS movements at self-selected speed were performed. The DynaPort® was fixed around the patients' waist by a belt. To adjust for real life conditions the DynaPort® was detached and reattached between the first and second set either by the same or different investigator (randomized allocation). The patients were seated on a armless adjustable chair, seat placed at knee height, arms folded across chest, feet placed 10 cm apart at the heels and shanks positioned at a 10-degree angle relative to the vertical. Participants stood up, maintained the standing position (4 sec), sat down and remained seated (4 sec). Parameters (average of 4 STS cycles) for total duration and duration and maximum angular velocity of flexion/extension were extracted for the sit-stand and stand-sit phase by a specific algorithm [1]. Test-retest reliability of the total sample and of subgroups (intra vs. inter-observer reliability) was calculated by using intra-class correlation coefficients (ICC).

**RESULTS**

Forty geriatric inpatients (mean age 84.0 years) with moderate cognitive impairment (Mini-Mental, mean score: 23.5) and functional limitations (Short-Physical-Performance-Batt., mean score: 5.5) were included in the study. No differences in baseline characteristics were obtained between the intra- and inter-observer group (p>0.37-0.815). Good (>0.7) to excellent reliability (>0.9) of STS parameter had been obtained for the total sample (except flexion duration). A higher number of excellent ICC values was found in the intra-observer group (50%) compared to the inter-observer group (10%). Higher ICCs were found for velocity than for duration.

**Table 1. Intraclass correlation coefficients (ICC) between test- and retest for the total group and subgroups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total group (n=40)</th>
<th>Intra-observer (n=21)</th>
<th>Inter-observer (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit-stand:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total_duration (sec)</td>
<td>.750</td>
<td>.703</td>
<td>.834</td>
</tr>
<tr>
<td>Flex_duration (sec)</td>
<td>.543</td>
<td>.468</td>
<td>.884</td>
</tr>
<tr>
<td>Flex_Max_AngVel (deg/sec)</td>
<td>.895</td>
<td>.947</td>
<td>.824</td>
</tr>
<tr>
<td>Ext_duration (sec)</td>
<td>.816</td>
<td>.848</td>
<td>.740</td>
</tr>
<tr>
<td>Ext_Max_AngVel (deg/sec)</td>
<td>.895</td>
<td>.951</td>
<td>.787</td>
</tr>
</tbody>
</table>

**DISCUSSION AND CONCLUSION**

Test-retest reliability of accelerometer-based sit-to-stand assessment in geriatric inpatients is good to excellent for the majority (90%) of parameters extracted. Highest reliability was found for angular velocity parameters when assessed by the same investigator (intra-observer). Reliability of parameters related to duration of movement phases has to be improved by further research.

**REFERENCES**

**P1-14** EFFECTIVENESS OF ACCELEROMETERS FOR EVALUATING UPPER LIMB INVOLVEMENT DURING GAIT

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**INTRODUCTION**
Traditional approaches to obtaining measures of performance in the home include human observation, cameras, logs, and wearable sensing. Uswatte et al. were able to show that accelerometry can be used to give a measure of relative arm use in individuals post-stroke [1]. Here, we evaluate the effectiveness of accelerometers in determining the type of limb use during gait.

**METHODS**
One non–disabled individual performed a battery of prescribed tasks while wearing 3-axis accelerometers (Personal Activity Monitor, Gulf Coast Concepts) on both wrists at the University of Southern California Center for Health Professionals laboratory. The participant walked 30m under 4 conditions: comfortable walking speed (C1), high speed (C2), comfortable speed with the right arm held to the chest (C3), and comfortable speed with the right arm held to the side (C4). We computed the Euclidean norm of the acceleration signals. We then performed spectral analyses of the norms for each of the four conditions, and computed the power in various frequency bands.

**RESULTS**
In conditions without arm restriction (C1 and C2), there are two fundamental frequency peaks (at 1 and 2Hz) (Figure 1a). In conditions with the right arm is restricted (C3 and C4), there is only one peak, at 2Hz (Figure 1b). To quantify the difference between unrestricted and restricted motions, we compute the power in the 0.1–1.3Hz and 1.3–2.6Hz frequency bands (B1 and B2) and the ratio B2/B1 (see Figure 1c). We find that, for all unrestricted limbs, the ratio of B2/B1 has $\mu=2.41$ with $\sigma=1.12$. For restricted limbs (arm held to chest or side), the ratio has $\mu=131$ with $\sigma=60.81$.

![Figure 1a: C1 power spectrum](image)

![Figure 1b: C3 power spectrum](image)

![Figure 1c: B1/B2 power ratio](image)

**DISCUSSION AND CONCLUSION**
The large difference in mean values between the unrestricted and restricted limb B1/B2 ratios implies that this ratio may be useful for distinguishing between activity due to artifacts of trunk motion, and activity due to active involvement of the limb. With larger sample sizes, we plan to establish statistically and clinically significant differences between these activity types. This will lead to tools that can be used for continuous monitoring of individuals post-stroke in the home.

**REFERENCES**

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**P1-15** STEPS PER DAY: A COMPARISON OF POPULAR ACTIVITY MONITORS

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**INTRODUCTION**
Measuring steps per day (SPD) is a practical method to evaluate physical activity (PA) in a free-living setting. Several activity monitors are available to measure SPD, however it is not known whether these devices produce similar step counts in a free-living environment. Therefore, the purpose of this study was to compare SPD recorded by three activity monitors including the ActiGraph GT3X, activPAL and Omron HJ-720-ITC.

**METHODS**
Free-living PA was monitored for 7 days in twelve moderately active subjects (age=24.5 ± 5.07 years, BMI = 23.5 ± 2.09 kg·m$^{-2}$) using the ActiGraph GT3X, activPAL (AP) and Omron Pedometer (PD). The ActiGraph was initialized two different ways, 1) using the ‘low frequency extension’ (AGL), and 2) using the ‘normal frequency’ mode (AGN). Participants wore the PD and two ActiGraph monitors on a belt around their waist and the AP was attached to the mid-thigh. Participants’ SPD from each monitor were determined at the end of the monitoring period. A linear mixed effects model was used to test for differences in SPD among monitors.

**RESULTS**
There were no significant differences in SPD recorded by the AGN and the PD. All other inter-monitor comparisons revealed significant differences in SPD.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Mean Absolute Difference (SPD)</th>
<th>Lower CI (SPD)</th>
<th>Upper CI (SPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGL vs. AGN*</td>
<td>6937</td>
<td>5620</td>
<td>8254</td>
</tr>
<tr>
<td>AGL vs. AP*</td>
<td>6140</td>
<td>4836</td>
<td>7444</td>
</tr>
<tr>
<td>AGL vs. PD*</td>
<td>6711</td>
<td>5685</td>
<td>8138</td>
</tr>
<tr>
<td>AGN vs. AP*</td>
<td>765</td>
<td>-1415</td>
<td>-114</td>
</tr>
<tr>
<td>AP vs. PD*</td>
<td>765</td>
<td>357</td>
<td>1174</td>
</tr>
<tr>
<td>AGN vs. PD</td>
<td>22</td>
<td>-411</td>
<td>454</td>
</tr>
</tbody>
</table>

*Significant difference between monitors

**DISCUSSION**
The only monitors that recorded similar SPD were the AGN and the PD. The AGL recorded much higher SPD (mean difference between 6140 and 6937) compared to all other monitors. The low frequency extension (LFE) used by the AGL monitor potentially enables the device to capture low intensity steps (e.g. shuffling) that may be characteristic of free-living activity. However, it is possible the LFE also leads to misclassification of non-ambulatory low intensity acceleration (e.g. artifacts) as steps, which would inflate the mean differences. In contrast, steps accumulated in bouts lasting less than 4 sec are not captured by the filter in the PD. Similarly, the filter in the AP does not capture steps accumulated in bouts lasting less than 10 sec. Thus, researchers should be cautious in comparing SPD across studies using different monitors. Future research should include a criterion measure to determine the validity of each monitor.

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P1-16 DETECTING TRANSFERS, STAIR ASCENT AND DESCENT AND CYCLING WITH AN ACCELEROMETER BASED ACTIVITY MONITOR

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INTRODUCTION
The assessment of activity in orthopedic patients is an important parameter to monitor improvement after treatment, especially following knee or hip arthroplasty. Previous studies have shown that resting (sitting, standing and walking) can be determined accurately in patients 1. Transfers (sit-to-stand), stair climbing and cycling are high demanding events and essential in the revalidation process. Our aim is to develop an objective activity monitor for orthopedic patients to quantify these events.

METHODS
A small 3D accelerometer (64x25x13mm, 18g) was attached onto the lateral upper leg with double sided tape. Healthy subjects (n=11, age=28±5 years) were the device under normal daily circumstances for one day and scored the amount of transfers (sit-to-stand), steps taken on stairs (up and down) and episodes of cycling in a diary. Sensor output was analyzed in Matlab using a nearest neighbour approach to detect transfers and differentiate between cycling and gait. A decision tree based on template resemblance and low pass filtered front-back acceleration was used to detect stair climbing. The difference between the results of the diary and the algorithm output (relative error in %) are reported.

RESULTS
On average subjects wore the sensor for a period of 10 hours and noted transfers (range 15–45, total 317), steps taken climbing the stairs (range 0–242, total 963) and descending stairs (range 7–217, total 1008) and episodes of cycling (0–3, total 7). Using less than 5 minutes calculation time per subject, the algorithm detected transfers, stair climbing, stair descending and cycling with an error of 23%, 16%, 28% and 9% respectively. The error per subject ranged from 0–80%, 3-46%, 8-54% respectively.

DISCUSSION AND CONCLUSION
Transfers were almost always over-detected. This is caused by the fact that knee-flexion activities (tying shoes, kneeling etc.) generate a signal closely resembling a sit-to-stand transfer. Including these activities would have yielded an error of nearly zero. For stair climbing most subjects have an acceptable accuracy, in one subject a significant under-detection was found, and in another an over-detection. For descending stairs the number of steps was under-detected in 4 subjects. Under-detection was mostly caused by the subjects going down the stairs too quickly, almost running. Over-detection was caused by that subject performing sports, yielding a similar signal as stair climbing. Upon optimization the algorithm can be used as a tool for clinical outcome assessment after orthopedic procedures.

REFERENCES

P1-17 ACCELEROMETER-BASED AUTOMATED AMBULATORY-ASSESSMENT OF MOBILITY IN PARKINSON’S DISEASE PATIENTS

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INTRODUCTION
The long term objective of this work is to develop an automated tool for assessing mobility in patients with Parkinson’s disease (PD) in daily life settings, based on a body-worn sensor. To this end, we investigated accelerometer-derived measures that presumably discriminate between control and PD groups and associations with clinical measures.

METHODS
22 patients with PD (mean age 65.9±5.9 yrs; H&Y stage 2.5±0.4) and 17 healthy controls (CO) (mean age 70.8±6 yrs) wore a 3D-accelerometer on the lower back while performing activities of daily-living (ADLs). The walking path included traversing several hallways, walking in an outdoor area, using stairs, strolling in a book store, and returning to the lab. Derived measures included average stride-duration, stride-variability, and the frequency, amplitude, width and slope of the dominant frequency. The differences between the results of the diary and the algorithm output (relative error in %) are reported.

RESULTS
On average subjects wore the sensor for a period of 10 hours and noted transfers (range 15–45, total 317), steps taken climbing the stairs (range 0–242, total 963) and descending stairs (range 7–217, total 1008) and episodes of cycling (0–3, total 7). Using less than 5 minutes calculation time per subject, the algorithm detected transfers, stair climbing, stair descending and cycling with a mean error of 23%, 16%, 28% and 9% respectively. The error per subject ranged from 0–80%, 3-46%, 8-54% respectively.

DISCUSSION AND CONCLUSION
Transfers were almost always over-detected. This is caused by the fact that knee-flexion activities (tying shoes, kneeling etc.) generate a signal closely resembling a sit-to-stand transfer. Including these activities would have yielded an error of nearly zero. For stair climbing most subjects have an acceptable accuracy, in one subject a significant under-detection was found, and in another an over-detection. For descending stairs the number of steps was under-detected in 4 subjects. Under-detection was mostly caused by the subjects going down the stairs too quickly, almost running. Over-detection was caused by that subject performing sports, yielding a similar signal as stair climbing. Upon optimization the algorithm can be used as a tool for clinical outcome assessment after orthopedic procedures.

REFERENCES

P1-18 VALIDITY OF NOVEL FALL METER IN RECORDING ACTIVITY AND FALLS IN CHILDREN

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INTRODUCTION
The purpose of this work was to test the validity of a novel accelerometer-based fall meter designed to measure activity and falls when worn at a child’s waist during daily activities. Fall meter data were compared to steps recorded by the StepWatch (Cyma Corp.), a highly reliable commercial pedometer worn at the ankle.

METHODS
Twelve typically developing children (ages 2 to 13 years) were provided fall meters and StepWatch (SW) monitors to be worn simultaneously for 4 days. Parents recorded when the devices were worn and their child’s daily activities. Steps from the SW and root mean square data from the fall meter were correlated.

RESULTS
Integrated data from both devices showed excellent correlation (Figure 1). Periods during which the fall meter recorded activity but no steps were recorded (arrows) could be episodes of trunk motion independent of walking such as reaching, leaning, swinging, and sliding. Falls were recorded more often for the younger children and corresponded to periods of intense activity such as evening goalie training for one child (Figure 2).

DISCUSSION AND CONCLUSION
Fall meter activity correlated with step count and included other motions independent of walking. Falls were identified during vigorous activities. The fall meter is being used to assess the efficacy of treatments designed to reduce falling in children with movement disorders.

REFERENCES

P1-16

P1-18

P1-17

RESULTS
The amplitude and slope were significantly lower in the PD group, compared to CO, in both frequency bands (amplitude: LF: 0.40±0.20[μV], 0.65±0.39[μV], p=0.03; for PD and CO, respectively). No significant difference was found in the main frequency of the locomotion band. UPDRS motor scores were significantly correlated with the amplitude, width and slope of the LM band (r=0.35, p<0.03).

DISCUSSION AND CONCLUSION
For walking in daily-life settings, frequency-based acceleration measures seem to be sensitive to PD, and are correlated with the motor symptoms of PD. These measures may serve augment the objective evaluation of disease progression and functional independence based on real-life performance.

ACKNOWLEDGEMENTS
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INTRODUCTION
Exercise Games (“ExecGames”) are increasingly recognised as motivational tools to ideally enhance fitness, balance and strength. As a prominent example, the Wi-Fit system which allows to control 3D-Games from the Wii-game station with a balance board, has been reported to be beneficial in a fracture healing process [1]. According to experts, however, balance -- especially the ability to stay poised on a board -- rarely reflects actual fitness ability. Concerns have been expressed about the development of “Wiiitis” [2], risks and side-effects caused by using balance boards (fractures [3], traumatic hemorthorax, dislocations, and head injuries). We were interested in a safe way to optimally enhance fitness, balance and strength. As a prominent example, the Wii Fit PC game only needs be updated by copying a modified game configuration file. The PC game “Moorhuhn Tales” can be controlled by a person wearing the actibelt-BLU. The actibelt platform can be used to monitor and discuss the changes in the post-acute rehabilitation phase, both by the patient and also by selected health care professionals and in the context of clinical trials. Before wide-spread application of ExecGames in the area of rehabilitation medicine studies will have to be conducted which look at usability, safety, efficacy and sustainability. We hope that the benefit of using the actibelt-platform outweighs the risks of developing “actibeltitis” and will eventually entice patients “to try the real thing and get some real exercise.” [6]

REFERENCES
P1-21 EVALUATION OF SHIMMER TO ASSESS STEP COUNTS OF PEOPLE WITH RHEUMATOID ARTHRITIS (RA) DURING DIFFERENT INTENSITIES OF ACTIVITY

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INTRODUCTION
Much of the research conducted to date assessing physical activity in the RA population has been completed using tools which have not been proven valid in this population. The aim of this study was to assess the validity of SHIMMER (Sensing Health with Intelligence, Modularity, Mobility and Experimental Reusability) wireless platform to estimate step counts in people with RA during differing intensities of activities of daily living.

METHODS
14 (8 male, 6 female) subjects participated in this study. All had a confirmed diagnosis of RA in conjunction with American College of Rheumatology (ACR) criteria, were on a stable drug regimen in the previous three months, ambulatory and over 18 years of age. Subjects performed a 75 minute standardized routine consisting of lifestyle and housework activities. The routine was divided into high, medium and low intensity components based on the updated Compendium of Physical Activities [1]. A SHIMMER was attached to each subject at the thigh. Bland and Altman and Intraclass Correlations were assessed between SHIMMER and direct step counts using PASS version 18.0 (Chicago, IL).

RESULTS
SHIMMER is most accurate at estimating step counts during high intensity activities (ICC = 0.93). Bland and Altman analyses also reflect this accuracy. It is less accurate at moderate (ICC = 0.64) and low intensity (ICC = 0.54) activities.

DISCUSSION AND CONCLUSION
The algorithms applied to SHIMMER have a strong ability to determine steps when foot contact is great, as in high intensity activities (walking, stair climbing, dusting) but less accurate in low and moderate intensity activities when clear stepping motion does not occur and the amplitude of the SHIMMER’s gyroscope angular velocity signal is reduced and more variable.

SHIMMER is accurate at estimating steps during high intensity activities of daily living in the RA population but less so at moderate and low intensity activities.

REFERENCES

P1-22 COMPARISON OF PHYSICAL ACTIVITY ASSESSED BY UNIAXIAL AND TRIAXIAL ACCELEROMETER IN ADOLESCENTS UNDER FREE-LIVING CONDITIONS: THE HELENA STUDY

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INTRODUCTION
Different types of accelerometers are available to assess physical activity (PA) patterns levels, and the choice about which to use depends on various factors: cost, physical characteristics (weight, size, and battery life), performance (number of axes, possible epochs, system of data transfer, recording duration, function of the epochs, and the memory capacity), the validity and the intra and interinstrument reliability. Given the large number of studies that have used uniaxial or triaxial devices, it is of interest to know whether the different devices give similar information about PA levels and patterns. The aim of this study was to compare PA levels and patterns obtained simultaneously by uniaxial accelerometer and triaxial accelerometer in adolescents in free-living conditions (FLC).

METHODS
Sixty-two participants, aged 13–16 years, were recruited to participate in this ancillary study, which is a part of the Healthy Lifestyle in Europe by Nutrition in Adolescence Study (HELENA). All participants wore a uniaxial accelerometer (ActiGraph GT1M®), and a triaxial accelerometer (RT3® – StayHealthy, Monrovia, CA) simultaneously for seven days. The levels of PA were expressed as counts per minute. The patterns were calculated by converting accelerometer data output as a percentage of time spent at sedentary, light, moderate, and vigorous PA per day, using thresholds defined previously for each accelerometer. Any discrepancy of the two accelerometers were assessed by two different statistics tests: Equivalence Test and Bland & Altman method.

RESULTS
Mean duration of data record available for analysis was 11.5 ± 2.5 hours/day. The mean PA was 204.1 ± 41.7 counts × h–1 for the RT3 and 353.2 ± 41.7 counts × h–1 for the ActiGraph. The equivalence test confirmed equivalence between the data from the triaxial accelerometer and uniaxial accelerometer at each intensity level (P < 0.001). The differences between the two devices were 2.1% ± 1% for sedentary activity, 1.4% ± 1.7% for light activity, 0.6% ± 0.5% for moderate activity, and 0.02% ± 0.09% for vigorous activity. The Bland & Altman method showed good agreement between data obtained between the both accelerometers (p < 0.05).

DISCUSSION AND CONCLUSION
In summary, this study demonstrates no differences between PA levels and patterns obtained by a uniaxial accelerometer (ActiGraph) and triaxial accelerometer (RT3) in adolescents in FLC. The choice of a uniaxial or triaxial accelerometer makes little difference in the assessment of PA pattern in free-living conditions. Therefore, both uniaxial or triaxial accelerometers can be used in clinical practice to quantify PA.

P1-23 DETECTING STEP COUNTS AND CADENCE IN PEOPLE WITH STROKE USING A NOVEL SHOE SENSOR

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INTRODUCTION
The recovery of walking ability is a major goal for people with stroke. Behavioral enhancing feedback is an important component of interventions to improve motor function in stroke. In order to provide effective feedback on walking activity, accurate methods of measuring walking activity in the community must be developed. The purpose of this study was to test the ability of a novel shoe based sensor (SmartShoe) to identify number of steps and cadence.

METHODS
Six individuals with chronic stroke participated in the study. Participants wore the SmartShoe while they completed four 2-minute walking trials at their self-selected pace (SSP) and four 2-minute fastest safe pace (FSP) around a 30-meter oval track. The SmartShoe consists of a flexible insole, which incorporates five force-sensitive resistors and a 3-dimensional accelerometer positioned on the back of the shoe. Pressure and acceleration data were sampled at 25Hz by an analog-to-digital converter and sent via Bluetooth to a smartphone. Data were downloaded and analyzed using an original algorithm to identify number of steps taken within the unaffected lower extremity (UALE), affected lower extremity (ALE) and cadence. A researcher counted number of steps from video data. Agreement between the researcher’s scores and the SmartShoe for number of steps taken and cadence was analyzed using Intraclass Correlation Coefficient 2,1 (ICC).

RESULTS
At SSP, participants took on average 83.4 (±21.4) steps with the UALE at a cadence of 41.9 (±10.8) steps/minute. At FSP, the SmartShoe identified 83.4 (±21.4) steps with the UALE, 84.2 (±21.0) steps with the ALE at a cadence of 41.5 (±10.3) steps/minute. At FSP, participants took on average 90.1 (±20.4) steps with the UALE, 90.1 (±20.4) steps with the ALE at a cadence of 44.5 (±10.2) steps/minute. The agreement between actual scores and the researcher’s scores was very high, ICC2,1 >0.95 for number of steps taken, and ICC2,1 >0.95 for steps/minute.

DISCUSSION AND CONCLUSION
The SmartShoe and accompanying detection algorithm was able to accurately identify walking activity in people with stroke. The SmartShoe could be used to measure the amount and intensity of walking activity in the real world, as well as to provide behavioral enhancing feedback as part of a comprehensive rehabilitation intervention to improve walking ability in people with stroke.
**P1-24 CLASSIFICATION OF POSTURES AND ACTIVITIES USING SHOE-BASED SENSORS AND LOGISTIC DISCRIMINATION**

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**INTRODUCTION**

Fast and reliable posture/activity recognition can be used to improve physical activity monitoring devices by providing estimates of specific types of activity, improving energy expenditure estimation and enhancing feedback to users. Previously we developed a very accurate model for posture and activity classification using Support Vectors Machines (SVM) [1, 2] in a shoe-based wearable sensor system. SVM approach, although very accurate, presents a high computing load to the processor and large memory demands even at the testing stage. High computational time and memory size requirements makes SVM approach practically unusable for real-time data processing especially in wearable devices and systems such as cell phones. We developed a significantly faster and less space demanding logistic discrimination approach for postures and activities classification using shoe-based sensor system.

**METHODS**

The study involved nine subjects (weight = 70.5 ± 15.8 kg; BMI = 25.2 ± 6.5) wearing wireless sensor system integrated into the shoe. The shoe system included five insole pressure sensors and a heel-mounted three-dimensional accelerometer. Subjects performed a variety of activities (sitting, standing, walking and cycling) at different intensities. Several metrics (such as mean, standard deviation and entropy) were derived from each sensor signal. A multinomial logistic regression model was developed for classification of every 2-sec recording into one of four posture/ activity groups (“Sat”, “Stand”, “Walk”, “Cycle”) using derived metrics. The model was validated using leave-one-out approach.

**RESULTS**

We compared the logistic discrimination model to our previously developed model for postures/activities recognition using SVM with Radial Basis Function (RBF) kernel. The logistic regression model provided accuracy similar to that of the SVM model (95.7% versus 95.2% of SVM) with significantly reduced time and memory space: both testing time and space at the testing (prediction) stage of the logistic discrimination took only 0.1s compared to 0.1s in the case of the SVM, where n is the size of the input and is the number of support vectors. Actual running time of the prediction stage of logistic discrimination model on a cellular phone was only 0.17% (or around 6.8 ms) from that of the SVM (4000 ms).

**DISCUSSION AND CONCLUSION**

The proposed logistic discrimination method for automatic posture and activity classification provides very accurate, fast and computationally feasible approach. This makes this method very applicable for the integration into a wearable cell phone-based physical activity monitoring system.

**REFERENCES**


**P1-25 MEASUREMENT OF WALKING SPEED IN UNCONTROLLED ENVIRONMENTS USING THE ACTIBELT PLATFORM**

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**INTRODUCTION**

Walking speed is increasingly considered as an important indicator of a subject’s health status [1, 2] and changes in walking speed measured in a clinical setting are used as outcome measure in various diseases. Major drawbacks are the time and effort needed, the measurement error and the high day-to-day variability [2]. A change of 0.1 m/sec and/or 10% is considered to be clinically meaningful [1], but the variability in a clinical setting in 5 repeated measurements is up to 20% [3]. Consequently, there is a need for the objective, high-quality long-term assessment of walking speed in uncontrolled environments. Recent developments in mobile accelerometry enable 7-days measurements and we investigated several candidate algorithms to extract gait speed from these accelerometry data.

**METHODS**

The actibelt platform (www.actibelt.com) uses a tri-axial, piezo-electric Bosch BMA150 accelerometer sensor operated at 100Hz, integrated in a belt buckle. The subjects for our study were recruited from healthy individuals who had signed informed consent forms. 17 participants, 41% male, age 32±15, wore the actibelt and operated a mobile gold-standard during the experiment. They were instructed to walk 5 times 1.5 minutes at 5 different self-selected walking speeds on the corridor of the building. Here we describe two out of 13 candidate algorithms used for parameter extraction. - Support vector machine “SVR-Energy”: the feature set for this special SVM consists of four extracted features, the sum of absolute values for each axis as well as the mean energy of the acceleration signal. The final model was calculated using a radial kernel. Parameters were found through 10-fold cross-validation.

- “Walk ratio” approach: this algorithm is based on estimating the distance covered in a certain time by including estimates of individual step lengths which are functions of the step frequency. The slope of the change of step length with step frequency can be taken as a constant or can be calculated by individual calibration.

**RESULTS**

The best performing algorithm “SVR-Energy” has a concordance correlation coefficient of 95% and a coverage probability CP3 of 0.83 (83% of the time the deviation from the gold standard is less than 0.3 m/s) and a CP2 of 64%. SVR-Energy even outperforms the best algorithm with individualized calibration. In order to assess the day-to-day variability we calculated a mixed effects model with random intercept to account for within subject data set. The day-to-day variability was 0.14 m/s, hence averaging weekly recordings would result in a variability of 0.053 m/s, about half the clinically threshold of 0.1 m/s.

**DISCUSSION AND CONCLUSION**

We have validated the high accuracy of a novel algorithm to measure walking speed in uncontrolled environments. Standard deviation of daily changes in walking speed over 1 week is smaller than what is needed to detect a meaningful change. Therefore, walking speed estimates from 7-day recordings are promising candidates for a novel patient oriented outcome measure that can detect meaningful changes in clinical trials in chronic disabling diseases such as multiple sclerosis and may be also used for personalized medicine.

**REFERENCES**


**P1-26 STEP ACTIVITY ASSESSMENT 4 AND 12 WEEKS AFTER MINIMALLY INVASIVE TOTAL HIP ARTHROPLASTY**

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**INTRODUCTION**

Total hip arthroplasty in one a highly successful treatment strategies in Orthopaedic surgery. Nevertheless, the surgical approach was modified in recent years with the application of minimally invasive approaches aiming to minimize the local damage and achieve better or faster rehabilitation. Recent reviews describe the procedure either as safe [1] or as risky [2] so that it is still controversially discussed. The aim of the present study was to evaluate the patients’ clinical outcome and functional restoration in daily life with standard scores and quantitative step activity assessments before and after surgery.

**METHODS**

Currently, 27 patients were included and agreed to participate. After outpatient visit with the decision for total hip arthroplasty, the patients were asked to wear a step counting accelerometer (“SAM” Step Activity Monitor, Orthocare Innovations) for one week during the waking hours. After surgery they wore the device again after 4 and 12 weeks, postoperatively. The device was worn around the right ankle where it recorded the number of gait cycles in one-minute intervals. The software determined the daily number of gait cycles as well as the distribution of activities at different cadences.

**RESULTS**

Fourteen of the 26 subjects are finished with follow-up assessments; the remaining 13 will be done by early 2011. Subjects wore the SAM for an average of 6.4 days with an average wear time of >12 hours. The number of daily steps did not increase after...
4 weeks but increased from approximately 3800 to 4400 gait cycles after 12 weeks (+18%). The number of gait cycles per hour of wear time increased by more than 20%. The time spent in high-intensity gait over 100 steps per minute.

DISCUSSION AND CONCLUSION

Even though the patients did not reach the values of a healthy population of over 5000 gait cycles they revealed a clearly improved gait activity already 12 weeks after minimally invasive total hip arthroplasty.

REFERENCES


OPTIMIZING INERTIAL MOTION CAPTURED MOTION USING HOLONOMIC CONSTRAINTS

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INTRODUCTION

Holonomic constraints like joint restrictions could be used to improve motion reconstruction from inertial measurement units (IMUs). This abstract presents preliminary results of a new method for motion reconstruction using optimization with a model subjected to holonomic constraints.

METHODS

During the simulation of a kicking like motion of a 2D double pendulum, both segment orientations were stored at a frequency of 100Hz (Figure 1a, model Degrees of Freedom (DoFs)) as well as virtual IMU signals (Figure 1b/d). Constant sensor noise was simulated with a normally distributed random signal and transient disturbances using a slowly decaying normally distributed random signal from t = 0.5 to 1.5s. The resulting signals were filtered using a second order 10 Hz low-pass Butterworth filter and used for motion reconstruction (Figure 1b/d).

The motion was reconstructed in an iterative manner, where an initial estimate of the DoFs for each next time step was based on integration of the sensor angular velocities. Subsequently, this initial estimate was optimized by using the DoF estimates of 10 time steps to drive a model subjected to holonomic constraints where consistency of all kinematic data is guaranteed (as illustrated by Andersen [1]). Using this optimization the error between model IMU signals (which are subjected to the holonomic constraints) and measured IMU signals can be minimized.

RESULTS

The results show the used sensor signals and the results with and without the extra optimization of DoF's estimates. The resulting DoFs error RMS are 3.6deg and 3.3deg for both DoFs with optimization (grey). Solid lines represent reference values, dotted lines unfiltered sensor signals and dashed lines filtered sensor signals and DoF estimates after optimization (the fine black dotted lines in figure a are without the optimization). Sensor noise RMS values: 27deg/s and 2m/s², sensor transient disturbance RMS values: 71deg/s and 3.1m/s². The resulting DoFs error RMS are 3.6deg and 3.3deg for both DoFs with optimization and 4.1deg and 4.4deg without optimization.

DISCUSSION AND CONCLUSION

Results show how inclusion of an optimization procedure using a model subjected to holonomic constraints can improve the motion reconstruction. Notice that the effects of the holonomic joint constraints are minimal in this simulation, as there were no sensor signals contradicting the joint DoFs, so further evaluation of this method is necessary. The main improvement can be seen from the reduced orientation bias of sensor two (grey) during the last third of the simulation; a reduction that is due to the comparison of model and sensor acceleration. The biggest errors in the simulation due to low frequent sensor bias could be corrected for by including the estimation of these biases based on model and sensor IMU differences during optimization.

REFERENCES


FEASIBILITY OF USING ACTIVITY MONITORS IN SURVEILLANCE STUDIES WITH 2 TO 3 YEAR OLD WHITE AND PAKISTANI CHILDREN

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INTRODUCTION

The use of motion sensors to objectively measure physical activity (PA) in young children has become increasingly common, due to the various advantages they have over other methods, such as parental report [1]. New and improved motion sensors are continuously being made available, leaving researchers with many methodological [1] and budgetary decisions. In young children, the reliability and validity of different motion sensors has been assessed in predominately white preschoolers. However, no published studies have assessed the feasibility (acceptability/appropriateness) of their use in children younger than 3 years old, or in children of different ethnicities. This study aims to assess the feasibility of using the Actiheart, Actigraph GT3X+ and the ActivPAL3 to assess PA and sedentary behavior (SB) in 2 to 3 year old Pakistani and White children, and their parents simultaneously.

METHODS

A minimum of 6 focus groups (3-6 participants) were conducted at Children’s Centres in Bradford, UK, with White and Pakistani mothers/caregivers of 2 to 3 year old children. The focus groups were run by a moderator and a note taker in English, or Urdu for non-English speaking Pakistanis. The use and positioning of the different motion sensors was explained to the mothers and their opinions on each device were assessed, in terms of the feasibility of their use with the child and both parents. This is an ongoing study, and the results presented are based on 3 focus groups completed to date.

RESULTS

Preliminary results show the Actigraph GT3X+ is the most preferred device for use in children and both parents, and the Actiheart showing the lowest acceptability, particularly for Pakistani parents/caregivers. Concerns raised include the children fiddling with the Actiheart due to curiosity or itching, or unsuitability in hairdresses/partners due to chest hair, the discomfort caused by the large size of the ActivPAL3 relative to the size of children’s thighs or incompatibility of use with tight clothing, and children fiddling with the Actigraph GT3X+ if presence was noted.

DISCUSSION AND CONCLUSION

These preliminary results raise important issues about the use of these motion sensors with very young children, and some ethnic differences in opinions have been identified. Future PA and SB surveillance studies should assess the practical feasibility of using different motion sensors with the target population before choosing the device, to enhance compliance and reduce the chances of recruiting a biased sample because certain types of participants are not willing to use the sensor.

REFERENCES

P1-29  DEVIATIONS IN DAILY PHYSICAL ACTIVITY PATTERNS IN PATIENTS WITH THE CHRONIC FATIGUE SYNDROME: A CASE CONTROL STUDY

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INTRODUCTION
Chronic fatigue syndrome (CFS) is a chronic disease for which it is hypothesised that low and deviating levels of physical activity play an important role in the development and maintenance of their fatigue. As a result treatment focuses on increasing the physical activity level and balancing activities over the day/week. However, until now it has been demonstrated that CFS patients indeed show lower levels of physical activity but it is unclear whether they indeed have a disbalanced pattern. As such the aim of this study is to gain more insight into the patterns of daily physical activity of patients with CFS in comparison with healthy controls.

METHODS
In this study 35 patients with CFS and in 35 age- and gender-matched healthy controls participated. The daily physical activity pattern was measured with a tri-axial accelerometer that was worn at the hip for seven consecutive days. Daily physical activities were measured at home during daytime (6.00–22.00). The physical activity level was computed per hour and per day part (morning, afternoon, evening). Moreover, the distribution of physical activities at low, medium and high intensity levels during the day were computed for evaluating activity intensity levels per day part. Finally, individual day to day fluctuations in performing physical activities and the between subject variability of both groups was computed and compared.

RESULTS
CFS patients were significantly less physically active in the afternoon and evening, spent fewer activities at high intensity levels and more at low intensity levels. Moreover, CFS patients showed more individual day to day fluctuations in the physical activity pattern during the afternoon and evening with respect to controls. However, the variability between subjects did not differ between both groups.

DISCUSSION AND CONCLUSION
This study demonstrated deviations in the daily physical activity pattern of patients with CFS as compared to healthy controls. Patients show as known a decreased physical activity level but also a deviated pattern. This deviating pattern is reflected in higher decrease in activities from the morning till evening as well as more variability in activity level over consecutive afternoons and evenings. This latter might probably be related to good and bad days; lower and higher levels of fatigue on different days and higher levels of fatigue as the day continues. However whether the amount of deviation is indeed related to the level of fatigue need to be further explored.

P1-30  ASSESSMENT OF TIME PATTERNS IN LONG-TERM RECORDINGS OF PHYSICAL ACTIVITY

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INTRODUCTION
Current technology allows continuous ambulatory monitoring for whole day(s) at a high time resolution of data on, for instance, postures and movements. While the resulting abundance of information offers thrilling opportunities to investigate new aspects of physical activity, it also presents a challenge to the researcher, compelled to extract a manageable set of variables. Some of these should reflect time patterns, which are known to be important to both short- and long-term effects of the activity [1]. The ‘Exposure Variation Analysis’ (EVA) offers a generic principle of how to simultaneously report the ‘how much’ (range) and ‘how fast’ (frequency) aspects of variation in any exposure time line, by measuring the occurrence of uninterrupted periods at a specified activity level and of a specified duration.

EVA IN THE LITERATURE
While EVA was originally developed for analyzing time patterns of muscle activity [2], its present applications also include postures and exercise intensity. In total, about 50 scientific publications have reported data obtained by EVA, with a large dominance of occupational studies. For muscle activity as well as postures, several different classifications of activity level and period duration have been applied. Several papers have presented ideas for summarizing an EVA, either by adding the occurrence of certain levels and durations of activity (e.g. [3]) or by calculating summary statistics on each EVA array. None of these approaches have so far been validated. Also the statistical analysis of EVAs remains to be satisfactorily resolved, even if some progress has been made.

FURTHER DEVELOPMENT OF EVA
In being a generic principle for analysis of variation, EVA includes the option of classifying activity at a dichotomous level, such as sitting vs. standing/walking, and deriving the corresponding time pattern. Ordinal classes of activity level can be replaced by a categorical set-up, for instance of occupations during a day, to provide the time pattern of changes between (occupational) categories.

Further development of EVA should concentrate on three major issues. 1) Standardization: For physical activity variables amenable to EVA, standardized classifications of levels and period durations should be developed and their properties examined. This is a prerequisite for comparing studies and, eventually, constructing EVA exposure data bases or performing meta-analyses. 2) Validation: EVA results should be validated; both in terms of face validity, i.e. whether EVA reflects the intended characteristics of the monitored activity, and predictive validity, i.e. whether the EVA result is associated with a relevant outcome, such as performance or disorders. 3) Statistics: While both descriptive statistics and statistical testing of EVAs present severe challenges, the lack of a comprehensible and interpretable statistical approach of how to handle EVAs impedes its extensive use in, e.g. epidemiologic studies and intervention research.

CONCLUSION
While EVA has gained widespread use as a method for analyzing the time pattern of various occupational exposures, it has so far been applied very rarely in sports science or public health studies. Further developments of EVA, which might increase its attractiveness as a generic analysis approach, need to focus on standardization, validation and statistical properties.

REFERENCES

P1-31  A NEW MAGNETOMETER-ACCELEROMETER APPROACH TO ASSESS WALKING ACTIVITY IN AMBULATORY CONDITIONS

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INTRODUCTION
Most of the devices currently used to assess the walking capacity in ambulatory conditions do not provide both the quantification and the recognition of surface walking conditions (level walking, going up or down a slope, going up- or down-stairs) [e. g. 1]. The aims of this present study were 1) to develop and validate the reliability of
quantitative gait assessment through step counting based on a single magnetometer sensor located on the shank, and 2) to develop and validate a method for automatic recognition of the surface walking condition based on two magneto-accelerometer sensors located on the shank and the thigh from healthy volunteers.

METHODS
Twenty-five normal volunteers performed a standard circuit in which they had to walk for 30 minutes over a variety of surface walking conditions. They were equipped simultaneously with the TRIDENT system: 3-axis magnetometer and 3-axis accelerometer sensors (3a3m), placed on the shank and the thigh of the right leg, and two other reference sensors: a commercial pedometer (the StepWatch Activity Monitor, SAM) and 3 Force-Sensing Resistors (FSR). For the quantification analysis, only data from the shank magnetometer were required. The different step counting approaches were compared using the Pearson correlation coefficient and the Bland-Altman methods in every surface walking condition. For the topological analysis, data from the 3a3m were processed to detect a set of signal parameters, most relevant to categorize 5 predetermined activity classes. Then a probabilistic approach was performed using a hidden Markov model (HHMM) with a 10-fold cross-validation method.

RESULTS
Regarding the quantification analysis, the step counts measured by the TRIDENT, FSR, and SAM were highly correlated for the level walking surfaces (r>0.83) and the Bland-Altman analysis revealed an overall ±5% limits of agreement. For the other walking surfaces, the agreement was better between TRIDENT and FSR, than between TRIDENT and SAM. Regarding the topological analysis, the percentages of correct classification varied between 92 and 99%.

DISCUSSION AND CONCLUSION
The present study demonstrates that a single magnetometer shank sensor is an accurate tool for step counting in various walking surfaces. When combined with accelerometers, automatic recognition of surface walking conditions in a standardized walking circuit is possible with a HHMM processing. The easy use and the robustness of the signal processing make the TRIDENT system highly applicable for clinical purposes, especially for the analysis of long walking periods in daily life conditions.

REFERENCES

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P1-32 IMPACT OF ACCELEROMETER EPOCHS ON CLASSIFICATION OF CHILDREN ACTIVITY PATTERNS

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INTRODUCTION
Children have intermittent activity patterns and this must be considered when assessing activity with accelerometers. This study examines the impact of accelerometer epoch duration on the recorded time spent in physical activity during recess. A second goal was to determine whether variability in activity is associated with overall time spent in activity.

METHODS
Data were obtained from one school in the Ready for Recess project. Participants (60, 3rd-5th grade children) wore an Actigraph accelerometer for four days. Data during recess were processed using two different methods to determine the impact of epoch length on group activity levels. One method used the recorded (5 s) epochs and the other used aggregated 1 min epochs (similar to ActiLife software). Both methods used the same equation (Freedson-Trost) to classify epochs into intensities (Sedentary, Light, Moderate and Vigorous). The relation between variability and time spent in activity was examined with an indicator of count variability (SD of absolute difference between 5 s counts).

RESULTS
Boys spent 25.6% time in Sedentary, 16.6% in Light, 35.6% in Moderate and 22.3% in Vigorous. Girls spent more time in Sedentary (33.9%) and Light (21.4%) but less time in Moderate (30.3%) and Vigorous (14.4%). When the same data were aggregated into 1 min epochs the allocations were drastically different. In boys, the respective allocations shifted to 10.7%, 18.5%, 54.0%, and 16.7% and in girls, the values shifted to 12.5%, 29.5%, 50.5%, and 7.5%. Time in Sedentary and Vigorous were considerably lower (61% and 35%, respectively) while time spent in Light and Moderate were considerably higher (27% and 59%, respectively). MVPA levels were reduced by 25.9%. The bias was consistent in boys and girls, however the underestimation of girls’ Vigorous activity was 2 times greater than boys (46% vs 25%). The indicator of epoch variability was positively correlated with percent time in Vigorous (r=0.72), Moderate (r=0.20), and Light (r=0.24), but negatively associated with Sedentary activity (r=-0.28). The associations for Vigorous were considerably higher in boys (r=0.83) than girls (r=0.51).

DISCUSSION AND CONCLUSION
The results reveal large differences in group activity profiles depending on how the data were processed. An indicator of activity variability was shown to be highly correlated with total time spent in MVPA confirming that activity in children is inherently intermittent (even within a minute).

Using shorter epochs (e.g. 5 seconds) captures children’s intermittent activity patterns and provides a more accurate indicator of time spent in MVPA.

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P1-33 THE FREQUENCY OF THE POSTURE TRANSITION AND SEDENTARY BEHAVIOURS IN PRESCHOOL CHILDREN

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INTRODUCTION
Prolonged sedentary activity is a risk factor for some disease in children and adults, even when an individual meets the minimum daily exercise guidelines [1, 2]. Furthermore, recent evidence from adults suggests that how sedentary behaviour is accumulated (number of sit-stand transitions; length and frequency of sedentary bouts) influences health risk [3]. However, there is no work yet in children.

The aim of this study was to determine the frequency of posture transitions (sit → stand, stand → sit) and to estimate time spent in sedentary behaviours (sit/lie) in preschool children, in a free-living environment.

METHODS
We studied 23 (sex 9M:14F; age (yrs) 4.5±0.7, mean, SD) preschool children attending nursery school in Glasgow using active PAL activity monitors (PAL Technologies). Each child wore the monitor continuously for 24 hrs a day for 5-7 days. The number of transition and the sitting time were calculated after the data was downloaded to computer

RESULTS
The number of transition could be calculated in 20 children who all had monitoring for 5 to 7 days. During waking, the mean number of posture transition was 16±3 per hour (n = 20). The mean sedentary time (sit/lie) % was 57.5±10 (n = 20). Some differences in how sedentary behaviour was accumulated between children were noted.

DISCUSSION AND CONCLUSION
These young children spend the majority of their waking time in behaviours with low energy expenditure. This is one of the first estimates of posture transitions in young children in their normal environment. Further studies will be needed to investigate the consequence of posture and posture transition in preschool children.

REFERENCES
P1-34  AUTOMATIC ANALYSIS OF SIT-TO-STAND MOVEMENTS USING A SINGLE SENSOR WITH ACCELEROMETERS AND GYROSCOPES

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INTRODUCTION
Much of our knowledge of sit-to-stand (STS) movements comes from force plates or camera based systems [1]. Body fixed sensors are easy to use, cheap, flexible and unobtrusive. We have used a single sensor and developed an automated approach for quantifying the STS for comparing STS old adults (OA) and of young adults (YA).

METHODS
A single sensor system with 3 accelerometers and 3 gyroscopes (DynaPort® Hybrid) was fixed around the waist. A method was developed to automatically identify the start and end of the sit-to-stand and stand to sit transitions. These transitions are automatically divided into a flexion and extension phase. Temporal and kinematic parameters were extracted (Table 1). 14 old adults (66.4±8.7 years; 165.6±10.2 cm; 65±12.9 kg) and 15 young adults (20.7±1.4 years; 183.2±8.7 cm; 72.9±9.2 kg) performed two sets of 5 sit to stand cycles (Figure 1). The Mann-Whitney U test and ω max were performed to compare the populations. The significance level was set at p < 0.05 for all statistical procedures.

Preliminary validation with elderly people in their home environment shows good results. Peak powers of 39 detected sit-to-stands can be detected. Positive prediction value is 80%. Slightly above one false detection per person was found. Peak powers of 39 detected sit-to-stands calculated with body mass normalized to 1kg were analyzed in Figure 1. A mean error of 0.61 Watt was observed between the calculations based on manually determined (star) and automatically determined (circle) transfer timing.

Table 1. Analysis of classification algorithms

<table>
<thead>
<tr>
<th></th>
<th>YA</th>
<th>OA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>sit to stand ω max flex</td>
<td>131.8 (29.6)</td>
<td>91.9 (20.2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>sit to stand ω max ext</td>
<td>60.9 (23.4)</td>
<td>53.2 (19.3)</td>
<td>0.323</td>
</tr>
<tr>
<td>sit to stand duration</td>
<td>1.5 (0.3)</td>
<td>2.4 (0.6)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>sit to stand flex duration</td>
<td>0.7 (0.1)</td>
<td>1.1 (0.2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>stand duration</td>
<td>0.3 (0.3)</td>
<td>1.7 (1.4)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Stand to sit ω max flex</td>
<td>83 (23.2)</td>
<td>44.6 (11.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Stand to sit ω max ext</td>
<td>101.8 (21.4)</td>
<td>108.3 (26.0)</td>
<td>0.527</td>
</tr>
<tr>
<td>stand to sit duration</td>
<td>1.6 (0.3)</td>
<td>2.4 (0.5)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>stand to sit flex duration</td>
<td>0.7 (0.1)</td>
<td>1.3 (0.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>stand to sit duration</td>
<td>0.9 (0.2)</td>
<td>1.1 (0.3)</td>
<td>0.024</td>
</tr>
<tr>
<td>sit duration</td>
<td>0.4 (0.2)</td>
<td>3.8 (3.0)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

RESULTS
Correlations between the maximum angular velocity during the sit-to-stand and stand-to-sit and the BMI are 0.67 and 0.62, respectively.

DISCUSSION AND CONCLUSION
The method is powerful for distinguishing the populations, especially during the flexion phase. Further work will focus on different STS strategies and interventions.

REFERENCES

Figure 1. An example of one STS cycle of an older adult with a relatively good performance.

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P1-35  SIT-TO-STAND TRANSFER DETECTION AND POWER ANALYSIS WITH ACCELEROMETER AND PRESSURE SENSOR

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INTRODUCTION
Falls are one of the major health risk factors in elderly people. Peak power of a sit-to-stand transfer has been suggested as a potentially useful parameter for early prediction of fall risk [1]. Hence, effective intervention can be applied for fall prevention. For this purpose, a long-term daily monitoring and analysis method is needed. In this abstract, we present a method of monitoring and analyzing power exertion during sit-to-stand transfer with a pendant-worn wireless sensor platform. Preliminary results of validation in home environment with 5 elderly people are presented.

METHODS
We present in this abstract the results from the preliminary validation. In total 55 sit-to-stand transfers were annotated in the collected data. Statistics in Table 1 show over 70% of sit-to-stands can be detected. Positive prediction value is 80%. Slightly above one false detection per person was found. Peak powers of 39 detected sit-to-stands calculated with body mass normalized to 1kg were analyzed in Figure 1. A mean error of 0.61 Watt was observed between the calculations based on manually determined (star) and automatically determined (circle) transfer timing.

Table 1. Analysis of classification algorithms

<table>
<thead>
<tr>
<th></th>
<th>True Positive</th>
<th>False Alarm</th>
<th>Sensitivity</th>
<th>Positive Predictive Value</th>
<th>False Alarm Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>39 (55)</td>
<td>10</td>
<td>71%</td>
<td>80%</td>
<td>1.1/p</td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSION
We developed a method of detecting sit-to-stand transfer and analyzing the transfer peak power. The method allows easy and unobtrusive measurements in daily life. Preliminary validation with elderly people in their home environment shows good result of positive prediction of sit-to-stand transfers. Automatic peak power calculation is in general well aligned with the results based on manual detection. Large scale field trial for extensive validation is under planning.

REFERENCES
P1-36  PREDICTING CHILDREN’S FREE-LIVING ENERGY EXPENDITURE

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INTRODUCTION
The assessment of energy cost in paediatric populations has typically occurred in laboratory settings, which usually obtain higher validity coefficients. However, laboratory based protocols may be limited in the assessment of free-living behaviours as creating environments that reflect such behaviours is difficult [1]. Few studies have provided children the option of engaging in activities of their own volition. The aim of the study was to predict children’s energy expenditure using multiple sites and measures when engaged in a range of free-living behaviours.

METHODS
Twenty eight children (13 boys, 15 girls) aged 10-11 years from one North-West school participated in the project. Children were fitted with a heart rate monitor, four GT1M Actigraphs (2 hip mounted, 2 wrist mounted), and the Metamax 3b system. Resting energy expenditure and heart rate was measured during 15 minutes of supine rest. Following this, children engaged in self-paced walking, self-paced running (5 min each), drawing, free-choice games and playground games (10 min each) in a randomised order, with 5 min of seated rest between each activity. During the activities, each child was observed using a modified SOFIT protocol. All activities took place on the school playground, with the exception of the drawing activity. Energy expenditure measured via indirect calorimetry was used as the criterion measure. Prediction of energy cost using a combination of physical activity measures was completed using multiple linear regressions with a stepwise backward method.

RESULTS
Energy cost was higher, but not significantly, during free-choice games (508.3 J.kg \(^{-1}\).min \(^{-1}\)) compared to playground games (465.5 J.kg \(^{-1}\).min \(^{-1}\)) and self-paced walking (361.6 J.kg \(^{-1}\).min \(^{-1}\)). Wrist-mounted accelerometer counts were significantly higher during free choice games and playground games than during self-paced walking (p<0.001). The single best measure of predicting energy cost for free-living behaviours was wrist-mounted accelerometer \(R^2 = 0.17\). For multisite activity assessment, the variance explained in energy cost during free-living behaviours was greater than single-site activity measures \(R^2 > 0.43\).

DISCUSSION AND CONCLUSION
Multiple regression equations explained a greater amount of variance in the energy cost of children’s free-living behaviours than any single measure alone. Notably, wrist counts (both dominant and non-dominant hand) were included in single and multiple regression equations, indicating that the energy cost of children’s free-living behaviours may be under-estimated when hip-mounted accelerometer is used. Developing energy expenditure equations during free-living activities in field-based settings may improve the prediction of physical activity in children.

REFERENCES

P1-37  EXPLORING THE RELATIONSHIP BETWEEN ENERGY EXPENDITURE AND ACTIVITY MONITORS WITH GAIT SPEED

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INTRODUCTION
Energy expenditure (EE), as estimated by many accelerometer based activity monitors, is calculated on the basis that the faster the body segment that the monitor is attached to moves the greater the EE. Most validation studies of such devices have explored this relationship over a wide range of walking speeds ranging from slow to fast, and correlated EE across the speed range. This potentially masks the facts that EE for slower gait is less dependent on speed than faster gait, or that pathological gait may be slower for an equivalent EE [1,2].

METHODS
Eight healthy volunteers (our aim is to recruit 20) walked around two cones 9.5m apart at five different speeds: Self selected (SS), 60%SS, 80%SS, 120%SS, 140%SS, for a duration of 5 minutes at each speed. For speeds other than SS this was controlled using a bleep at each cone to indicate the participants had achieved the desired pace. Volunteers wore the K4b2 gas analyser, the Actigraph(GX3), a uniaxial ActivPal, and a Senseware Armband (Version5.1). EE was calculated for the 4th minute for all devices at each speed. Correlation coefficients of speed with EE for each device were calculated across all speeds, at SS and above, and at speeds slower than SS.

RESULTS
The correlations for all speeds and for speeds at or above SS were all strong and highly significant (figure 1). However for the speeds slower than SS the correlation between K4 EE became non significant as did that of the Senseware Armband, whereas the correlations for the Actigraph and the ActivPal with speed remained strong and significant.

REFERENCES
P1-38  THE TRAVELLING GREEN STUDY: TREATMENT OF MISSING AND OUTLYING DATA
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INTRODUCTION
Missing and outlying data pose a considerable challenge to researchers conducting physical activity related studies. This abstract describes and discusses the types of missing and outlying data encountered in the ‘Travelling Green’ (TG) study, and techniques used to deal with these data. The TG study used a quasi-experimental design to investigate the effect of a 6-week school based intervention on children’s walking to school.

METHODS
Participants were 166 Scottish children (60% male) aged 8-9. Data were collected over one week pre- and post-intervention/control using a travel questionnaire, accelerometer (Actigraph GT1M), and travel diary. Types, patterns of, and reasons for missing data were discussed by the research team. Available data replacement methods were identified and reviewed, before the most suitable were selected.

RESULTS
Types of missing data included: whole questionnaire; individual questionnaire items; whole-week and daily GT1M data; and missing travel diary. Reasons for missing data were: absence on day of questionnaire administration; on holiday; left school; failing to complete some questionnaire items; daily absence; forgetting to wear GT1M; GT1M malfunction; and GT1M and travel diary loss. Pre-intervention, 11 participants (6.6%) had completely missing questionnaire data. GT1M data were missing for 78 of 768 days (11.7%), and 12 participants (7.2%) had missing GT1M data for the whole week. Post-intervention, 3 participants (1.8%) had completely missing questionnaire data. GT1M data were missing for 169 of 684 days (25.5%), and 13 participants (7.8%) had missing GT1M data for the whole week. 3 Participants (1.8%) had no GT1M data for both pre and post intervention. 10 (6%) and 24 (14.5%) participants lost their travel diaries for pre- and post- intervention, respectively. Individual questionnaire items had varying levels of missing data. Outlying daily GT1M steps were identified as being <1,000 and >30,000 steps/day according to previously-described recommendations [1]. No daily step outliers were identified pre intervention, and three outlying (all < 1,000) daily step values were identified post intervention. Missing data were replaced using the following techniques: individual information centered mean[2]; group mean; replace post-intervention data with pre-intervention data (assuming no change); and vice versa for missing pre-intervention data.

DISCUSSION AND CONCLUSION
Large, long-term multidisciplinary studies produce various patterns of missing data from multiple variables. Researchers should consider the various available data replacement techniques and select the most appropriate for their data, rather than taking a uniform approach to all data replacement.

REFERENCES

P1-39  A METHOD TO ESTIMATE RELATIVE ORIENTATIONS OF BODY SEGMENTS DURING MOVEMENT USING ACCELEROMETER
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INTRODUCTION
Quantitative assessment of human body movements includes the analysis of joint orientations. We propose a new method to estimate relative orientation between body segments using a single 3D accelerometer per segment under the following conditions:
(1) The total acceleration on both segments is the same. They are only measured in different coordinate frames.
(2) The direction of the total acceleration changes with time.
(3) The relative orientation changes relatively slowly with respect to the total acceleration.

These conditions may be satisfied in certain situations, for example on the segments of the fingers of a hand during functional movements.

METHODS
We tested this method using an experimental setup with inertial sensors on a kinematic body chain with fixed relative orientations. The relative distance between the accelerometers was 47 mm.

RESULTS
Accurate relative orientations were obtained when performing horizontal translational movements (Figure 1 Left), but as expected, errors occurred at higher angular velocities during pure rotations (Figure 1 Right).

Figure 1. Two experimental measurements: The plots on the first and second row show the magnitude of accelerations and angular velocities in the sensor frames of both accelerometers. The plots on the third row show the angle between the estimated and actual orientation. Left: cyclic translational movements over 45 cm in the horizontal plane at approximately 0.8 Hz. Right: cyclic rotational movements over 180 degrees at approximately 0.8 Hz. The distance between the axis of rotation and accelerometers was 35 mm and 75 mm respectively.

ACKNOWLEDGEMENT
This study was financially supported by the Dutch technology foundation STW under the PowerSensor project.

P1-40  LONG TERM MONITORING OF KNEE FLEXION ANGLE: A SPECTRUM ANALYSIS
Urwin SG1, Kader D2,3, St Clair Gibson A1,2, Caplan N1,2, Stewart S1,2, 1Department of Sport and Exercise Sciences, Northumbria University, Newcastle upon Tyne, England; 2Orthopaedic Department, North East NHS Surgery Centre; 3North East Orthopaedic and Sports Injury Research Group (OASIR), Queen Elizabeth Hospital, Gateshead, England

INTRODUCTION
Joint range of movement (ROM) of clinical groups is routinely measured in laboratory and clinical settings. Due to potential behaviour modification during scientific or clinical consultations, this may not accurately reflect normal ROM over an extended period. The objective of this investigation was to therefore obtain normative data of knee flexion angular displacements during seven days activity in asymptomatic participants for comparative use in clinical trials.

METHODS
A flexible electrogoniometer (SG150, Biometrics, UK) was used to monitor right knee flexion angular displacement in the sagittal plane, using a portable data logger (MIE Medical Research, UK), sampled at 200Hz. The device was attached to the skin over the lateral border of the knee, in line with the anterior superior iliac spine and the lateral malleolus, equidistant between the anterior and posterior borders of the thigh and Shank. Participants (n = 10) were fitted with the system at 8am in the laboratory and subsequently asked to return seven hours later in order to obtain a representative sample of their normal ROM during a cross-section of an average day, away from laboratory observation.

RESULTS
Mean findings suggest that the largest percentage (27.30%) of the seven hour monitoring period was spent with the knee flexed between ±20° to ±40° of flexion. The percentages across the ranges were as follows for angular displacement: ±10° to ±20° = 10.96% ± 2.24%, ±20° to ±30° = 12.45% ± 15.14%, ±10° to ±20° = 8.48% ± 4.54%, ±20° to ±30° = 15.31% ± 6.05%, ±30° to ±40° = 11.98% ± 6.09%, ±40° to ±50° = 10.89% ± 4.73%, ±50° to ±60° = 9.55% ± 4.56%, ±60° to ±70° = 8.76% ± 6.24%, ±70° to ±80° = 5.64% ± 2.85%, ±80° to ±90° = 3.89% ± 4.63%, ±90° to ±100° = 2.24% ± 4.06%, ±100° to <110° = 0.31% ± 0.78%. The mean angular velocity spectrum showed that for 43.23% ± 1.71% of the monitoring time participants flexed their knee at a rate of between 0 – 100°/s, with a mean extension angular velocity (42.77% ± 2.48%) also between 0 – 100°/s.

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DISCUSSION AND CONCLUSION
This study has shown that asymptomatic participants spend the greatest duration of time with the knee flexed between 20º to <40º of flexion; a range that satisfies the increments of all activity movement cycles [3]. Current research is ongoing using this method to compare clinical populations in the outpatient setting for use as an objective rehabilitation monitoring tool in total knee replacement patients.

REFERENCES

P1-41 MEASUREMENT PROPERTIES OF A PARK USE QUESTIONNAIRE AMONG NORTH CAROLINA ADULTS
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INTRODUCTION
Parks provide public space for activities, such as physical activity, to occur. Psychomotorically sound self-report questionnaires to assess park use would be useful when considering surveillance, correlates, and determinants of park use, as well as interventions to increase park use. The aim of this study was to determine the convergent validity and test-retest reliability of a brief questionnaire to assess park use.

METHODS
Forty-nine adult participants living in central North Carolina, United States recruited from six parks (median age 35 years) completed a brief survey on park use once each week, over the course of four weeks. The survey assessed usual and past week park use, duration of park visits, and activities engaged in while at the park. Participants were a global positioning system (GPS) monitor (Qstarz BT-Q1000X) for three weeks. Using an algorithm applied to the GPS data, we determined the number and duration of park visits for each week and on average over the 3 weeks. Validity was assessed using Spearman correlation coefficients (SCC) by comparing usual and past week park use and duration of visits from the questionnaire to the GPS data. Reliability was assessed using percent agreement and SCC by comparing usual park use and duration of visits reported on the questionnaire for each paired week: baseline/1, baseline/2, baseline/3, 1/2, 1/3, and 2/3.

RESULTS
For past week validity, the questions about the past week were compared to average park visit frequency and duration on the GPS during the same week. The SCC agreement on the question about past week frequency of park visits ranged from 0.64 to 0.78, while the question about past week park visit duration ranged from 0.72 to 0.81.

For usual week validity, the questions about a usual week were compared to the GPS findings averaged over 3 weeks. The SCC agreement on the question about usual frequency of park visits ranged from 0.64 to 0.65, while the question about usual park visit duration ranged from 0.40 to 0.62.

The assessment of test-retest reliability using SCC on the usual frequency of park visits ranged from 0.86 to 0.97 (percent agreement 69%-90%). The assessment of test-retest reliability using SCC on the usual duration of park visits ranged from 0.76 to 0.94 (percent agreement 71%-96%).

DISCUSSION AND CONCLUSION
The questionnaire to assess usual and past week park use showed acceptable validity and reliability. This finding should be confirmed in other geographic locations and populations. Acknowledgment: This work was supported by a grant from the National Institutes of Health (#1 R01 HL092569-01A1).

P1-42 WRIST ACCELEROMETER IN ASSESSMENT OF ACTIVITY ENERGY EXPENDITURE DURING INTENSIVE TRAINING PERIOD
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INTRODUCTION
Activity monitoring from the wrist has been found useful and accurate in the measurement of energy expenditure in walking and hiking, but the accuracy has varied in daily tasks and sports activities. We wanted to compare Polar activity monitor and doubly labeled water (DLW) technique in the measurement of activity energy expenditure in military training. The device includes 1D accelerometer and it utilizes a movement counting and filtering procedure in accordance with the European Patent 1532924 [1].

METHODS
Voluntary male conscripts (n=24, Age 19–20 years, VO2max = 30-58 ml/kg/min, Body Mass 56-111 kg) participated in a 7-day study. Their training included typical physically demanding military tasks such as marching, material handling and shooting exercises. In addition to training and recovery in the garrison, they participated in 1-day combat shooting exercise and 4-day overnight field training.

Each conscript wore a custom version of Polar activity monitor (FA20) on the non-dominant wrist. Activity counts were stored in memory at one minute intervals. Curvilinear equation was used to transform the counts to metabolic equivalents (0.9 – 17.5 MET), which were further adjusted by body height. Reference energy expenditure was measured with DLW according to the Maastricht Protocol [2]. Average physical activity level (PAL) was determined for each individual with both methods. Activity energy expenditure was calculated as AEE/kg = (0.9 × PAL – 1) × BMR/Body Mass. BMR was estimated with Schofield equation.

RESULTS
Average PAL (mean±SD) was 2.18±0.18 and 2.18±0.24 MET, and the average daily AEE/kg was 88.8±18.4 and 88.8±23.4 kcal/kg/day measured with Polar activity monitor and DLW, respectively (p = ns). AEE/kg measured by the two methods correlated with r=0.79 (p<0.001). Bland-Altman plot showed a slight negative trend between the mean and the difference of the methods (95% CI: -0.42, p=0.042). Mean absolute difference was 11.6 kcal/kg/day (12.9%).

DISCUSSION AND CONCLUSION
When compared to DLW over 7 days of intensive military training, Polar activity monitor measured similar physical activity level and energy expenditure. Between-method subject variance was smaller in Polar activity monitor than in DLW. As the conscripts basically followed the same daily program, the smaller variance may be related to low sensitivity of accelerometers in general for individual economy of work and amount of load carried.

REFERENCES

P1-43 NOVEL ANALYTIC METHODS TO ESTIMATE PHYSICAL ACTIVITY FROM FREE-LIVING ACCELEROMETER DATA: THE SOJOURNAL METHOD
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INTRODUCTION
An accelerometer records measurements related to a person’s movement, and those measurements have the potential to estimate energy expenditure validity and to uncover the pattern and content of a person’s activities and “inactivities.” New statistical methods have started to realize that potential, but they have mostly been validated in the lab on subjects who do prescribed activities for fixed amounts of time. These methods do not estimate when a subject transitions from one activity to another. In order to use the methods outside the lab in studies of “free-living” people though, data processing methods must both identify homogenous regions of activity / in-activity and estimate the associated energy expenditure and activity mode.
METHODS
This work has two parts. Part 1: We develop neural networks (ANN) to estimate physical activity energy expenditure and mode (activity or inactivity type) from a 1-second epoch hip-mounted single-axis Actigraph data (Staudenmayer et al. [1]). We estimated and validated these methods using indirect calorimetry on subjects tested in 2 labs (n=24 and n=277) who did prescribed sets of activities for fixed durations. Part 2: We examine one subject’s free-living actigraphy in detail to compare two ways of analyzing Actigraph recordings in a free-living setting. One way divides the person’s recordings into minute segments and applies the ANN. The second way is new. It uses a detailed analysis of the Actigraph recordings over time to segment the data into periods of inactivity and “sojourns” of activity and then applies the ANN to those segments.

RESULTS
Part 1: When the model was estimated in lab 1 (n=24) and tested in lab 2 (n=277), estimated METs had a bias = (0.1,0.2) METs (95% CI) and root mean squared error = 1.6 METs. Activity mode was correctly classified for (88%, 92%) of the minutes. Part 2: Detailed analysis of actigraphy from one subject demonstrates that the “sojourn” method can increase the accuracy of estimated MET hours by >10% and provide novel insight into a person’s activity / inactivity patterns.

DISCUSSION AND CONCLUSION
When people do a prescribed set of activities for fixed durations, the ANN provides valid estimates of physical activity from 1-second epoch hip-mounted single-axis Actigraph measurements. In order to apply those methods to Actigraph measurements in free-living settings though, we first need to estimate the activity / inactivity transitions and regions of homogenous activity or inactivity. The “sojourn” method is an innovative approach to make those estimates.

REFERENCES

Supported by: 1RC1HL099557-01 and R01 CA121005-01

P1-44  USING COMBINED ACCELEROMETER AND HEART RATE DATA TO ESTIMATE PHYSICAL FITNESS
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INTRODUCTION
To obtain insight into a subject’s physical fitness and to monitoring training progress of athletes and patients participating in rehabilitation programs, often VO2max, the maximum oxygen uptake during exercise, is used. However, downside of most (sub) maximal exercise tests is that it gives a momentary estimate of VO2max and often the test is too strenuous for the patients to carry out. Ideally, an estimate of VO2max is obtained from monitoring subjects during their daily life activities, without the need for a predefined exercise protocol. As a first step in obtaining VO2max from daily life activities we researched whether we can obtain a VO2max estimate from combining heart rate and level of activity during walking at a treadmill at different speeds.

METHOD
Twenty five healthy subjects (18 male/ 7 female) aged between 21 and 29 years were recruited. Reference VO2max was obtained by performing a sub-maximal single stage treadmill walking test [1]. Daily life walking exercise was simulated by walking at two different speeds on a treadmill (4 and 5.5 km/h), during which heart rate and 3D accelerometer data were measured using a Mobis-19F and MT9b sensor. The relation between measured heart rate and accelerometer output during steady state exercise (>3min) at the different walking speeds was used as indication of exercise intensity. Stepwise linear regression analysis was performed on subject characteristics (age, gender, weight, length, BMI) and intercept and slope of the relation between heart rate and accelerometer output as independent variables for estimating VO2max.

RESULTS
A linear regression model using a combination of slope and intercept parameters of the relation between heart rate and level of activity, together with gender revealed the highest percentage of explained variance (R²=0.92) and had a standard error of the estimate (SEE) of 1.70 ml O2/kg min+1 with VO2max. Fig. 1 shows the estimates versus measured VO2max scores.

P1-45  THE INFLUENCE OF THE ADDITION OF ELECTROMYOGRAPHY OF LOW BACK EXTENDORS TO HIDDEN MARKOV MODELING BASED ACTIVITY CLASSIFICATION
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INTRODUCTION
In previous studies Hidden Markov Modeling (HMM) technology has proven to be a promising technology for classification of human activities in work related situations [1]. Previous studies used 3D acceleration and angular velocity data of sensors on the sternum, sacrum and left upper leg. Results were further improved by pre-processing the data using Principle Component Analysis (PCA). In continuation this paper studies the effect of adding Electromyographic (EMG) recordings of low back extensors.

METHODS
Work related activities were simulated in laboratory based measurements. Three subjects performed sequences of activities (lifting (3 weights), walking, standing and sitting), 3D acceleration and 3D angular velocity data was recorded using 3 MTx sensors (Kesnas, The Netherlands) on the sternum, sacrum and left upper leg. The obtained inertial data was “segment calibrated” [2] to represent the movement of the three body segments, low-pass filtered (10 Hz). EMG data from the left and right m. erector spinae was processed according to Kleissen [3]. All data was down sampled (25 Hz) and normalized using an adapted normalization method in which the standard deviation per signal type (e.g. acceleration) was used for conservation of 3D information. Data was preprocessed using PCA. No data reduction was applied. Activities were manually annotated, including time-stamps as indicated in [1], PCA raked data according to its information contribution, which was used to evaluate the importance of EMG. Classification results with and without EMG data were compared.

RESULTS
In all three subjects EMG data showed a top 10 ranking amongst 20 features. So did acceleration signals in frontal and vertical directions and of the angular velocity in the sagittal direction. Adding EMG improved classification results from 92 to 98%, from 80 to 81%, and from 97 to 99% when weights were neglected. When taking lifting different weights as separate activities (in 1 subject), adding EMG improved classification results from 50 to 78% (no PCA) and from 65 to 89% (with PCA).

DISCUSSION AND CONCLUSION
Fusing heart rate and accelerometer data during steady state activities seems a promising method for ambulant estimation of VO2max. Our results show a good estimation of VO2max which is comparable to commonly used sub-maximal laboratory tests. The next step is to find out whether in daily life sufficient steady state activity moments exist for an accurate estimation of VO2max. Furthermore subject age range and physical fitness level will be extended to get a more generally applicable estimation.

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DISCUSSION AND CONCLUSION

Results show that adding EMG input data to a HMM based classifier improves the classification results in a typical work related application. This is reflected in the contribution ranking of the signals as shown by PCA.

Addition of EMG does not only improve the classification results, but promises to be a base for a ambulatory estimation of back load exposure using limited hardware.

REFERENCES


P1-46

AUTOMATIC IDENTIFICATION OF INERTIAL SENSORS ON THE HUMAN BODY SEGMENTS

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INTRODUCTION

In the last few years, inertial sensors (accelerometers and gyroscopes) in combination with magnetic sensors was proven to be a suitable ambulatory alternative to traditional human motion tracking systems based on optical position measurements. While accurate full 6 degrees of freedom information is available [1], these inertial sensor systems still have some drawbacks, e.g. each sensor has to be attached to a certain predefined body segment.

The goal of this project is to develop a ‘Click-On-and-Play’ ambulatory 3D human motion capture system, i.e. a set of (wireless) inertial sensors which can be placed on the human body at arbitrary positions, because they will be identified and localized automatically.

METHODS

In this study the automatic identification (or classification) of the inertial sensors is investigated, i.e. the automatic assessment of the body segment to which each inertial sensor is attached.

Walking data was recorded from ten healthy subjects using an Xsens MVN motion capture system with full body configuration (17 inertial sensors). Subjects were asked to walk for about 5-8 seconds at normal speed. After rotating the sensor data to the global frame and aligning the walking directions for all the subjects with the positive y-axis, features as variance, mean, and correlations between sensors were extracted from x, y and z-components and from magnitudes of the accelerations and angular velocities. As a classifier a decision tree based on the C4.5 algorithm was developed (with cross-validation) using Weka (Waikato Environment for Knowledge Analysis).

RESULTS

From 31 walking trials (527 sensors), 523 sensors were correctly classified (99.24%). For left/right identification inter-axis correlation coefficients were used. The accelerations of sensors on the right side of the body showed higher correlations between the positive y-axis (pointing to the left) and the positive x-and/or z-axis (pointing to the front and/or up) than the accelerations of sensors on the left side of the body.

DISCUSSION AND CONCLUSION

For human walking, most of the inertial sensors can be identified automatically. Other daily-life activities will be investigated next.

REFERENCES


P1-47

THE PRESENCE AND DURATION OF REACTIVITY TO PEDOMETERS IN YOUNG ADULTS

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INTRODUCTION

Pedometers are increasingly being used to objectively measure free-living ambulatory activity, however the impact of wearing a pedometer, and recording daily step counts, on participants’ activity level has received limited attention. If activity changes as a result of wearing the pedometer, defined as reactivity, this could affect the validity of pedometer-determined activity data. Only when participants are unaware that their activity levels are being monitored (termed covert monitoring) can a true investigation into reactivity be undertaken [1]. Studies employing covert monitoring to examine the presence of reactivity have shown that participants increase their step counts by approximately 1600 steps/day when wearing a pedometer and recording steps in a daily diary [2,3], however the duration of this effect is unknown. This study examined the presence and duration of pedometer reactivity in a sample of young adults.

METHODS

On the first visit to the laboratory 48 participants (88% female: age = 19.1±3.0 years, BMI = 22.7±3.9 kg/m²) were told that they would be participating in the study, provided with a sealed pedometer (New Lifestyles NL-1000) and informed that it was a ‘Body Posture Monitor’ (covert condition). Participants wore the pedometer throughout waking hours for 1 week. Upon return to the laboratory, stored step counts were downloaded and participants were informed that the device was a pedometer. Participants were then requested to wear the pedometer unsealed for 14 days and to record their daily step count in an activity diary (diary condition, week 1 and 2). Mean daily step counts recorded during the covert condition and during the first and second weeks of the diary condition were compared using a repeated-measures ANOVA.

RESULTS

There was a significant overall effect of condition (covert condition = 861±3391 steps/day; diary week 1 = 986±3125 steps/day; diary week 2 = 773±3189 steps/day; F = 13.3, p<0.001), with Bonferroni-corrected post hoc analyses revealing that mean daily step counts were significantly higher in week 1 of the diary condition in comparison to those recorded during the covert condition, and during week 2 of the diary condition (both p<0.001).

DISCUSSION AND CONCLUSION

The current findings suggest that reactivity to wearing a pedometer and recording daily step counts is greatest during the first week of monitoring, however participants are likely to return to their usual activity levels if the monitoring period is extended for a second week. These findings have methodological implications for researchers interested in the use of pedometers for the assessment of habitual ambulatory activity.

REFERENCES


P1-48

SEASONAL VARIATION AND SEX DIFFERENCES IN THE DISTRIBUTION OF STEPPING IN 11-13 YEAR OLD SCOTTISH SCHOOL CHILDREN

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INTRODUCTION

Variability in daily average physical activity (PA) between seasons has been highlighted in studies? Br J Sports Med, 2008; 42: 68-70. for adolescents (1). The majority of studies showed greater activity in spring/summer compared to autumn/winter (2). There is limited evidence of how the distribution of PA changes during the day, between seasons. In this study, PA of Scottish adolescents is reported as ‘step count’ within hourly intervals during the day. It was hypothesised that step count would be greater in summer compared to winter, and that boys’ activity would be higher than girls’ at both time-points.
METHODS
Thirty three participants (baseline mean age = 12.2 years, 54% female) provided seven days of PA data in November/December 2009 and May/June 2010. Step count was measured at each time point using a PA monitor (activPAL

RESULTS
Participants had greater average daily step counts (p<.001) in summer (median=12,878) compared to winter (median=10,512). More steps were taken in the summer compared to the winter from 5-6pm (p=0.03), 6-7pm (p=0.01), 7-8pm (p<0.01) and 8-9pm (p<0.001), but not during school hours.

Total daily steps were higher in summer compared to winter for both boys and girls (boys, p=0.015; girls, p=0.003). There were no significant sex differences at either time point when analyzing total daily step count. However, hourly analysis revealed differences at the summer measurement with boys’ step count greater than girls between 1-2pm (p=0.043), 7-8pm (p=0.032) and 8-9pm (p=0.043).

DISCUSSION AND CONCLUSION
Results support previous research suggesting PA levels are higher in summer compared to winter (2). The hourly analysis revealed that the main differences occurred out of school hours in the evening. The average daily step number was greater in summer than winter for both boys and girls. Based on total daily step counts there were no differences between boys and girls at either measurement point. However, when examined on an hour by hour basis, significant differences between the sexes were seen.

These results demonstrate the importance of taking season into account in exploring longitudinal variation in PA, as the results appear to contradict age related declines in adolescent activity in Scotland (3). The sex difference in summer may highlight the beginnings of the recognised distinction apparent in later adolescence. Future intervention studies should consider both time of year and time of day within their design.

REFERENCES

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P1-50 A PHYSIOLOGICAL ASSESSMENT OF THE HAND DURING COMPUTER OPERATIONS

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INTRODUCTION
Using computers has become common practice at home and in the modern office work place. Keyboard and mouse usage are essential input devices that have been known to trigger the development of work related upper limb disorders (WRULD) [1]. Within the work setting, WRULDs rank highly in the U.K., second only to back complaints. While some studies have shown no strong association of keyboard and computer work in relation to WRULDs such as carpal tunnel syndrome (CTS) [2], many believe computer use provides an excessive occupational risk for CTS [3]. This study investigates the biomechanical and physiological changes at the hand during the operation of a keyboard and mouse.

METHODS
Nine students (5 males and 4 females) aged between 23 and 33 years participated in the study. They were asymptomatic and free from any WRULDs. The office activity experiment was performed using Microsoft Office Word and Excel packages as the following tasks were performed: data entry, mouse clicking and dragging, and mouse scrolling. The duration of the experiment was 30 minutes. Each subject was allowed a 10 second break which entailed resting the wrist and forearm in a neutral position. Participants were a custom-made Lycra® flexible electromyographic glove (FEG) as a comparative study of the left and right hands was performed. The sequence of experiments was randomized and there was no order regarding which hand was tested first.

Hand volume, hand temperature and tendon travel measurements were assessed and analyzed. Descriptive statistics and ANOVA were used to interpret the data.

RESULTS
Both hands presented similar joint motion patterns during the performance of the 30 minute office activity. All participants produced a higher flexor digitorum superficialis (FDS) tendon travel compared to the flexor digitorum profundus (FDP) tendon travel. The mean (SD) for the FDS tendon travel was 9051 (3320) mm and 9712 (4195) mm for the left and right hands while the mean (SD) for the FDP tendon travel was 7514 (4395) mm and 6240 (3473) mm for the left and right hands respectively. Both hands from all participants produced differences (P<0.05) in hand volumetric measurements. Seven out of nine participants produced hand volume increments over 3 ml. The left (and right) hand minimum and maximum temperatures ranged between 29.1°C and 35°C (30.6°C and 36.4°C).

DISCUSSION AND CONCLUSION
The study has shown some potential outcome measurements of the resultant effect of performing office related activities. The tendon travel results provide an in-vivo interpretation of the level of displacements the tendons can undergo. All participants that showed an increment in hand volume subsequently showed a rise in their final hand temperatures. For a better understanding of WRULDs more research is necessary in terms of evaluating hand function from a muscle activity, nerve function and soft tissue perspective.

REFERENCES
CHANGE HAPPEN?

average number of steps taken at different cadences (1-19, 20-39, 40-59, 60-79, steps/day to increases of 2,835 steps/day. Participants who either decreased (DEC) or increased (INC) in the non-purposeful movement cadence levels (i.e., < 60 steps/min) while the changes in those who increased their overall steps/day occurred in the purposeful (i.e., walking) cadence levels. These results provide insights into appropriate cadence targets to increase overall physical activity levels for future interventions.

RESULTS

methods

Female, non-fallers (n=8, gait speed=137(13.8) cm/s), fallers with similar walking speed (n=8, gait speed=88(6.8) cm/s) were recruited from the TRL research clinic (www.trilcentre.org). Participants were kinematic sensors with 6DOF (SHIMMER) on the lower limbs while walking at selected normal speed along a straight clinical corridor for a distance of 30m. The standard deviation of stride time (stride-to-stride variability) was measured by the temporal location of peaks in the accelerometer signal in the sagittal plane, processed using Matlab[7.4). Double support time and stride width were also measured using GAITRite® as a measure of stability in the three groups.

RESULTS

Non-faller Faller (normal speed) Faller (slow speed) Gait Velocity 137(12.7) cm/s 129(13.8) cm/s 88(6.4) cm/s P2.01 = .381 P < .01 Stride-to-stride variability (sd) 0.017 (sec) 0.017 (sec) 0.032 (sec) P2.01 = .85 P < .01 % Double Support Time 22.8(3.1) % 24.4(2.4) % 28.5(2.9) % P2.01 = .94 P > .01 Stride Width 9.5(1.9) cm 8.1(2.2) cm 9.6(2.1) cm P2.01 = 1.05 P > .3

DISCUSSION AND CONCLUSION

In our study comparing fallers walking at different self selected walking speed, the fallers that walked at similar speeds to non-fallers did not differ in stride-to-stride variability, double support time or stride width. Fallers walking at slower self selected walking speed displayed higher stride-to-stride variability and increased the percentage of time spent in the more stable double support phase of gait. It is concluded that some fallers reduce walking speed to increase stability but at a cost of increased variability, which may predispose to further falls.

REFERENCES


P1-51 INFLUENCE OF GAIT SPEED ON VARIABILITY AND STABILITY IN FALLERS

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INTRODUCTION

It has been reported that variability in gait is increased in those with a history of falls, Maki [1]. However it is unclear whether this is an intrinsic feature of fallers or whether variability is influenced by gait speed. This study investigates gait variability and stability in a group of female older people with a history of at least one fall in the previous two years.

P1-52 PATTERNS OF CHANGE IN DAILY STEP COUNTS, WHERE DOES THE CHANGE HAPPEN?

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PURPOSE

To examine the change in the average daily steps taken at different cadence (steps/ min) levels when a change in total steps/day occurs.

METHODS

A total of 43 people participated in a one week intervention with the goal to increase time spent in moderate-to-vigorous physical activity. Participants wore a GT3X accelerometer for 7 consecutive days before and after the one-week intervention. There was a wide range of changes in steps/day, ranging from decreases of 3,900 steps/day to increases of 2,835 steps/day. Participants who either decreased (DEC) or increased (INC) their steps/day by 1,500 steps or more were used in this analysis. The average number of steps taken at different cadences (1-19, 20-39, 40-59, 60-79, 80-99, 100-119, and 120+ steps/min) was calculated for pre- and post-intervention data. Paired sample t-tests were used to compare pre- and post-results within each group.

RESULTS

Although participants (n = 7) averaged 7,259 ± 4,653 steps/day pre-intervention and 5,283 ± 2,898 steps/day post-intervention, IND (n = 9) participants averaged 6,088 ± 2,902 and 8,069 ± 2,963 steps/day pre- and post-intervention, respectively. The results by cadence levels for the DEC and INC groups can be seen in the Table below. Significant differences (p <.05) were found for the 1-19, 20-39, and 40-59 cadence levels for the DEC group and in the 40-49, 60-79, and 80-99 cadence levels in the INC group.

Note: * denotes significance p < .05

CONCLUSION

In this preliminary investigation in a sample of overweight/obese participants, the change in steps/day among participants who decreased their total steps/day occurred in the non-purposeful movement cadence levels (i.e., < 60 steps/min) while the changes in those who increased their overall steps/day occurred in the purposeful (i.e., walking) cadence levels. These results provide insights into appropriate cadence targets to increase overall physical activity levels for future interventions.

P1-53 WALKING STRIDE RATE CURVES IN CHILDREN AND YOUTH WITH THE STEPWATCH

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INTRODUCTION

Interpretation of pedometer- and accelerometer-based walking activity data is currently based on the individual numeric variables of counts, steps or strides/day, percent time active, and/or some metric of intensity of walking activity.[1] This paper describes a novel single format analysis[2] method of walking stride rate data derived from 5 days of StepWatch (SW) data, in typically developing youth (TDY) and explores the stability of curves over a 2-week monitoring epoch.

METHODS

This study developed walking stride rate trajectory curves from a cross-sectional sample of 428 TDY across seven age groups between 2 and 15 years. [3] Curve stability over 2 weeks was examined in 20 children (age groups 5-7 and 10-11 years). The average minutes spent at each stride rate (strides per minute) were calculated across 5 days (4 weekdays and 1 weekend day) to generate a representative stride rate trajectory curve from SW data. Inactivity and peak stride rates were compared across age groups with ANOVA and stability examined with Hotelling’sT2 test.

RESULTS

Time spent inactive each day appears to be a U shaped nonlinear relationship (p < .001) from 2 to 15 years of age. Mean group trajectory curves change with 8- to 15-years-olds demonstrating a greater amount of time in the 40-60 strides/min range than youth 2-7 years. Peak strides/min rates significantly decrease with increasing age (p < .001). Mean stride rate trajectories are similar for boys and girls for ages 2-9 years, with girls less than boys (but not outside the 95% CI) for the 20-60 strides/ min ranges for 10- to 15-year-olds by visual analysis. Stability of the curves over 14 days derived from the summation of 5 days of monitoring suggests no visual or statistical difference (p = .38 -.95).

DISCUSSION AND CONCLUSION

Walking patterns, levels and peak stride rates appear to change with age in TDY. No gender differences were noted with acceptable curve stability within 14 days. This “snapshot” analysis of stride activity with the SW captures day-to-day walking activity in a single visual format combining levels of inactivity, peak stride rates and walking patterns with the mean stride rate trajectory curve. This work lays the foundation for the development of ambulatory activity profiles that are descriptive of the quantitative aspects of walking activity within the context of daily life for children and youth.
INTRODUCTION
Regular physical activity has a beneficial impact on health. Physical activity guidelines recommend a minimum of 30 accumulated minutes of moderate intensity activity for adults on most days, where moderate intensity is described as the equivalent of brisk walking. While exercise has a dose-response relationship with health benefits, little research has been carried out into the environments most likely to generate higher intensity exercise. The aim of this study was to examine the difference between a 30-minute self-paced brisk walk taken in two different environments: park and urban.

METHODS
Participants were instructed to walk briskly for 30 minutes at two predefined locations in Glasgow, Scotland. A researcher followed at a distance. A cross-over design was used with participants carrying out both walks on the same day; Test order was randomised. Cadence was recorded using an achyPAL™ activity monitor attached to the participant’s thigh, and heart rate (HR) using a Polar s610i monitor. Cadence thresholds of 96 steps/minute (men) and 107 steps/minute (women) were used to identify moderate or vigorous intensity exercise[1]. Talled paired t-tests were used to analyse differences in mean cadence and HR between the two environments.

RESULTS
A convenience sample of 40 healthy adults took part (16 male, 24 female, mean age 22.9 ± 5.53 years). 39 of the 40 participants achieved a mean cadence above the minimum threshold required for moderate intensity activity for both walks. There was a significant difference in the mean cadence achieved between the two environments (park: 119.11 ± 8.50 steps/minute (mean ± SD), urban: 110.80 ± 8.95 steps/minute (mean ± SD), < 0.01). Individual walking profiles revealed that participants walked at a similar cadence during both walks, but stopped more frequently during urban walks. The difference in mean cadence is supported by a significantly higher mean HR in 70.5% of the walkers during park walks compared to urban walks.

DISCUSSION AND CONCLUSION
While both environments supported walking at a moderate or vigorous intensity, walkers were able to achieve a higher average intensity of exercise in the park due to the lack of interruptions. Hence, a brisk walk in a park may provide a higher intensity of exercise compared with an urban environment. The physiological effect of the lack of interruptions may provide a higher intensity of exercise in the park due to the participant’s thigh, and heart rate (HR) using a Polar s610i monitor. Cadence thresholds of 96 steps/minute (men) and 107 steps/minute (women) were used to identify moderate or vigorous intensity exercise[1]. Talled paired t-tests were used to analyse differences in mean cadence and HR between the two environments.

REFERENCES

ACKNOWLEDGMENTS
This work was supported by a National Health and Medical Research Council of Australia Early Career Fellowship (GTE161150047).
METHODological problems and potential solutions to extract meaningful and valid information from high dimensional biomedical data sets in general and from genomic and accelerometric data in particular, share common concerns in having to deal with many more variables than patients (p>>n). Apart from secure long-term storage of the heterogeneous data sets, careful selection of the right level of complexity of the models to avoid over-fitting and efforts to validate findings on independent data sets by independent groups is essential.

Various hardware platforms with reasonable design features and a sufficient minimum level of usability, precision and battery lifetime are available for use in clinical trials and in telemedicine applications (actibelt, Mayo biomedical platform, BOSCH motion sensor/BOSCH TeleMedicine Plus) were presented. Some basic algorithms exist, eg step counting, fall detection, velocity estimation, gait asymmetry and balance scores, but more work needs to be done for finding new algorithms and comparing, refining and validating existing ones. The field would benefit from common standards for data collection and comparing algorithms. It seems promising that new, meaningful patient-oriented outcome measures can be extracted from 7-days accelerometry data, but more standardized high-quality data collection, resources for data analysis and agreement on the correct methods for validation will be needed to show, for instance, the surrogate properties of novel outcome parameters.

DISCUSSION AND CONCLUSION

Mobile accelerometry has great potential for improving human health by contributing to the diagnosis of gait and balance disorders in daily life and clinical practice, improving outcome measures in chronic disabling diseases as well as a tool for prescribing and monitoring exercise therapy. It also provides the potential for greater insight into associations between physical activity and disease risks eg, cardiovascular disease either independently or through interaction with genetic variants. Standardization of sampling methods, data formats and validation rules for assessing performance are needed, and sharing and publishing raw data would be advantageous, but entails difficult IP issues. At a later stage decision-support tools may couple information about lifestyle including physical activity profiles and risk genes. This will most likely start with prediction of responders/non-responders to treatment and rare diseases with a strong genetic background component. Independent assessment of the impact of the technologies and tools in clinical practice is desirable.

REFERENCES


P1-56

BOUTS OF PHYSICAL ACTIVITY AND OBESITY IN PRE-SCHOOL CHILDREN

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BACKGROUND AND AIMS

Whether bouts of different physical activity (PA) intensities are associated with body fat in preschool children is not known. The aim of this study was to analyze the association of different intensity bouts of PA with body fat in Portuguese children aged 3-6 years (n=310) during weekdays and weekend.

METHODS

Body fat was assessed by skinfold thickness (SKF) measured at triceps and subscapular. Each skinfold was adjusted for age and sex, and children were assigned to the non-overweight group if they had 2 SKF below the 85th age and sex specific percentile, to the overweight group if they had 1 SKF above the 85th, and to the obese group if they had 2 SKF above the 85th. PA was assessed by accelerometers during at least 4 days (at least 1 weekend). Average weekly number of 1 min bouts of light, moderate and vigorous PA was calculated, and was analysis and grouped by tertiles.

RESULTS

We observed no statistically significant differences between categories of SKF and all intensities of bouts during weekdays (all p>0.05). Likewise, no statistically significant differences were found between categories of skinfolds and bouts of light and moderate PA (p>0.05) during weekends. In contrast, we observed an association between bouts of vigorous PA and body fat during weekends (p<0.009). 84.6% of the children in the lowest third of bouts of vigorous PA were obese.

CONCLUSION

The findings suggest that bouts of vigorous PA during weekends are associated with body fat already at pre-school age.
EXPLORATORY STUDY OF PROMOTING AND MEASURING PHYSICAL ACTIVITY IN ETHNIC MINORITY CHILDREN IN THE UK: THE DASH-DEAL OBESITY PREVENTION STUDY

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INTRODUCTION
There is a critical need for effective models of obesity prevention among children in ethnically diverse settings such as the UK. Ethnic differences in physical activity are evident in UK children [1]. This paper describes the assessment of potential physical activity intervention components and measurement tools during an exploratory obesity prevention study in London, UK.

METHODS
The DiET and Active Living study [1] is targeted towards ethnic minority children and examines schools and places of worship as potential intervention settings. Fifty-five participants (26 girls, 26 boys) were involved in feasibility testing of physical activity measures (ActiHeart, Youth Physical Activity Questionnaire, self-efficacy) and 168 took part in a physical activity related intervention session. Data were collected between September 2008 and March 2009, and analyzed between January and June 2010.

RESULTS
Intervention sessions combining theoretical messages with practical activities provided higher levels of enjoyment among participants than educational sessions. There was no evidence of ethnic or gender bias in the measurement of physical activity, self-efficacy and the evaluation of these measures or potential intervention components with the exception of higher quality ActiHeart data found in girls. Parents and key contacts in the community and congregations were supportive of the initiative. Delivery of intervention sessions and the repeatability of measures in places of worship were, however, compromised by irregular attendance and limited infrastructural support.

DISCUSSION AND CONCLUSION
It was possible to identify the potential content and format of an intervention which would be appropriate for an ethnically diverse sample of children in the UK. The content of the intervention was shaped by the children themselves and contained different activities that everyone enjoyed. Feedback from teachers, parents and key contacts in places of worship signaled approval. Piloted instruments to measure physical activity behavior and self-efficacy appeared to need little cultural amendment. The findings reported here suggest that the feasibility of delivering intervention sessions and the collection of repeated measures may be better in schools compared with places of worship. This highlights the need for a complex framework to address how best to deliver an intervention and also promote long-term compliance in an increasingly diverse society.

REFERENCES

MIXING METHODS TO PROVIDE A HOLISTIC UNDERSTANDING OF ETHNIC DIFFERENCES IN PHYSICAL ACTIVITY BEHAVIOURS OF GIRLS AGED 9-11 YEARS IN TEESIDE

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INTRODUCTION
South Asian minority groups in the UK are at greater risk of heart disease and diabetes than the general White population. Physical activity plays an important role in the onset of these diseases. A recent study using accelerometers showed that girls had lower levels of physical activity than boys, and South Asian girls had lower levels of activity than White girls [1]. However, there is little information available to explain these differences.

This study sets out to provide objective measurements of differences in physical activity levels in White British and British Pakistani girls aged 9–11 years, and by using a range of mixed methods aims to provide a more holistic understanding of physical activity behaviour within these groups. We chose to include only British Pakistani girls as there is good reason to expect important differences between different South Asian groups.

METHODS
Eighty White British and 80 British Pakistani girls were recruited from primary schools on Teeside. The Actigraph GT3, was used to collect objective measurements of physical activity levels and sedentary behaviour for 2 weekend and 2 week days. Three 24-hour activity recalls, including 1 weekend day, were used to characterise types of physical activity behaviour. The physical activity questionnaire for children (PAQ-C) provided self-rated measures of physical activity and variations in activity types. Focus groups were used to investigate differences in attitudes to physical activity. Break, lunch time and after school activity were observed. Parental interviews explored familial influences on children’s physical activity behaviour.

DISCUSSION AND CONCLUSION
Preliminary analyses of Actigraph data and PAQ-C results suggest that British Pakistani girls were less active than White girls. Actigraph data showed that differences in activity were greatest on Saturdays and after school, and recalls, focus groups and parental interviews are used to explain these patterns. Using multiple mixed methods to investigate physical activity behaviours of White British and British Pakistani girls provides an understanding of differences in physical activity behaviours between the two groups and allows us to explore the sources of...
these differences. Such knowledge is vital for the development of effective interventions to increase levels of physical activity.

**REFERENCES**


**P1-61 RELIABILITY OF THE ACCELEROMETER-BASED GAIT MONITORING FOR CHILDREN WITH CEREBRAL PALSY**

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**INTRODUCTION**

Accurate monitoring of pathological gait is significant clinical insights for failing of the children with cerebral palsy (CP). Conventional motion capture systems have been used to monitor gait characteristics. However, the major drawbacks of these systems include expensive cost, lack of portability and difficult clinical settings [1]. Recently, we developed an inexpensive and portable technique using an accelerometer for pathological gait monitoring [2]. In this study, we evaluated the reliability of the developed accelerometer-based gait monitoring technique for children with CP.

**METHODS**

Seven children with CP (age 6.4±1.4 yrs, height 113.0±13.4 cm, weight 21.2±6.2 kg) were recruited from a community hospital. A three axes accelerometer (CXL02LF3, Crossbow, US) was placed on the surface of the 2nd sacrum to detect gait steps. A six optical camera-based motion capture system (Vicon, Oxford Metrics Ltd., UK) as the standard of reference was used to evaluate our technique and two reflective markers were attached on each heel. Both data were synchronously recorded at a sample rate of 120 Hz while the children walked on the 6-meter walkway at their self-selected speed. Detailed measurement protocol was described in [2]. To evaluate the reliability, retest was taken at the same hour of the next week under the control of the same protocol.

**RESULTS AND DISCUSSION**

We evaluated the reliability of developed technique using Bland-Altman plot and correlation statistics. The mean ± standard deviation of the step-time and the accelerometer data along with the 95% limits of agreement (LOA = ±1.96 SD) was 4.11±15.75 ms (LOA = −35.9 ms and 26.8 ms), and retest result was 3.14±11.92 ms (−19.6 ms and 25.9 ms). The correlation coefficient of the step-time between both data was 0.97 (p<0.001) and retest result was 0.98 (p<0.001). These results demonstrated that the developed technique was reliable and suitable for gait monitoring of the children with CP.

**CONCLUSION**

This present study demonstrated the reliability and suitability of the developed technique for children with CP by comparing with the conventional system. Our findings provide clinical insights when designing an inexpensive and portable gait monitoring equipment for evaluation and intervention of the pathological gait. Further researches are needed to research other pathological gait patient groups.

**REFERENCES**


This work was supported by the Industrial Strategic Technology Development Program (10030006, “The Development of Biosignal Convergence OxS Platform for Wellness-Care & Integration Technology”) funded by the Ministry of Knowledge Economy (MKE, Korea).

**P1-62 ACCELEROMETER MEASURED LEVEL OF PHYSICAL ACTIVITY INDOORS AND OUTDOORS DURING PRESCHOOL TIME IN SWEDEN AND UNITED STATES**

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**INTRODUCTION**

It is important to understand the determinants of physical activity needed to influence policy and create environments that promote physical activity among preschool children. Physical activity levels were studied with the aims to compare outdoor and indoor activity and to analyze minutes spent in sedentary, light, moderate and vigorous physical activity in 3- to 5-year-old boys and girls during preschool time in Raleigh North Carolina United States and Malmö Sweden.

**METHODS**

Accelerometer determined physical activity in 55 three to five-year-old children was recorded during preschool time for 5 consecutive days at four sites. The children wore an Actigraph GT1M Monitor.

**RESULTS**

Preschool children spent significantly more time indoors than outdoors (<p<.001). Significantly more moderate and vigorous intensity (MVPA) was observed outdoors (<p<001). The Malmö children performed significantly more counts/min indoors (<p<001) and had a significantly higher percentage of MVPA indoor (<p<001) than the Raleigh children. MVPA during outdoor time did not differ between Raleigh and Malmö.

**DISCUSSION AND CONCLUSION**

In this study we found a difference in objectively measured physical activity among preschoolers aged 3-5 between a US setting and a Swedish setting. Higher levels of objectively measured physical activity (pedometers) in Swedish children compared to US children (age 7-14 years) has been previously reported [1]. This difference, that seems to prevail to at least 18 years of age [2], thus seems to start out as early as at preschool age. Time spent in MVPA at preschool was very short and predominantly adopted outside in both countries. We conclude that outdoor time seems to be a universal trigger of MVPA and should therefore be encouraged.

**REFERENCES**

[1] Vincent, SD, Pangrazi RP, Raustorp A. Activity levels and body mass index of preschoolers aged 3-5 between a US setting and a Swedish setting. Higher levels of objectively measured physical activity (pedometers) in Swedish children compared to US children (age 7-14 years) has been previously reported [1]. This difference, that seems to prevail to at least 18 years of age [2], thus seems to start out as early as at preschool age. Time spent in MVPA at preschool was very short and predominantly adopted outside in both countries. We conclude that outdoor time seems to be a universal trigger of MVPA and should therefore be encouraged.

**P1-63 LIFESTYLE FACTORS THAT INFLUENCE AMBULATORY ACTIVITY IN YOUTH**

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**INTRODUCTION**

Research studies often quantify physical activity in order to determine how an intervention influences physical activity. However, confounding factors can mask the true affects of interventions. Since few studies have attempted to determine the lifestyle factors associated with greater activity, this study investigated the lifestyle factors that have the greatest influence on ambulatory activity of youth.

**METHODS**

The protocol was approved by Western IRB, funded by NIH SBIR grant R44 HD 39036-02, and conducted by Cyma Corporation. Subjects were required to be 10 to 17 years old, ambulatory, no present injury or illness, no history of chronic disease, and a BMI ≤ 39. Following enrollment, subjects were asked 39 questions about lifestyle topics on demographics, occupation, and home life. Subjects then wore a StepWatch activity monitor [1] (Orthocare Innovations, Seattle, WA) for 7 ± 0.6 days. The following activity measures were calculated for each full 24-hour day and then averaged across the included days: 1) Daily steps – strides/day; 2) Peak perf – strides/min of the most
RESULTS
Youth were more active if they had younger siblings (5-10 years old) and less active if they had older siblings (≥16 years old) (Table 1). Since there was no correlation between age of youth and activity levels, the effect of sibling age on activity levels was not found to be significant (p>0.05). The results remained consistent if these factors were unbalanced between control and treatment groups or not (city vs. suburb), and number of days a week on a computer. This is because changes in youth should also monitor the subject’s sibling age (if any), home neighborhood, and future research studies aiming to quantify ambulatory activity effects of interventions during all activities.

Lifestyle Factors

Table 1 — Lifestyle factors that were statistically associated with greater or reduced activity levels in youth (p<0.05). Each arrow represents one of the 11 activity measures.

<table>
<thead>
<tr>
<th>Lifestyle Factors</th>
<th>Increased Activity</th>
<th>Decreased Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live with Children 5-10 years old</td>
<td>↑↑↑↑↑</td>
<td>↓</td>
</tr>
<tr>
<td>Live with Children &gt;16yrs old</td>
<td>↓↓</td>
<td></td>
</tr>
<tr>
<td>Live in the City</td>
<td>↑↑↑↑↑↑↑↑</td>
<td></td>
</tr>
<tr>
<td>Live in the Suburbs</td>
<td>↓↓↓↓↓↓↓↓↓</td>
<td></td>
</tr>
<tr>
<td>Days on Computer</td>
<td>↓↓↓↓↓↓↓↓</td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSION
Future research studies aiming to quantify ambulatory activity effects of interventions in youth should also monitor the subject’s sibling age (if any), home neighborhood (city vs. suburb), and number of days a week on a computer. This is because changes in these lifestyle factors could influence ambulatory activity and, therefore, confound results if these factors are unbalanced between control and treatment groups or not controlled in the statistical analysis.

REFERENCES

P1-64 THE USE OF AN ACTIVE COMPUTER GAME TO INCREASE ENERGY EXPENDITURE

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INTRODUCTION
An increase in the use of multimedia devices was observed especially in children [1]. At the same time reduced physical activity is a major topic in more and more investigations concerning childhood. No direct correlation between the use of computer games and reduced physical activity was determined however nowadays active computer games try to link multimedia use and physical activity. Aim of the study was to assess the level of exertion reached by playing Tennis and Boxing on the Nintendo wii.

METHODS
The study included 20 participants between 10 and 17 years of age (Table 1). On the Nintendowii the following activities were assessed: playing tennis while sitting (Tsit) and while standing (Tstand), boxing seated (Bsit) and standing position (Bstand). Furthermore sitting/resting (Rest) and running on a treadmill at self-selected (Run) were assessed to gain reference values. All activities were conducted for seven minutes followed by 3 minutes of rest. The order of activities was randomly assigned. During all activities Participants heart rate (HR) was measured with a Polar heart rate monitor and energy expenditure (EE) was assessed with the Sensewear Pro 2 Armband.

Table 1: Participants anthropometric data

<table>
<thead>
<tr>
<th>Participants</th>
<th>Age (yrs)</th>
<th>Height (m)</th>
<th>weight (kg)</th>
<th>BMI (kg/m2)</th>
<th>female/male</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.8 ± 2.0</td>
<td>1.61 ± 0.14</td>
<td>50.5 ± 12.3</td>
<td>16.3 ± 6.6</td>
<td>14/7</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: HR and Mets during different activities

<table>
<thead>
<tr>
<th>Rest</th>
<th>Run</th>
<th>Tstand</th>
<th>Tsit</th>
<th>Bstand</th>
<th>Bitt</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR (beats/min)</td>
<td>80.3 ± 12.9</td>
<td>140.2 ± 16.8</td>
<td>105.3 ± 16.5</td>
<td>93.4 ± 13.5</td>
<td>119.6 ± 20.6</td>
</tr>
<tr>
<td>EE (mets/h)</td>
<td>1.5 ± 0.6</td>
<td>6.6 ± 1.8</td>
<td>5.3 ± 2.3</td>
<td>4.7 ± 2.7</td>
<td>6.5 ± 2.0</td>
</tr>
</tbody>
</table>

P1-65 USE OF 3-Axis ACCELEROMETER TO ASSESS ACTIVITY AND POSTURE IN CHRONIC PAIN PATIENTS RECEIVING SPINAL CORD STIMULATION THERAPY

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INTRODUCTION
Chronic pain patients’ report of activity can be problematic and may not reflect true activity levels. An objective measurement of activity would provide a more accurate picture of patient function for use by pain clinicians and clinical researchers. Furthermore, longitudinal posture detection (lying on the back or side, sitting, or standing) may provide additional important functional information not captured in other activity monitoring devices. This study was devised to determine the usefulness and validity of an objective activity recording device for persons receiving spinal cord stimulation (SCS) therapy.

METHODS
This prospective, multi-center, open label, feasibility study is being conducted to evaluate activity and posture parameters collected via a Micro Ambulatory Data Recorder (Micro ADR). The Micro ADR is a small, waterproof custom-made research tool. It attaches to the patient via an adhesive bandage and records posture and activity over the course of multiple days. The Micro ADR samples the 3-axis accelerometer every 5.125 s (0.2 Hz). Patients with chronic low back pain who were considered for SCS as a part of their normal medical treatment (independent of the study) were recruited for this study. Accelerometer and health assessment data (Visual Analog Scale (VAS) for pain, Roland Disability Scale (RDS), and others) were collected at baseline, during device trial, post-implant, and at 4, 12, and 24 weeks following the SCS trial. All subjects completed pre and post questionnaires and entered daily ratings of pain and activity on an eDiary.

RESULTS
Fifteen subjects were enrolled and identified as responders to SCS therapy. Health assessment data were evaluated, comparing baseline to SCS trial. The VAS pain score changed significantly from 5.7 ± 2.8 to 3.1 ± 2.6 (p<0.05). The RDS showed an average improvement of 15% (n.s.). Correlations between the accelerometer data and eDiary data suggest adequate reliability and validity of the Micro ADR.
DISCUSSION AND CONCLUSION
This on-going validation study will continue to assess the relationship between physical activity and posture parameters derived from tri-axial accelerometry and self-report measures. Initial results suggest that the Micro ADR is a reliable and valid objective measure of function among persons with back pain undergoing SCS therapy. The Micro ADR is an investigational device and is not approved for commercial use. This research is supported by Medtronic, Inc.

MEASURING SITTING AND STANDING AT WORK SEPARATELY: VALIDATING THE BRIEF OCCUPATIONAL SITTING AND PHYSICAL ACTIVITY QUESTIONNAIRE (OSPAQ)

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INTRODUCTION
Sitting at work is an emerging occupational health risk [1]. Few instruments designed for use in population-based research measure occupational sitting and standing as distinct behaviours [2]. The aim of this study was to develop and validate a brief measure of occupational sitting and physical activity.

METHODS
A convenience sample (N=99, 61% female) was recruited from two medium-sized workplaces and by word-of-mouth in Sydney, Australia. Participants completed the Occupational Sitting and Physical Activity Questionnaire (OSPAQ) on two occasions, one week apart. On each test occasion, participants reported the time they spent sitting, standing, walking and doing physically demanding tasks at work (OMS-percent, proportion of workday; and OMS-min, minutes per workday). Participants also wore an Actigraph accelerometer for the seven days in between the test and retest, recording the times they wore the accelerometer, the days they worked, and their work times in a logbook. Analyses determined test-retest reliability with intraclass correlation coefficients (ICC) and assessed criterion validity against accelerometers using Spearman’s rho.

RESULTS
The test-retest ICCs for occupational sitting, standing and walking ranged from 0.73-0.90 for OSPAQ-min and ranged 0.75-0.95 for OSPAQ-percent. Spearman’s correlation coefficients between accelerometer-measured sedentary time at work and self-reported sitting time at work suggested moderate to high correlations (OMS-min, r=0.65; OMS-percent, r=0.50). Moderate validity correlations were found for measuring standing at work (OMS-min, r=0.49; OMS-percent, r=0.54). Validity correlations for measuring walking at work were lower (OMS-min, r=0.29; OMS-percent, r=0.28).

DISCUSSION AND CONCLUSION
The OSPAQ has excellent test-retest reliability and moderate to high validity for estimating relative and absolute time spent sitting and standing at work and is comparable to existing occupational physical activity measures for assessing time spent walking at work. Future research would help refine the OSPAQ by investigating the generalisability of the instrument to other population subgroups, such as men with lower levels of education, and workers in less sedentary or more physically active or demanding occupations.

The OSPAQ brief instrument measures sitting and standing at work as distinct behaviours and would be suitable for use in large samples and in studies measuring numerous health behaviours and outcomes.

REFERENCES
FALL DETECTION METHOD FOR ELDERLY PEOPLE WITH WEARABLE SENSOR

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INTRODUCTION

Societies are rapidly aging and more elderly people are living alone. About one in three fall each year leading to serious injury and even death. Therefore, falls must be detected immediately even in private houses. We already proposed and evaluated a fall detection method with a wearable sensor [1]. Its fall detection rate was 100% for all 420 events in an experiment, comparable to other studies [2]. However, the subjects were young people since the elderly cannot perform intentional falls due to risk of injury. As a first step, this paper proposes a fall detection method and evaluates it using an experimental approach that simulates the elderly.

METHODS

Three voluntary subjects wearing a Hitachi Wireless-T unit on their right waist performed intentional falls and other actions. All subjects were males, ranging in age from 22 to 24. The sensor captured acceleration and angular velocity data, simultaneously. All performed 4 types of intentional falls (forward falls from standing position and tripping, and lateral, and backward falls from standing) and other 6 actions for daily activities (regular walking, stair walking, walking with luggage, standing up and sitting down from a chair, lying in bed, and running). Falls from a semi-collapsed position were performed in a laboratory environment. The other actions were also slowly performed. The fall detection method described here is an extension of [1] with a different threshold value. Both methods (original and enhanced) were compared. Subsequent trials will increase the number of subjects and involve elderly subjects.

RESULTS

Table 1 shows fall detection rate. These results confirm that the fall detection method is effective for the elderly.

DISCUSSION AND CONCLUSION

This paper proposed an enhancement of our previous fall detection method for elderly people. Our future work will increase the number of subjects and samples, including with elderly people in future work.

REFERENCES


SEDENTARY BEHAVIOUR AND PHYSICAL ACTIVITY IN OLDER ADULTS: LIVEWELL

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INTRODUCTION

Clinical trials in older adults (OA) have shown that increased physical activity (PA) raises energy and overall levels of wellbeing [1]. The aim of this pilot study was to assess the physical activity profiles of OAs in the peri-retirement period (55-70yrs) and examine the interplay between sedentary behavior and bouts of physical activity as part of the LiveWell project. Of special interest were the bouts of prolonged (sustained) activity. Through such analysis LiveWell aims to promote a healthier lifestyle by enabling OA to change/increase their PA.

METHODS

Five retired older adults (1 F, 4 M) aged 60-70 (64.4 ± 2.7yrs, BMI 26.3 ± 2.2) were recruited. The participants wore the validated activPAL™ physical activity logger for a continuous period of 24h [2]. Minutex® processed the activity data and categorised moments of activity based upon pre-determined activity bouts of: Short (1-19 seconds), Moderate (20-59s), High (60-299s), Prolonged (300+ s). These bouts are measured as counts. The program also calculated the number of steps for prolonged bouts of stepping (walking) and compared this with total number of steps.

RESULTS

On average, the group spent 74.8% sitting/lying, 14.7% standing and 10.5% stepping i.e. <1 minute. Some OA (n = 2) participated in no (meaningful) prolonged bouts of stepping i.e. <1 minute. Some OA participated in no (meaningful) prolonged bouts of stepping, though initial analysis showed that those OA completed 6000-7500 steps during the 24h period. This represents an important aspect of ambulatory activity distribution based upon the pre-determined activity bouts. For the prolonged activity bout (300+ s) the OA’s number of steps averaged 2825 (range, 0-8184), equivalent to just 22.7% of total stepping time.

DISCUSSION AND CONCLUSION

Analyses from this pilot study show that there were very few prolonged bouts of stepping and sedentary behavior was interrupted by generally only short/moderate bouts of stepping i.e. <1 minute. Some OA (n = 2) participated in no (meaningful) prolonged bouts of stepping, though initial analysis showed that those OA completed 6000-7500 steps during the 24h period.
function in OA and represents fewer patterns of activity. This inactivity could lead to adverse effects on cardiovascular function and other health outcomes later in life. LiveWell will analyse data, such as these, to develop interventions which encourage OA to change/increase their patterns of PA.

LiveWell is funded by the Lifelong Health and Wellbeing initiative - a funding collaboration between the UK’s research councils and Health Departments

REFERENCES


P1-71 OBJECTIVE PHYSICAL ACTIVITY MONITORING OF OLDER PATIENTS

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INTRODUCTION

Older patients in hospital undergoing rehabilitation have been shown to spend a limited time engaging in upright activities and periods of unbroken sedentary behaviour have been reported [1,2]. The benefits of physical activity to health and function are well established and the detrimental effects of sedentary behaviour are increasingly being recognised. Consequently, any interventions which modify these behaviours are of interest to clinicians. The purpose of this study was to examine if a physical activity monitoring technique could be used in a hospital setting to determine changes in the levels and patterns of physical activity following an intervention.

METHODS

The postural physical activity of two independent groups of patients, aged ≥ 65 years, in a rehabilitation hospital was recorded. Participants were medically stable and undergoing rehabilitation in which promoting physical activity was a primary aim (exclusions: score <10 on the Elderly Mobility (EMS) scale and/or ≤8 in the Abbreviated Mental Test (AMT)). Between the measurement periods, the physiotherapy service within the hospital was altered. The participants’ postural physical activity was recorded continuously, over a week, using a small body-worn physical activity monitor (activPAL(TM)). Minutes of upright time (standing/walking) for every hour on all days was calculated for each participant in both groups and the results explored using a three-way ANOVA. Differences in demographic and functional data were investigated using Mann-Whitney tests.

RESULTS

Data were retrieved from 40 patients (20 in each group). No differences were found between groups in age or AMT, however, the EMS test was significant suggesting the post-intervention group was functionally more able. The daily upright time for the groups was: pre-intervention 72.1±47.1 min; post-intervention 65.0±24.8 mins (mean±sd). The ANOVA revealed no significant difference in upright time averaged over the day between groups (p=0.27). However, there were significant main effects of day and hour (p<0.01). Activity on Sundays was less than weekdays. The pattern of upright activity across the day showed the past-intervention group to be more active earlier in the day.

DISCUSSION AND CONCLUSION

The global measure of daily mean upright time revealed no difference between the groups, however, it was possible to identify more subtle differences in behaviour using a continuous monitoring technique. As part of the intervention, patients were given more help in the morning to allow physiotherapy to start earlier in the day and this may be reflected in altered activity patterns.

REFERENCES


P1-72 BASELINE SEDENTARY BEHAVIOUR OF OLDER ADULTS RECRUITED TO A PRIMARY CARE-BASED WALKING STUDY

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INTRODUCTION

Research has shown that physical activity and sedentary behaviour are independent risk factors for the development of chronic disease [1]. Furthermore, it is apparent that the way in which sedentary behaviour is accumulated is pertinent, with prolonged, uninterrupted sedentary events being a greater risk factor [2]. Although a day to day routine can be amongst the most inactive in society, little objective information is known about the sedentary behaviour of older adults. The purpose of the study was to explore the sedentary behaviour, at baseline, of adults aged ≥65 years enrolled in a primary care-based walking study.

METHODS

Participants were patients aged ≥65 years from a medical practice in Glasgow. From the practice list, a GP screened out patients who were medically unsuitable for the study. The remaining patients were eligible if they lived independently and did not meet physical activity guidelines. Postural physical activity was recorded continuously, over a week, using a body-worn physical activity monitor (activPAL(TM)). Mean daytime (between 08.00 and 20.00) and hourly sedentary (sitting/walking) behaviour was calculated for the group. Periods of daytime sedentary behaviour were categorised according to the length of the event (<30 minutes, 30-60 minutes and >60 minutes). The mean number of events and time spent in each category were calculated for each day.

RESULTS

287 older adults were identified from the practice and of these, 41 met the inclusion criteria and agreed to participate in the study. Baseline activPAL™ data were retrieved from 37 participants (13 men); age 70±5.4 years (mean±sd). Participants were found to be sedentary for 59% (7.1±1.4 hours) of the 12 hour daytime period (08.00-20.00) and this was accumulated in 37±8 events. Most events (69.3%) were less than 30 minutes duration and these made up 48% of the total sedentary time. Although accounting for only 3.5% of events, 27% of time was accumulated in uninterrupted sitting events lasting more than an hour. The remainder (7.2% of events and 25% of time) was attributed to sitting periods of between 30-60 minutes. For individual participants, the longest uninterrupted sitting event ranged from 1.0 to 5.7 hours.

DISCUSSION AND CONCLUSION

In this group of older adults, who were not active at a level recommended for health, a large proportion of the daytime was spent in sedentary pursuits. A considerable proportion of this time was accumulated in long uninterrupted events. Public health guidelines are primarily directed at promoting physical activity rather than limiting sedentary behaviour. As it is an independent health risk factor, additional advice concerning sedentary behaviour would complement the active living public health message.

REFERENCES

DISTRIBUTED PARTNERS, THE ASSISTED LIVING ВАСИХ РЕАКЦИЙ НА ОПОРУ РИСОВАНИЯ

**P1-73**

**DETERMINANTS OF SEDENTARY BEHAVIOR IN RESIDENTS OF ASSISTED LIVING**

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**INTRODUCTION**

Older adults over age 65 are the fastest growing segment of the Canadian population, and are expected to more than double in number by 2031 [1]. Assisted living (AL) residences represent a semi-independent form of housing for individuals who are able to make decisions, but require assistance with tasks such as shopping, food preparation, and housekeeping. As a middle option between home support and institutional care, AL continues to grow in Canada. A necessary goal of AL facilities is to promote physical activity and reduce sedentary behaviours among residents [2]. However, little is known about the baseline physical activity patterns of older adults residing in AL. In the current study, we tested the hypothesis that activity patterns in AL residents (as recorded by wearable accelerometers) would associate with measures of physical, cognitive and psychosocial function.

**METHODS**

We recruited 124 participants (of mean age 67 yrs, SD = 7) from thirteen AL sites. Each participant wore a waist-mounted accelerometer (model GT1M, Actigraph, Pensacola, FL) for between one and seven consecutive days. We only analyzed periods where the unit was being worn (neglecting segments where activity = 0 for longer than one hour), and regarded sedentary behaviour as fewer than 50 counts/minute. For each participant, we also acquired data using the Timed Up and Go (TUG), Short Physical Performance Battery test (SPPB), Montreal Cognitive Assessment (MoCA), Modified Falls Efficacy (MFE) and Short Geriatric Depression Scale (GDS). We used MATLAB and SPSS software in data analysis.

**RESULTS**

On average, participants spent 88.4% ± 4.8 of their waking hours in sedentary behavior. Activity count was associated with scores on the TUG test (p<0.001), SPPB (p=0.008), MFE (p=0.024) and GDS (p=0.044).

**DISCUSSION AND CONCLUSION**

Participants in our study spent an average of 88.4% of their waking hours in sedentary behavior, which is much higher than previously reported for community-dwelling seniors. This may relate to the reduced need for AL tenants to cook or clean, and the small distance between apartments and amenities. These results suggest that efforts are required to design programs of physical activity to decrease sedentary behaviors in AL residents.

**REFERENCES**


**P1-74**

**COMPARING CADENCE-DETERMINED MVPA TO ACTIGRAPH-DETERMINED MVPA IN OLDER ADULTS**

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**INTRODUCTION**

Common physical activity guidelines for adults recommend 30 minutes of daily physical activity at a moderate-to-vigorous intensity (MVPA ≥ 3 METs). Tudor-Locke et al. [1] found 3 METs corresponded to walking at approximately 100 steps·min⁻¹, subsequently Rowe et al. [2] developed 3 MET cutpoints for height/stride length. The purpose of this study was to compare cadence-determined MVPA to accelerometer-determined MVPA from a norm- and criterion-referenced perspective in older adults (OA).

**METHODS**

Physical activity was measured over 7 days in 70 adults aged over 60 yr, using Actigraph 7164 accelerometers. Daily minutes of MVPA were calculated using the Freedson 1995 2.5·min⁻¹ cutpoint[3] (Freedson-MVPA), Tudor-Locke 100·min⁻¹ cutpoint (100steps-MVPA) and Rowe height-related cadence cutpoints (Ht-MVPA). Means were compared using a dependent 1-way ANOVA, associations were estimated using intraclass correlation coefficients (ICC; 2-way ANOVA model), and criterion-referenced agreement was evaluated using modified kappa, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV), with days classified as either “meeting” (>30 mins) or “not meeting” (<30 mins) the recommended daily amount of MVPA.

**RESULTS**

Mean ± SD daily MVPA minutes were 14.63 ± 21.04 (Freedson-MVPA), 8.49 ± 15.66 (100steps-MVPA) and 6.63 ± 13.85 (Ht-MVPA). Mean Freedson-MVPA minutes were significantly (p < .05) and meaningfully (Cohen’s d = 0.33 and 0.46) higher than both cadence-determined estimates of MVPA minutes. 100steps-MVPA minutes were also significantly (p < .05) but trivially (Cohen’s d = 0.13) higher than Ht-MVPA minutes. ICC was high between Freedson-MVPA minutes and both 100steps-MVPA minutes (ICC = .83) and Ht-MVPA minutes (ICC = .80). For identifying days that met/did not meet recommended daily MVPA time, cadence-determined MVPA and Freedson-MVPA showed generally high agreement (modified kappa = .81 and .78) with high positive and negative predictive results (PPV = .98 and .90, NPV = .89 and .91). Specificity was high (.98 and .99), but sensitivity was very low (.43 and .53).

**DISCUSSION AND CONCLUSION**

In OAs, there is a strong relationship between cadence-determined MVPA and Freedson-MVPA time, although estimates of mean MVPA time were lower when determined by cadence than by the Actigraph/Freedson method. Most criterion-referenced measures of agreement were high, except that sensitivity was very low. This could be due to systematic bias for OAs of either recently-developed cadence guidelines, or of the Freedson cutpoints, or both. Further research is needed into the use of the Freedom Actigraph equations and cadence equations for estimating METs in OAs.

**REFERENCES**


**P1-75**

**PHYSICAL ACTIVITY AND MOVEMENT PATTERNS OF COMMUNITY-DWELLING OLDER ADULTS PARTICIPATING IN A HOME-BASED FALLS PREVENTION INTERVENTION: A PILOT STUDY**

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**INTRODUCTION**

In light of the ageing global population and the increasing focus on preventative healthcare, effective interventions to prevent falls among community-dwelling older adults are widely sought-after. Evidence suggests that exercise and home modification are the most effective single interventions for preventing falls among community-dwelling older adults [1]. However, the effects of such interventions on both objective markers of movement performance and daily physical activity patterns of older adults are not well understood. Thus, the aims of this pilot study were to assess the feasibility of objectively assessing and monitoring physical activity and movement patterns of community-dwelling older adults who participated in a home-based falls prevention intervention.

**METHODS**

Participants (n=4) aged over 75 years who were identified by their general practitioners as being at risk of falling were invited to undertake an intervention consisting of home environmental assessment and modifications, strength and balance training, and a walking program. Those who consented participated in the intervention which was implemented over 5 home visits − 2 by an occupational therapist and 3 by a physiotherapist. At baseline and 12-week follow-up accelerometer and gyroscope data were collected in the home during scripted activities (Chair Stand Test, 4-Test Balance Scale, Timed Up and Go) using a system of 5 sensors (Shimmer Research, Dublin, Ireland). Sensors were located at the chest, trunk, waist and pocket, with a push-button sensor also used to identify the onset and completion of each activity. Free-living physical activity patterns were also monitored at baseline and follow-up for 3 days using a single waist-mounted accelerometer.

**RESULTS**

Results pending (study due for completion January 2011). It is anticipated that the results will display physical activity patterns over 3 days in participants before and after intervention. In addition, information on movement patterns during scripted
activities before and after intervention will be obtained. The researchers also expect to provide useful evidence to support future work in this area, since feasibility issues - as well as baseline and follow-up characteristics - will be identified.

DISCUSSION AND CONCLUSION

It is anticipated that the results of this study will provide valuable pilot information on the effects of a home-based falls prevention intervention on patterns of physical activity and movement in older adults, and also indicate the utility of wearable sensors for objectively monitoring both physical activity and movement during assessment of clients in the home. It is hoped that this data will inform future work in this area.

REFERENCES


P1-76 PHYSICAL ACTIVITY LEVELS FOLLOWING FUNCTIONAL MANAGEMENT OF ACUTE ANKLE SPRAINS

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INTRODUCTION

Ankle sprains are one of the most common forms of soft tissue injuries. The majority of acute ankle sprains are managed functionally, involving mobilisation, with instructions on early ambulation. However, there are significant variations in clinical recommendations for managing these injuries. The objective of this study is to describe the free-living physical activity (PA) levels of participants in a randomised controlled trial, treated with two types of functional treatment.

METHODS

Participants aged 16-65 years with an acute ankle sprain were recruited [1], from a Hospital Emergency Department or University Sports Injury Clinic. Individuals were randomly allocated to one of two functional treatment groups. The standard treatment group (n=16) were given written advice on applying ice and compression and early weight bearing/walking. Participants in the exercise group (n=18) were given the same advice plus a range of therapeutic non-weight bearing exercises. An un-injured control group (n=18) were recruited from the university staff list for comparison.

PA was measured using an activPAL accelerometer, attached to the injured leg and worn for 7 consecutive days, beginning in the 48 hours after injury. The activPAL device infers posture from the position of the thigh and classifies it as sitting/lying, standing or walking. Reported ICCs for inter-device reliability range from 0.79–0.97 [2]. Levels of free-living PA were reported as the mean number of steps, time spent sitting/lying, standing and walking, the number of times each individual stood up and sat down per day. Time spent in light, moderate and high intensity exercise per day was calculated using pre-defined walking speeds [3].

RESULTS

The standard group spent significantly less time walking (1.22 hours/day) and took fewer steps (5621 steps/day) compared to both the exercise group (1.66 hours/day, p=0.04, 7886 steps/day, p=0.03) and the un-injured control group (1.7 hours/day, p=0.02, 8844 steps/day, p=0.002). Compared to the un-injured control group, both the standard and exercise groups spent less time in moderate intensity (14.49 mins/day, p=0.001 & 22.51 mins/day, p=0.003 respectively) and high intensity activity (0.07 mins/day, p=0.001 & 0.02 mins/day, p=0.005 respectively).

DISCUSSION AND CONCLUSION

PA levels after ankle sprain are lower than those of un-injured individuals, with most limitation placed on moderate and high intensity activities. There was also evidence that normal PA is most likely to be maintained by initiating a therapeutic exercise program in the acute phases.

REFERENCES


P1-77 UPRIGHT WALKING ACTIVITY AFTER SPINAL CORD INJURY

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INTRODUCTION

Regaining walking ability is an important aim of rehabilitation for the spinal cord injured (SCI) patient and it is estimated that up to one third of patients recover some walking ability during their rehabilitation [1]. For many, walking is their primary means of physical activity; however their physical activity levels are unknown. The purpose of this study was to monitor and compare the upright walking physical activity levels of SCI patients in the rehabilitation setting, in their late stages of rehabilitation, and at two time points following discharge from hospital.

METHODS

Nine heterogeneous patients (7 male, 2 female. 51.6±13.9 years, SCI level C4-L3 ASIA C-D) were recruited from the Queen Elizabeth National Spinal Injury Unit, Glasgow, UK. Participants walked independently using crutches (n=5), unilateral stick (n=3) or a walking frame (n=1). Upright activity was measured for seven consecutive days using the activPAL physical activity monitor (Pal Technologies Ltd, Glasgow, UK). Patients were measured at three time points, rehabilitation setting (n=9), six weeks (n=7), and six (n=8) months after discharge from hospital.

RESULTS

In the rehabilitation setting patients achieved an average of 1,062 steps/day (range 67–3,239 steps/day), spending an average of 1.28 hrs upright (range 0.28–3.25 hrs), with an average of 23 sit-to-stand (STS) transitions (range 5–67). Six weeks after discharge patients achieved 1,074 steps/day (range 44–3,762 steps/day), spending an average of 1.24 hrs upright (range 0.12–2.33 hrs), with an average of 23 STS transitions (range 5–64). At six months after discharge patients achieved an average of 2,118 steps/day (range 69–5,136 steps/day), spending an average of 2.95 hrs upright (range 0.57–4.48 hrs), with an average of 32 STS transitions (range 5–75).

DISCUSSION AND CONCLUSION

This study found that physical activity levels due to walking were lowest in the rehabilitation setting. Outcomes of steps/day, upright time and STS transitions greatly increased at six months after discharge in comparison to the rehabilitation setting and six weeks after discharge. This may be because over time patients have improved confidence, endurance and walking ability. Within the group, however, individual physical activity profiles could vary greatly between patients. It is important that rehabilitation provides the appropriate input to encourage patients with SCI to be physically active, to live fulfilled lives in the community and to reduce the incidence of secondary complications after SCI.

This study was funded as part of a PhD studentship at Glasgow Caledonian University.

REFERENCES

RESULTS
In the rehabilitation setting patients propelled their wheelchair for an average of 1.02±1.1 hrs (maximum 5.53hrs) and travelled a distance of 2.63±0.67km (maximum 8.41km). Six weeks after discharge patients propelled their wheelchair for an average of 1.12±0.9hrs (maximum 4.22hrs) and travelled a distance of 1.81±1.79km (maximum 6.62km). Six months after discharge patients propelled their wheelchair for an average of 0.92±0.94hrs (maximum 3.52hrs) and travelled a distance of 1.88±2.21km (maximum 8.74km). Overall, patients had an average speed of 6.48km/hr.

DISCUSSION AND CONCLUSION
In this study patients tended to propel further in the rehabilitation setting than in the community setting at both six weeks and six months after their discharge. Mean times spent mobilising were similar at all three time points, with a tendency for this to be lower six months after discharge than in a rehabilitation setting. This may be due to changes in the environment with difficulties propelling a wheelchair within the home and in the community. Some patients may have spent more time in walking activities. This is a novel technique which can be used to monitor physical activity in populations such as SCI.

REFERENCES

P1-79 A FEASIBILITY STUDY ON MOBILE ACCELEROMETRY AS A TOOL TO MEASURE PHYSICAL ACTIVITY IN MULTIPLE SCLEROSIS PATIENTS
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INTRODUCTION
Physical activity (PA) can be used as outcome measure to allow an objective evaluation of long-term disability. At the same time it can be used as treatment option at all stages of the neurodegenerative disease Multiple Sclerosis. In order to accurately quantify the exact “dose of treatment” for exercise therapy with PA, reliable devices and measurements are needed to assess the PA of MS patients in daily life. Aim of this study was to explore the usability of accelerometry in an exercise therapy setting and the association between disease status and physical activity as a biomarker.

METHODS
In an exploratory study 19 MS patients performed a week measurement of PA, which was assessed with the tri-axial accelerometer actibelt® [1] and Baecke questionnaire. Exercise capacity VO2max was measured by spiroergometry. Collected acceleration data were pre-processed by noise filtering and compared with MS relevant patient data: sex, age, height, weight, MS course, EDSS, VO2max, social status, work-, sport- and leisure-time index. Parameters extracted from the acceleration data were activity temperature (i.e. the mean activity over a certain period), walking speed, number of steps, step length, active and exercise minutes, coherence length and adherence. Spearman correlation coefficients and multilinear model coefficients together with a step-wise model selection procedure were used to assess the association between patient data and accelerometry parameters.

RESULTS
Data on 19 patients (17 female, 2 male; mean age 41.6±11.1) were available for analysis. Clinical patients characteristics were EDSS range 1.5–6, MS course: 14 RRMS, 5 SPMS, mean VO2 max 23.9 ± 5.9 ml/kg/min. 75% of patients were the actibelt® >10hrs per day on average (mean 12±5.9 h). Walking speed was significantly associated with age (<0.033, p=0.004), VO2 max (0.632, p=0.005) and EDSS (0.584, p=0.011). The final multiple model for walking speed which was adjusted for all baseline variables included EDSS (-0.089, p=0.001), sex (-0.107 male ref. female, p=0.039), social status (-0.015 homemaker, 0.136 retired, 0.143 unemployed ref. employed, p=0.011), sport index (0.039, p=0.102), and VO2 max (0.010, p=0.005).

DISCUSSION AND CONCLUSION
Patient adherence suggests a high usability and confirms results from earlier, independent studies. Meaningful parameters which show plausible interactions with patient data can be extracted from week measurements. The actibelt® platform may be used to analyse the impact of exercise therapy on novel, patient-oriented outcome measures (e.g. walking speed).

REFERENCES

P1-80 PHYSICAL ACTIVITY OF ELDERLY STROKE PATIENTS DURING REHABILITATION
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INTRODUCTION
In older adults physical activity (PA) is promoted for public health preventive efforts as well as it is a major target in the rehabilitation process. Up-to-now assessment tools of motor performance are prone to floor or ceiling effects and do not include any aspect of participation during rehabilitation. The aim of the study was to document progress in stroke rehabilitation not only by measures of physical capacity, but also by measures of PA without floor or ceiling effects.

METHODS
Ninety-two stroke patients of a geriatric rehabilitation unit (mean age 82 years, 61% women) were included into this observational study. Physical capacity was assessed at admission (T1) and 2 weeks later (T2) by the single tests of the Short Physical Performance Battery [1], including balance in unsupported standing, repeated chair rise and gait speed. PA was measured over 9 hours starting at 9 AM through an ambulatory activity monitor based on accelerometers and gyroscopes, with cumulative walking time (CWT) and total time on feet (TTF) as outcome variables [2]. The patients underwent a standard inpatient rehabilitation including physiotherapy, occupational therapy, and speech therapy, each as group and individual therapy.

RESULTS
The assessment of PA was feasible with every patient available, without floor or ceiling effects, whereas floor effects were documented for a considerable percentage of patients in all tests of physical capacity (balance T1: 5%, T2: 2%; chair rise T1: 10%, T2: 9%; gait speed T1: 11%, T2: 5%). Ceiling effects were registered only for the balance test (T1: 17.4%, T2: 22.8%). Improvements were documented in all median values of physical capacity (all p<0.001) as well as in PA (T1: CWT=23.3 min, T2: CWT=28.4 min, p<0.001; T1:TTF=104.9 min, T2:TTF=125.3 min, p<0.001). Spearman’s coefficient of correlation between measures of physical capacity and measures of PA were at T1: r=0.409 to r=0.675 and at T2: r=0.375 to r=0.595.

DISCUSSION AND CONCLUSION
It is concluded that the assessment of PA by activity monitoring is a valuable measure to document the process of rehabilitation without floor or ceiling effects. Although there is some association between physical capacity and PA, measures of physical capacity cannot serve as a surrogate marker of PA, but may provide additional information.

REFERENCES
**P1-81** ASSOCIATION BETWEEN HABITUAL PHYSICAL ACTIVITY AND MOBILITY IN YOUNG AND OLDER INDIVIDUALS LIVING IN A CITY DISTRICT

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**INTRODUCTION**
Nowadays sedentary lifestyles inexorably affect the mobility of city dwellers. Quality of life declines drastically among older people as cardio-respiratory, neuromuscular and biomechanical factors underlying mobility deteriorate gradually with ageing [1]. However, to date there is no comprehensive information about the relationship between the age-related decline of these factors and the levels of habitual physical activity (HPA) of city dwellers. The aim of this study, therefore, is to evaluate the association of cardio-respiratory, neuromuscular and biomechanical factors underlying mobility with HPA levels in young and older individuals living in an urban context.

**METHODS**
Twenty-four young (aged 28±2 years; mean±SD) and 24 older (70±3 years) healthy participants living in a city district underwent evaluation of mobility and monitoring of HPA. Evaluation of mobility included: an incremental cycling test to estimate ventilatory threshold (VT) and a walking test to estimate energy cost per unit of distance (WECd) through a metabolimeter (K4b2, Cosmed); vertical jump (VJ) on a force platform (Bertec Co., 40-80cm) to estimate maximal power. HPA was monitored during a whole day by a wearable system of biaxial accelerometers (IDEEA, MiniSun). Hierarchical clustering [2] was performed and statistical differences between clusters were investigated using One-way ANOVA. Significance was set at P < 0.05.

**RESULTS**
Two levels of HPA were identified by hierarchical clustering in both young and older participants: a higher (H) and a lower (L) HPA level. The table shows the comparison between H and L for a subset of parameters of HPA and mobility (* significantly different from L).

<table>
<thead>
<tr>
<th>parameter (unit of measure)</th>
<th>H</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>total activity counts (n)</td>
<td>24573.9 ± 5152.9*</td>
<td>19538.0 ± 5820.1*</td>
</tr>
<tr>
<td>mean walking speed (m·min⁻¹)</td>
<td>68.7 ± 8.5*</td>
<td>59.8 ± 5.6*</td>
</tr>
<tr>
<td>transitions speed (m·min⁻¹)</td>
<td>0.5 ± 0.4*</td>
<td>0.30 ± 0.17*</td>
</tr>
<tr>
<td>VT (ml·min⁻¹·kg⁻¹)</td>
<td>25.2 ± 10.0*</td>
<td>18.8 ± 5.6*</td>
</tr>
<tr>
<td>VJ peak power (W)</td>
<td>2557.7 ± 936.8*</td>
<td>2044.1 ± 832.5*</td>
</tr>
<tr>
<td>WECd (J·min⁻¹·kg⁻¹)</td>
<td>1.9 ± 0.8</td>
<td>2.1 ± 0.6</td>
</tr>
</tbody>
</table>

Furthermore, irrespective of HPA levels and age, VT correlated mainly to mean speed during habitual walking (0.4<r<0.5) and climbing stairs (0.5<r<0.6); VJ peak power correlated mainly to mean power during habitual transitions such as sit-to-stand (0.4<r<0.5); WECd showed negative correlations (r=-0.4) exclusively to habitual physical activity (HPA) thresholds (VT) and a walking test to estimate energy cost per unit of distance (WECd).

**DISCUSSION AND CONCLUSION**
Two main HPA levels were identified in all participants, both young and older. Most HPA and mobility parameters were significantly higher in cluster H than in L. Irrespective of HPA levels and age, mobility parameters were associated mainly with execution speed and power of specific daily activities, rather than with the total amount of HPA.

**REFERENCES**

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**P1-82** A PAIR-MATCHED COMPARISON OF OBJECTIVELY MEASURED SEDENTARY AND PHYSICAL ACTIVITY LEVELS OF OBESE/OVERWEIGHT DOGS WITH NORMAL WEIGHT DOGS

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**INTRODUCTION**
Accurate measurement of canine physical activity (PA) is important in obesity treatment and prevention in veterinary medicine [1]. Methods of PA measurement often rely on owner recall and thus open to the same cognitive problems recognised in human PA measurement [1]. Accelerometry has been shown to be a valid, practical and reliable method for objectively measuring PA in dogs [2]. The aim of this study was to compare objectively measured PA levels in overweight/obese dogs with normal weight dogs.

**METHODS**
Thirty-four dogs, including 14 pair-matched for breed, age and sex, were identified as normal, overweight or obese by Body Conditioning Score (BCS). GT3X accelerometers (Actigraph, FL) were worn dorsally on the dogs’ collars for 7 days, 24 hours/day. Measures of mean daily PA (cpm) and % time spent in different PA categories were determined using previously identified cut-points [2] and compared between BCS.

**RESULTS**
Mean daily PA was significantly lower in obese and overweight dogs compared with normal weight (p=0.029, 95% Confidence Interval (422, 5639)). Obese/overweight dogs spent 4.6% more time sedentary, 1.2% and 3.2% less time in light and vigorous PA respectively than normal weight dogs, although these weren’t significant (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>ALL DOGS (N=34)</th>
<th>PAIRED DOGS ONLY (N=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal (N=18)</td>
<td>Overweight (N=9)</td>
</tr>
<tr>
<td>Daily PA volume (cpm)</td>
<td>16945 (2051)</td>
<td>6347 (2062)</td>
</tr>
<tr>
<td>Time sed. (%)</td>
<td>61.4 (6.0)</td>
<td>62.4 (7.7)</td>
</tr>
<tr>
<td>Time light (%)</td>
<td>17.9 (3.3)</td>
<td>16.9 (4.3)</td>
</tr>
<tr>
<td>Time vig. (%)</td>
<td>20.7 (6.2)</td>
<td>19.6 (4.6)</td>
</tr>
</tbody>
</table>

**DISCUSSION AND CONCLUSION**
Objectively assessed mean daily PA in overweight/obese dogs is lower than normal weight dogs. Pattern of PA in overweight/obese dogs showed a trend towards less time spent in light and vigorous PA, Actigraphs are tolerated well by dogs and provide detailed PA assessment. Accurate PA assessment can aid monitoring of effects of obesity treatment and the use of canines as a tool for weight reduction in humans.

**REFERENCES**

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**P1-83**

**ASSESSING PHYSICAL ACTIVITY IN BRITISH PAKISTANI WOMEN**

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**INTRODUCTION**

The aims of this study were to assess the quality of data on physical activity obtained by recall from British Pakistani women, and to explore the feasibility of using accelerometer-based physical activity monitors to provide a more objective measure of physical activity in this group. Previously only questionnaire data have been published, and have indicated low levels of activity [1].

**METHODS**

In this largely qualitative study, 22 British Pakistani women were asked to wear accelerometers (the GT1M Actigraph and/or the Sensewear Armband) for four days. Participants also provided two 24-hour recalls of activities, for a Sunday and a Monday, and were interviewed about physical activity and their experiences with the monitors.

**RESULTS**

Women reported spending most of their time in housework and childcare. They had difficulty in recalling the timing of these usually unstructured activities. Understandings of what constitutes moderate or vigorous physical activity, as required by questionnaires, varied markedly. 1/26 blocks (at least 10 minutes) of moderate to vigorous activity identified by accelerometer on Sundays and Mondays took place in the home. Most women wore the monitors as requested, but a number of problems were reported and a significant minority of datasets (6/14 for the Actigraph and 5/14 for the Sensewear Armband) was incomplete, despite relatively intense interactions with the researchers. Women generally found the Actigraph comfortable and unobtrusive, but sometimes forgot to wear it. A number of women said the Sensewear Armband was uncomfortable to wear, and was embarrassingly bulky under traditional tight-sleeved kameez tops and some chose to take it off.

**DISCUSSION AND CONCLUSION**

We conclude that most questionnaire measures fail to provide an accurate assessment of physical activity in British Pakistani women because they do not include an assessment of moderate to vigorous activity conducted within the home. Where questionnaires do ask women about their activities in the home, difficulties in recalling time spent in activities and in assessing the intensity of activities are likely to lead to invalid data. This suggests that accelerometer data will be preferable. However, collecting sufficient accelerometer data for large-scale studies of activity in British Pakistani women will be challenging.

**REFERENCES**


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**P1-84**

**PEAK POWER DURING THE SIT-TO-STAND TRANSFER IN OLDER ADULTS; EFFECTS OF AN 8-WEEK BALANCE AND STRENGTH TRAINING INTERVENTION**

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**INTRODUCTION**

Studies have demonstrated that decreases in muscle strength and/or power are associated with functional limitations in older people, and that the combination of strength and balance training can improve functional performance. A recent study demonstrated the possibility to estimate power characteristics during the sit-to-stand (STS) transfer based on hybrid motion sensors [1]. This abstract presents preliminary results of the ongoing training groups which have been reported in an earlier study [1]. These first results demonstrate a decreased STS duration and increase in peak power after an 8-week strength and balance training. These pre-post changes in STS parameters were associated with increases in leg extensor strength. Further results of the ongoing training groups should confirm that peak power and STS duration as determined based on motions sensors are sensitive to the effects of balance and strength training.

**RESULTS**

This abstract presents results which were obtained in a first group of 6 elderly persons (2 males, 4 females, age range 74-84 years) who completed the intervention. Ongoing interventions in other groups have not yet been finished. Table 1 presents mean STS parameters as measured at a self-chosen normal and fast speed. The results are based on data obtained at the right trochanter major.

<table>
<thead>
<tr>
<th>STS duration (s)</th>
<th>STS peak power (Watt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Fast</td>
</tr>
<tr>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>1.88 ± 0.49</td>
<td>1.84 ± 0.37</td>
</tr>
<tr>
<td>1.66 ± 0.47</td>
<td>1.35 ± 0.19</td>
</tr>
</tbody>
</table>

**DISCUSSION AND CONCLUSION**

The obtained STS durations and peak power values were within the range of values which have been reported in an earlier study [1]. These first results demonstrate a decreased STS duration and increase in peak power after an 8-week strength and balance training. These pre-post changes in STS parameters were associated with increases in leg extensor strength. Further results of the ongoing training groups should confirm that peak power and STS duration as determined based on motions sensors are sensitive to the effects of balance and strength training.

**REFERENCES**


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**P1-85**

**A COMPARISON OF QUESTIONNAIRE AND ACCELEROMETRY MEASUREMENT OF PHYSICAL ACTIVITY IN OBESE YOUTH**

Vanhelst J1, 2, Fardy P1, Mikulovic J1, Bui-Xuan G1, Theunynck D1, Bégin L1, 2

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**INTRODUCTION**

Techniques to assess physical activity (PA) in free living conditions (FLC) include: PA questionnaires (PAQ), doubly labeled water, pedometry, heart rate monitoring, indirect calorimetry or accelerometry. The PAQ is widely used because it is low cost, easily administered, and enables large numbers to be tested simultaneously. However, questionnaires are subjective which makes them susceptible to over or under reporting, particularly in youth. Children and adolescents may also have difficulty in assessing intensity of activity. To the best of our knowledge, there are no studies comparing the use of questionnaires and accelerometry in measuring differences in physical activity in obese youth.

The aim of the present study was to compare PA as measured by PAQ vs. accelerometer output. A second aim was to examine changes in physical activity after one-year of intervention program with both methods of measurement.

**METHODS**

Twenty-eight obese youth (12.8 ± 2.9 years, 157.1 ± 13.9 cm, 80.2 ± 25.5 kg, and 31.7 ± 6 kg/m²) participated to the intervention program. The program consisted of a unique program of PA that emphasized playing games. Activity sessions were offered two hours per week. PA was complemented with health education every 3 months. At baseline and the end of program intervention, an accelerometer (RT3, Stayhealthy®, Monrovia, CA, USA) was attached to the belt of each subject and worn on the right hip for seven consecutive days in FLC. PAQ were administered following seven days of accelerometry monitoring to compare differences in habitual PA between the two methods.

**RESULTS**

Pre intervention, obese youth spent on average 116.1 min of time in MVPA in one week, assessed by accelerometry compared with 210.2 min. with the PAQ. Following intervention subjects spent significantly more time in MVPA, 210.3 min with accelerometry vs. 316.1 min. using the PAQ. Time spent in MVPA obtained by PAQ was significantly greater than that obtained by accelerometer, both pre and post intervention. Results showed also a significant change between baseline and following intervention program in both methods of assessment (P < 0.001).
**DISCUSSION AND CONCLUSION**

Our results show large differences to estimate PA in FLC. Obese youth have difficulty with the PAQ in remembering accurately their PA over seven days and in accurately differentiating among various levels of effort. Another potential measurement problem with questionnaires may result from obese youth answering what they were “to do”, and not what “they did”. Because the intervention program included substantial information on health education and the importance of physical activity, the questionnaire responses may have been influenced by what was learned regarding activity requirements needed to have a positive impact on health. In summary, although self-reported physical activity questionnaires are relatively easy to administer and score, results from the present study show some limitations in measuring PA in obese youth. Alternative methods must be considered. Accelerometry may be the best compromise taking into account validity and feasibility in evaluating PA in children and adolescents in free living conditions.

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**P1-86 TIPS-SHIRT: INTELLIGENT TEXTRONIC PLATFORM FOR OBESE CHILDREN**

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**INTRODUCTION**

Regarding to the patient’s monitoring in free-living conditions, a structure is required to provide the specialist with information to evaluate the patient habits and design with the greatest effectiveness the best treatment for him. The possession of various kinds of information during real situations will be very important for the next generation therapies. The aim of the platform is to provide real-time data to develop Ambient Intelligence scenarios that will treat an e-therapy for Child Obesity.

1. Develop a new Smart Fabric and electronic sensor for the detection of physical habits on e-therapies
2. Facilitate physicians & psychologists with a new evaluation tool for the treatment
3. Validate a new ambulatory tool for the detection of physical activity habits in obese children population

**METHODS**

TIPS-shirt it’s presented (TIPS: therapy intelligent personal sensor), User will wear this Smart fabric to detect physical habits and physiological response. It was implemented an Smart Fabric collaborating with NUBU medical [14] that can register vital constants for e-therapies treatments. It has been calculated a new model estimation for obese children that combines biomechanics and physiological parameters.

For validating algorithms, filters implemented on TIPS module and feasibility of smart fabrics electrodes a laboratory protocol was implemented. Also, results from a clinical study for validating sensor and getting best mathematical models for metabolic consumption estimation on obese children (n=20) has been made at the Pediatric Unit of “Hospital General Universitario” from Valencia. The boys completed sedentary activities (play videogames & watching a film) and make a Balke Modified Effort Test on treadmill.

**RESULTS**

Laboratories experiments for validating TIPS-shirt shows good performance for RR interval detection (sensibility of 98.8% on resting phase, 99.7% on walking phase & 95.7% on running phase). Accelerometer signal show a good estimation on different levels of intensity. Results show a good correlation between standard heart rate measuring on indirect calorimeter and heart rate measuring from Smart Shirt (r²=0.95). Obese children Model combination from accelerometer and ECG shows that prediction models extracted from obese people with TIPS-shirt presents a good results for estimating oxygen consumption. (resting phase: bias error= 0.027%, balke phase bias error=3.23%)

**DISCUSSION AND CONCLUSION**

The results have validated TIPS-shirt as a good ambulatory sensor platform for activity and metabolic estimation on obese clinical therapies. This studies was conducted in a controlled laboratory setting. Therefore, the developed Physical Activity Intensity prediction equations should not be used without caution for free-living prediction of PAEE. Next experiments on Hospital inside ETIOBE project will contrast the validity for this platform.

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**P1-87 AMBULATORY ASSESSMENT OF MULTI-SEGMENT FOOT JOINTS ANGLE FOR OUTCOME EVALUATION OF ANKLE OSTEOARTHRITIS TREATMENTS**

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**INTRODUCTION**

Lower limb joint angles showed to be meaningful outcome measures for clinical evaluations [1]. However, the range of motion (ROM) of multi-segment foot joints in daily gait measured by ambulatory devices has not been used for this purpose. On the other hand, total ankle replacement (TAR) and ankle arthrodesis (AA) are suggested as surgical treatments for ankle osteoarthritis (AO). Outcome evaluation of these treatments is of clinical interest for decision making about them [2]. The aim of this study was to propose ROM of multi-segment foot joints measured by ambulatory inertial sensors as objective outcome measures for AO treatments.

**METHODS**

46 subjects were involved in this study: 15 patients with AO, 12 patients with TAR, 9 patients with AA and 10 age-matched healthy subjects (Control). Inertial measurements units (IMU) composed of 3 gyroscopes and 3 accelerometers were installed on their affected foot over Shank, hindfoot and forefoot. Patients walked two trials of 50 meters in hospital corridor and a portable data-logger (Physilog, CH) recorded the data at 200 Hz. The ROM of Shank-Hindfoot and Hindfoot-Forefoot joints were calculated in Sagittal, Coronal and Transverse planes similar to [1]. Joints ROmS were compared between each patient group (AO, TAR and AA) and control group using Wilcoxon rank-sum test.

**RESULTS**

The joint ROMs and the comparisons between the patients and controls are presented in Table 1.

<table>
<thead>
<tr>
<th>Joint</th>
<th>Control</th>
<th>AO</th>
<th>TAR</th>
<th>AA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shank-Hindfoot</td>
<td>14.5±1.4</td>
<td>11.5±3.7</td>
<td>13.9±5.7</td>
<td>8.5±4.9</td>
</tr>
<tr>
<td>Hindfoot-Forefoot</td>
<td>13.8±8.6</td>
<td>10±2.7</td>
<td>11.8±6.0</td>
<td>9.8±3.5</td>
</tr>
<tr>
<td>Coronal</td>
<td>9.1±2.1</td>
<td>7.2±4.3</td>
<td>9.3±6.5</td>
<td>5.4±2.0</td>
</tr>
<tr>
<td>Shank-Hindfoot</td>
<td>4.6±4.1</td>
<td>5.9±2.6</td>
<td>5.3±3.3</td>
<td>4.2±2.7</td>
</tr>
<tr>
<td>Hindfoot-Forefoot</td>
<td>9.5±6.8</td>
<td>5.9±2.8</td>
<td>6.8±3.1</td>
<td>5.3±1.9</td>
</tr>
<tr>
<td>Transverse</td>
<td>5.2±3.6</td>
<td>3.4±1.6</td>
<td>4.3±2.0</td>
<td>4.3±2.6</td>
</tr>
</tbody>
</table>

**DISCUSSION AND CONCLUSION**

Shank-Hindfoot joint ROM in Transverse plane showed significant difference with controls even after TAR and AA which indicates improvement. Thus, in general, TAR showed closer joint functions to controls than AA. This study showed the suitability of ambulatory assessment of multi-segment foot joint angles using IMUs for objective outcome evaluation of ankle osteoarthritis treatments.

**REFERENCES**

QUANTIFYING INTERMITTENT EXERCISE IN FOOTBALL MATCHES USING
STEPWATCH ACTIVITY MONITORS

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USA

INTRODUCTION
Player movement during football matches consists of combinations of alternating
high and low intensity movements. Quantifying the high-intensity work rate and the
subsequent period of recovery that follows would aid coaches in designing efficient
training protocols that prepare players for the high-intensity intermittent exercise of
match play.

METHODS
Five football players wore StepWatch Activity Monitors during a friendly match.
Step rates during each 3-second interval were identified and summed to produce
a “square-wave” of intensity to describe the interval work: upward bars indicated
periods of intense exercise and downward bars indicated periods of walking or
jogging for recovery. Mean, maximum and minimum step rates were calculated
for each period of high intensity work and for each period of low intensity work that
followed. The purpose of this project was to create a method to objectively define and
visually describe the interval work during football and other high intensity intermittent
exercises.

RESULTS
The five players (center forward, central midfielder, wing midfielder, central defender
and wing defender) produced visually distinctive work/rest patterns consistent with
their positions. For example, the center forward showed the effects of accumulated
fatigue in the 90th-95th minutes.

DISCUSSION AND CONCLUSION
This method describes the interval work of football and the effects of fatigue on
tactical roles during the match. These data inform training protocol design to trigger
the molecular signaling response that empowers players to maintain a tactical threat
until the final moments of a match.
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P2-01 DETERMINATION OF_THRESHOLDS FOR DEFINING PHYSICAL ACTIVITY LEVELS USING THE NEW VIVAGO® ACCELEROMETER

Vanhesl J¹,², Hurlot R¹, Mikulevic J¹, Bui-Xuan G¹, Fardy P¹, Béghin L¹,², Theunynck D¹
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P2-02 A GOLD STANDARD FOR MOBILE ACCELEROMETRY

Fasching M¹, Fliegauf A¹, Soehlholzer T¹, Daumer M¹,²
¹SCLMSR e.V. – The Human Motion Institute, Munich, Germany; ²CONTEMPLAS GmbH, Kempten, Germany; ³Trium Analysis Online GmbH, Munich, Germany

P2-03 VALIDATION OF THE ACTIVPAL™ ACTIVITY MONITOR AS A MEASURE OF ENERGY EXPENDITURE IN PATIENTS WITH CHRONIC LOW BACK PAIN

Griffin D¹, Harmon D¹, Kennedy N¹
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P2-04 COMPARISON OF ACTIGRAPH GT1M AND GT3X IN STANDARDIZED AND FREE LIVING CONDITIONS

Kaminsky LA¹, Ozekoe C¹, Hargens TA³
¹Ball State University, Human Performance Laboratory, Muncie, IN, USA

P2-05 PRACTICAL UTILITY AND RELIABILITY OF THE ACTIVPAL MONITOR FOR MEASURING POSTURE IN FREE-LIVING PRE-SCHOOL CHILDREN

McGowan A¹, Dall PM¹, Granat MH¹, Young P¹, Paton JY¹, Reilly JJ¹,²
¹Lifecourse Nutrition & Health, University of Glasgow; ²School of Health Glasgow Caledonian University; ³University of Strathclyde, Scotland

P2-06 NEW STANDARD FOR CALCULATING ANGLE RANDOM WALK

McNames J¹,², Pearson S¹,³, Greenberg A¹
¹Biomedical Signal Processing Laboratory, Portland State University, Portland, Oregon, USA; ²APDM Inc, Portland, Oregon, United States

P2-07 CONCURRENT VALIDITY OF A NEW WIRELESS OPTICAL PROXIMITY SENSOR (OPS) FOR MEASURING MINIMUM FOOT CLEARANCE (MFC).

Ken A¹, Rafferty D¹, Dall PM²
¹Biosengineering Unit, University of Strathclyde, Glasgow, UK; ²School of Health. Glasgow Caledonian University, Glasgow, UK

P2-08 FINDER2E: SOFTWARE TO CHARACTERISE PHYSICAL ACTIVITY AND ENERGY EXPENDITURE OVER SHORT TIME INTERVALS IN FREE-LIVING VOLUNTEERS

Roussel S¹, Lasmes M²,², Spriet C³,², Walter A²,³, Morio B¹, Lacomme P², Boirie Y¹, Morio B¹
¹INRA, Unité de Nutrition Humaine UMR1019, CRNH d’Auvergne, Clermont Ferrand, France; ²Laboratoire d’Informatique (LIMOS, UMR CNRS 6158), Campus des Cézeaux, 63177 Aubière Cedex, France

P2-09 ACTIHEART VS. SENSEWEAR ARMBAND FOR PREDICTION OF ENERGY EXPENDITURE IN CONTROLLED AND FREE-LIVING CONDITIONS

Roussel S¹, Montaurier C¹, Normand S¹, Sauvinet V¹, Lacomme P¹, Boirie Y¹, Morio B¹
¹INRA, Unité de Nutrition Humaine UMR1019, CRNH d’Auvergne, Clermont Ferrand, France; ²CRNH Rhône-Alpes, Lyon, France; ³Laboratoire d’Informatique (LIMOS, UMR CNRS 6158), Campus des Cézeaux, 63177 Aubière Cedex, France

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van Wegen EE¹, Rietberg MB¹, Uitdehaag BM², van Rent BC³, Kwakkel G³
¹Research Institute MOVE, department Rehabilitation Medicine; ²Department of Neurology; ³Department of Epidemiology and Biostatistics; ⁴EMGO Institute, VU University Medical Center, The Netherlands

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Choo PL¹, Crowther I¹, Richards H¹, Sugavanam T¹, van Wijk F³
¹Queen Margaret University, Edinburgh, Scotland, UK; ²Glasgow Caledonian University, Glasgow, Scotland, UK

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Vanhesl J¹,², Baquet G¹, Gottrand F¹, Béghin L¹,²
¹Inserm U995, IFR114, Faculté de médecine, Université Lille 2, France; ²EA 4110, Laboratoire R.E.L.A.C.S, Université du Littoral Côte d’Opale, Dunkerque, France; ³EA4408, Faculté des Sciences du Sport, Université de Lille 2, Ronchin, France; ⁴CIC-9301-CHU-Inserm de Lille, CHRU de Lille, France

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Verbost V¹, Van Cauwenbergh E¹, De Coen V¹, Cardon G¹, Maes L¹, De Bourdeaudhuij I¹
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van Haaren B¹,², Gnam JP¹,², Helmholdt S¹, Anastasopoulou P¹, Bös K¹
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Killane I¹, Browlett G¹, Reilly RB¹
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Bergmann JM¹, McGregor AH¹
¹Medical Engineering Solutions in Osteoarthritis Centre of Excellence, Imperial College London, London, UK

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Felke M¹, Hermans F¹, Rodhe I¹, Björkman M¹, Lindén M¹, Gunnberg P¹
¹School of Innovation, Design and Engineering, Mälardalen University, Västerås, Sweden; ²Department of Information Technology, Uppsala University, Uppsala, Sweden
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1g.tec Guger Technologies OG, Schiedlberg, Austria

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Rosenbaum D1, Winter C1, Mülle C1, 1Institute for Experimental Musculoskeletal Medicine, University Hospital, Münster, Germany

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1House of Competence, hiPER.Campus, Karlsruhe Institute of Technology, Karlsruhe, Germany

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1INESCOR Footwear Technological Institute, Elda, Spain; 2ALGROUP, Eiche, Spain; 3Calzados Hergar S.A.

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Hernández-delgado AS1, García-Ugalde F1, Vega-Gonzalez A1
1Electrical Engineering Department, Faculty of Engineering; 2Neuroscience Department, Institute of Cellular Physiology, National Autonomous University of Mexico, Mexico City, Mexico

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Daumer M1,2, Stolle C1, Heller P1, Bockstahler B3
1SLCMR e.V. – The Human Motion Institute, Munich, Germany; 2Trium Analysis Online GmbH, Munich, Germany; 3Movement Science Group Vienna, University of Veterinary Medicine, Vienna, Austria

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1Clarkson University, Potsdam, NY, USA; 2University of Alabama, Tuscaloosa AL, USA

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Torres O1, Andrade H1, Henao H1, Montoya A1
1Universidad Pontificia Bolivariana, Medellin, Colombia

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Sear C1, Neuaus A1, Taylor WR1, Daumer M1,2
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Salatari A1, Mancini M1, Horak FB1
1Department of Neurology, Oregon Health & Science University, Portland, USA

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Burton NW1
1School of Human Movement Studies, The University of Queensland, Brisbane, Australia

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Finlayson J1, Turner A1, Granat M1
1School of Health, Glasgow Caledonian University, Glasgow, Scotland, UK

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1Centre for Hip Health and Mobility; 2Department of Family Practice; 3School of Human Kinetics; 4Department of Physical Therapy, University of British Columbia, Vancouver, Canada

ACCELEROMETER DERIVED MOVEMENT PATTERN DIFFERENCES ACROSS AGE
Strath SJ1, Keenan KG1, Hart TL1, Grimm EK1, Miller NE1, Swartz AM1
1Physical Activity & Health Research Laboratory, University of Wisconsin-Milwaukee, Milwaukee, USA

HOW RELIABLE AND VALID ARE TIME USE SURVEYS FOR ASSESSING PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR?
van der Ploeg HP1, Merom D1, Chau J1, Bittman M1, Trost S1, Bauman AE1
1Cluster for Physical Activity and Health, Sydney School of Public Health, University of Sydney, Australia; 2Discipline of Sociology, School of Behavioural, Cognitive and Social Sciences, University of New England, Australia; 3Departments of Nutrition and Exercise Science, Oregon State University, Oregon, USA

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Ray E1, Krafft P1, Freedson PS1, Staudenmayer J1
1Deparment of Mathematics and Statistics; 2Department of Kinesiology University of Massachusetts - Amherst, Amherst, MA, USA

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1Faculty of Kinesiology, University of New Brunswick, Fredericton, NB, Canada
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1Department of Health Sciences, University of Jyväskylä, Finland; 1Faculty of Physical Education and Sport Sciences, Semmelweis University, Budapest, Hungary; 1Department of Medical Rehabilitation, Oulu University Hospital and Institute of Health Sciences, University of Oulu, Oulu, Finland; 1Department of Preventive Medicine, University of Tennessee Health Science Center, Memphis, TN, USA

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1Middle Tennessee State University, Murfreesboro, TN, USA

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Faber G6, Chang CC1, Kingma I1, Demerleijn J1
1Department of Environmental Health, Harvard School of Public Health, Boston, MA, USA; 1Liberty Mutual Research Institute for Safety, Hopkinton, MA, USA; 6Research Institute MOVE, Faculty of Human Movement Sciences, VU University Amsterdam, The Netherlands

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1Department of Large Animal Sciences, Faculty of Life Sciences, University of Copenhagen, Denmark; 1Structure & Motion lab, The Royal Veterinary College, North Mymms, UK

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1School of Health and Human Performance, Dublin City University, Dublin, Ireland

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Brunton LB1, Balink, SAAN1, Grimm, B1, Blom AW2
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Harrington DM1, Joyce JP1, Dowd KP2, Donnelly AE1
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Macfarlane PA1, Rumpf M2, Visser MF3
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P2-85 ASSOCIATIONS BETWEEN VO2 AND THE GT3X ACCELEROMETER DURING FREE LIVING ACTIVITIES

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P2-88 COMPARISON OF THE GT3X ACTIGRAH WITH THE GT1M ACTIGRAH FOR ASSESSMENT OF ACTIVITY IN CHILDREN AND VALIDATION OF THE GT3X INCLINOMETER FUNCTION
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Determining thresholds for defining physical activity levels using the new Vivago® accelerometer

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Introduction

Measuring physical activity (PA) accurately is particularly important in treating and preventing obesity. Accelerometry represents an objective, inexpensive and non-invasive method to measure PA. The advantages of accelerometry are precision, accuracy, small size, low weight and ease of use. The purpose of the present study is to measure the validity of the Vivago® accelerometer, a new device for assessing PA, and to define thresholds for different levels of physical activity using Vivago accelerometer counts.

Methods

Twenty-one healthy adults aged 20–34 yr were recruited for the study. Vivago® is a uniaxial accelerometer worn at the wrist of the subject (Vivago Wellness®, Paris, France). The activity signal, which is constructed from the measured force changes at the unit’s movement sensor, is continuously recorded on average once per minute. The same accelerometer was used for all subjects. Oxygen consumption (VO2) and carbon dioxide production (VCO2) were measured every 10 s for 10 min during each activity using a gas analyzer (Respironics Novametrix Medical System® inc, NICO 7300, Wallingford, USA and Datex®, Ohmeda, USA). Subjects wore an adapted mask that was connected by cable (usually the connection is by plastic tubing) to the gas analyzer. Subjects performed four consecutive 10 minute periods of activity at increasing levels of intensity from sedentary to vigorous. Intensities of activity were defined as sedentary (resting on a bed, and reading a book), light (walking slowly at 4 km·h⁻¹); moderate (walking at 6 km·h⁻¹ and running slowly at 8 km·h⁻¹); and vigorous (running at 10 km·h⁻¹). A treadmill (Marquette 2000, SOMA Technology®, Cheshire, USA) was used to represent activity categories and accelerometer counts were: sedentary, 0–15 counts·min⁻¹; light, 16–40 counts·min⁻¹; moderate, 41–85 counts·min⁻¹; and vigorous activity, >85 counts·min⁻¹. Pearson Product-Moment correlation was used to determine the relationship between accelerometry data output and oxygen consumption (r = 0.9; p < 0.001).

Results

Activity categories and accelerometer counts were: sedentary, 0–15 counts·min⁻¹; light, 16–40 counts·min⁻¹; moderate, 41–85 counts·min⁻¹; and vigorous activity, >85 counts·min⁻¹. Pearson Product-Moment correlation was used to determine the relationship between accelerometry data output and oxygen consumption (r = 0.9; p < 0.001).

Discussion and conclusion

Vivago accelerometer is a sensitive technique to assess physical activity in free living conditions and can be used in clinical practice. Using these thresholds, the Vivago accelerometer can now quantify sedentary, light, moderate and vigorous physical activity in free living conditions.

A Gold Standard for Mobile Accelerometry

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Introduction

Gold standards must work. While validating algorithms for the “actibelt® RCT” – a tri-axial, waist-mounted accelerometer for usage in clinical trials – it soon became evident that even the most simple movements like a step have to be studied carefully in order to allow an efficient and reliable detection by algorithms [1]. For this reason, a novel gold standard to analyze human motion coupled with mobile accelerometry was required. The gold standard for movement pattern detection had to fulfill various requirements: the most important criterion was the possibility to record video and accelerometric data simultaneously. Furthermore, it should be as mobile as possible to enable outdoor measurements and study movement behavior at realistic conditions of daily life. Additionally the system should be able to export the recorded video and accelerometry data in a format that is suitable for further analysis and processing on all common desktop computers.

Materials and Methods

We used as a starting point for software adaptations the software package “TEMPLO”, the mobile accelerometry platform “actibelt BLU” including Bluetooth connectivity and a special format for data streaming, and a Basler High Speed camera that allows high frame-rate videos (up to 100 fps) of movement patterns.

With TEMPLO frame per frame analysis of the data is possible. Furthermore it offers the export in common video formats and offers an interface for specific algorithms.

Results

We developed an interface between “actibelt® BLUE” and the Software “TEMPLO” that allows simultaneous recording and display of accelerometry data and video at 100Hz [Fig 1]. TEMPLO can run on a notebook and the camera system can be operated with a battery, such that with the mobile accelerometer and the bluetooth-link to the notebook we have a flexible gold standard for mobile accelerometry.

Discussion and conclusion

With the “marriage” of a mobile video and accelerometry recording system we expect to get new insights about the link between mobile motion and acceleration patterns that can be used to develop, refine and validate novel algorithms for mobile accelerometry.

Literature


Figure 1: Screen shot of TEMPLO linked to an actibelt BLU recording
P2-03 VALIDATION OF THE ACTiVPAl™ ACTIVITY MONITOR AS A MEASURE OF ENERGY EXPENDITURE IN PATIENTS WITH CHRONIC LOW BACK PAIN

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INTRODUCTION
The ActiVPAl™ activity monitor is a valid and suitable measure of postural physical activity in patients with chronic low back pain (CLBP) (Ryan et al., 2008). The ActiVPAl™ however has not been validated as a measure of energy expenditure (EE). The main aim of the current study was to examine the association between accelerometer (ACC) counts, steps count and EE in patients with CLBP during treadmill walking.

METHODS
Participants with CLBP were required to walk for 7 minutes at three different speeds on a treadmill (3.2, 4.4, 5.6 km/hr) while wearing an ActiVPAl™ activity monitor on each leg. EE was measured using indirect calorimetry (Irxon® Mobile). The average MET value for minutes 3-7 for each participant for each speed was calculated by dividing the activity EE by measured, resting EE. Bivariate correlational analysis and linear regression were used to examine the relationship(s) between EE (METs), step count (steps/min) and ACC counts (counts/min).

RESULTS
Data for nine participants (44.2 ± 11.36 years; median BMI=30.25 (20.5-34.5)) are reported. Three participants chose not to walk at 5.6km/hr. There was a moderate and significant relationship between average MET values and step count (r=0.716, p<0.001; 24 data points). Linear regression analysis revealed a moderate relationship between ACC counts and average MET values (r²=0.436, p<0.01; 24 data points). Examination of the scatter plot revealed three potential outliers (high MET values with relatively lower ACC counts). When the linear regression analysis was repeated with the outliers excluded, the relationship between average MET values and ACC counts was strong and significant (r²=0.73, p<0.001; 21 data points).

DISCUSSION/CONCLUSION
There was a moderate relationship between ACC from the ActiVPAl™ and EE in patients with CLBP when performing treadmill-based walking. These preliminary findings suggest that the ActiVPAl™ may be a suitable measure of EE in patients with CLBP. The presence of some outliers in the data requires attention. There is evidence in the literature that a subgroup of patients with CLBP use excessive lumbar muscle activity (van der Hulst et al., 2010). This may result in an increase in EE without an increase in step count or ACC counts. This is a potential explanation for the outliers in the current data. For this sub-group of patients, the relationship between ACC counts and EE may be distorted. This will be further explored in future data analysis.

REFERENCES

P2-04 COMPARISON OF ACTIGRAPH GT1M AND GT3X IN STANDARDIZED AND FREE LIVING CONDITIONS

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INTRODUCTION
The Actigraph GT1M accelerometer has been widely used in many research studies. In 2009, Actigraph released the GT3X version, which offers similar features for characterizing physical activity along with expanded capabilities. As current and future studies will utilize the GT3X, it is important to determine if both models provide comparable output. Thus, the aim of the study was to compare measures between the GT1M and GT3X accelerometers in standardized and free-living conditions.

METHODS
Thirty-seven subjects (21 women, 16 men; age 25.8 ± 2 years; body mass index 24.9 ± 0.6 kg/m²) participated in this study. The subjects arrived in the laboratory and were instructed to place the accelerometers (one GT1M, one GT3X) on their waistband in line with the right and left anterior axillary line. Each subject walked on a treadmill at speeds of 2.4, 3.2, 4.0, 4.8, 5.6, and 6.4 km/hr for 5 minutes each. Subjects were instructed to wear both accelerometers for all waking hours for 3 consecutive days while completing their usual activities. Data output (60 second epochs) between the two accelerometers were analyzed with t-tests with significance set at p < 0.05.

RESULTS
The mean steady-state activity counts/minute for both accelerometers were not statistically different for the standardized treadmill walking speeds. The mean minutes/day (f) and activity counts/minute for intensity classifications with both accelerometers were not statistically different for the free-living condition.

Correlations for all comparisons were significant, r > .85 (exception slowest speed r=0.77).

DISCUSSION AND CONCLUSION
Both mean comparisons and correlations suggest that data output from standardized slow to fast walking speeds and in a free living situation are very similar between the GT1M and GT3X models. Thus, comparison of data sets using either monitor would be appropriate relative to intensity classifications.

P2-05 PRACTICAL UTILITY AND RELIABILITY OF THE ACTiVPAl MONITOR FOR MEASURING POSTURE IN FREE-LIVING PRE-SCHOOL CHILDREN

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INTRODUCTION
Behavioural components of Non-exercise activity Thermogenesis (NEAT), notably posture (time spent sitting versus standing), may be important to the development of childhood obesity. However, there is currently no evidence on the practical utility and reliability of objective methods of quantifying posture in free-living young children. The present study therefore aimed to test the practical utility and reliability of the actiVPAl monitor for measurement of posture (sitting time) in free-living pre-school children.

METHODS
A convenience sample of 20 pre-school children (age range 3.7-4.9y) was asked to wear the actiVPAl monitor for 24 hours a day, for 7 consecutive days. Practical utility was assessed via the number of missing/invalid data points and through questionnaire (10 questions) and parent/guardian report. Reliability was assessed by between day comparisons and study length analysis. Pair-wise comparisons by general linear model ANOVA were carried out to test for any significant differences between days. Analysis of study length was by two methods: between-day Intraclasse Correlation Coefficients (ICC) and a clinical reliability analysis from 95% confidence interval (CI) ranges.

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Table 1

<table>
<thead>
<tr>
<th>Speed (km/hr)</th>
<th>GT1M</th>
<th>GT3X</th>
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<tbody>
<tr>
<td>2.4</td>
<td>1286 ± 61</td>
<td>2208 ± 82</td>
</tr>
<tr>
<td>3.2</td>
<td>2150 ± 83</td>
<td>3123 ± 107</td>
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<tr>
<td>4.0</td>
<td>3038 ± 116</td>
<td>4044 ± 151</td>
</tr>
<tr>
<td>4.8</td>
<td>3831 ± 179</td>
<td>4686 ± 173</td>
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<tr>
<td>5.6</td>
<td>4628 ± 195</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Activity Level</th>
<th>GT1M</th>
<th>GT3X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inactive</td>
<td>745 ± 15</td>
<td>735 ± 13</td>
</tr>
<tr>
<td>Light I</td>
<td>77 ± 4</td>
<td>78 ± 4</td>
</tr>
<tr>
<td>Light II</td>
<td>51 ± 3</td>
<td>51 ± 3</td>
</tr>
<tr>
<td>Light III</td>
<td>40 ± 3</td>
<td>41 ± 3</td>
</tr>
<tr>
<td>Moderate</td>
<td>5 ± 1</td>
<td>4 ± 1</td>
</tr>
<tr>
<td>Vigorous</td>
<td>3630 ± 88</td>
<td>3750 ± 95</td>
</tr>
<tr>
<td></td>
<td>7273 ± 376</td>
<td>7542 ± 356</td>
</tr>
</tbody>
</table>

RESULTS
Only 6.1% of data points were missing/invalid over the study period (an average of 10.1/h/child over the week). Five of the 200 questionnaire responses indicated practical utility problems—these related to length of study—7 days and 24 hours per day—and comfort of the monitor. No significant difference between any of the days was observed by pair-wise comparison (p=0.707). An ICC of 0.88 was defined as reliable and this level was achieved after 5 days of monitoring (95% CI 0.80-0.99). The clinically reliable CI range was defined as 2.5 hours as this represents a clinically significant difference in sitting time. A clinically reliable CI range was achieved at a mean length of 5 days monitoring (95% CI 4.3-5.8).

DISCUSSION AND CONCLUSION
This study suggests that the practical utility of the activPAL is high in free-living pre-school children, and that young children will wear the monitor overnight. Reliability for measurement of sitting time is also high so long as at least 4-5 days are monitored.

P2-06
NEW STANDARD FOR CALCULATING ANGLE RANDOM WALK

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INTRODUCTION
Low cost MEMS inertial sensors are increasingly being used to estimate orientation and position over short periods of time. Orientation is typically obtained by numerically integrating the rotational rates measured by triaxial gyroscopes. The performance of the gyroscopes for this task is appropriately quantified by the angle random walk (ARW). This is a measure of how rapidly the angular error standard deviation increases with time. The ARW is typically expressed in units of degrees per square root of an hour. This implicitly assumes that the growth in ARW is proportional to the square root of time. This assumption is accurate when the gyroscope noise is additive and white (uncorrelated with a flat power spectral density). The assumption of white additive noise is widespread and the ARW is often calculated directly from the noise density of the gyroscope provided by device manufacturers [1-3].

The primary problem with this approach is that the noise properties of most gyroscopes, and MEMS gyroscopes in particular, is not white and often contains slow random drift. This drift can cause a much more rapid growth in the estimated ARW and, in the extreme, can approach a growth that is proportional to the integration duration, rather than the square root of duration that occurs with white additive noise.

PROPOSED METHOD
We propose a direct method for estimating the ARW from long recordings in which the device is stationary. It is trivial and computationally efficient to numerically integrate each axis of a gyroscope over arbitrary segment durations for a large number of signal segments. The average error standard deviation can then be calculated as a function of the integration duration. However, low frequency drift will result in an apparent offset that can last for long periods of time and cause a growth in the error standard deviation that is proportional to the integration duration.

In most applications this is an overestimate of the error that would actually occur in practice because one can often estimate the bias during a stationary period and that occurs before the movement of interest. We propose a simple alternative in which the bias is estimated as the average measured rate during a specified period immediately preceding each integration period. This is similar to the popular and widely used zero-reference updates that detect stationary periods to eliminate accumulated velocity errors and estimate drift bias in inertial sensors. For MEMS inertial sensors a bias estimation period of approximately 30 s is appropriate and consistent with the change in drift estimated by Allan Variance plots.

REFERENCES

P2-07
CONCURRENT VALIDITY OF A NEW WIRELESS OPTICAL PROXIMITY SENSOR (OPS) FOR MEASURING MINIMUM FOOT CLEARANCE (MFC)

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INTRODUCTION
The high annual rate of falling in the older population poses a huge challenge for health and social services. One of the most common causes of a fall is a trip while walking [1], when the swinging foot unintentionally makes contact with the ground. This has naturally led to some researchers measuring minimum foot clearance (MFC). These studies have been undertaken in laboratory settings using 3D Motion capture systems requiring the participants to walk in discrete bursts resulting in a series of snapshots rather than a continuous collection of gait. The use of a treadmill may allow data to be captured from multiple steps but poses problems of generalisability into over ground gait. It has been reported that in addition to quantifying the absolute value in MFC it is also important to quantify the variability present in the measurement [2].

METHODS
Twenty subjects walked at three velocities Preferred Walking Speed (PWS), Slow PWS (SPWS) and Fast PWS (FPWS) repeating each velocity 3 times. An optical proximity sensor (OPS) that produces a voltage directly proportional to the distance from the sensor to the nearest object was attached to the shoe so that the OPS could measure height above the ground at the head of the 1st metatarsal, offset by the shoe and sensor height. A reflective marker was placed on the outer casing of the OPS and tracked with a motion analysis system. Both systems were synchronised and sampled at 50Hz. The lowest point during the swing phase (Figure 1) was recorded and these data explored using ICCs. Variability in the data was quantified using CoV and tested for differences using a Anova.

RESULTS
There was excellent agreement between the two systems. ICCs of 0.91 (all speeds), 0.90 (PWS), 0.93 (SPWS) and 0.89 (FPWS) were recorded. No statistical difference was observed using a Anova.

These results represent a strong agreement between the two systems in measuring MFC and variability of MFC.

DISCUSSION AND CONCLUSION
OPS is a device that can measure both absolute value and the amount of variation in MFC, and also gives rise to the potential to collect data over long periods and in natural settings allowing the quantification of MFC in environments more akin to natural free living.

REFERENCES
**P2-08**  
**FINDER2E: SOFTWARE TO CHARACTERISE PHYSICAL ACTIVITY AND ENERGY EXPENDITURE OVER SHORT TIME INTERVALS IN FREE-LIVING VOLUNTEERS**  
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**INTRODUCTION**  
Typical monitors such as Actiheart and SenseWear Armband provide day-by-day estimation of energy expenditure. It is also possible to access minute-by-minute estimation of energy expenditure and parameters (heart rate, accelerometer, body temperature, …) recorded by these monitors. In our study, we need to be able to easily manage recordings from both monitors and from indirect calorimetry and to extract all pertinent data over short time intervals for each volunteer. The Finder2E software we promote, provides a user-friendly interface for mathematical treatment of data including interpolation, regression, smoothing, means and other statistical computations over short periods, and advanced chart series representations. This Java-based software is compatible with Windows, Mac OS X or Linux environments. To the best of our knowledge, it is the first software in the energy expenditure field able to simultaneously process all of the files provided by SenseWear Armband, Actiheart, or indirect calorimetry for one or several volunteers over short time intervals. Thus, Finder2E saves a great deal of time by avoiding reiterated treatments for each volunteer.  

**METHODS**  
The last study carried out by INRA in 2009 provided a large database that includes more than 38 million pieces of physiological data for 120 adults aged 36 to 55 years, either in free-living conditions or in a calorimetric rooms. All volunteers wore an Actiheart and a SenseWear Armband. The observation of raw data files shows: the files start and end at different times; there are numerous missing data for long periods of time while the volunteers were wearing monitors, measurements provided by monitors suffered from artefacts; the high variation of individual heart rate and of energy expenditure. Thus, the following data preparation must be applied: standardisation: all the files start and end at the same time; extrapolation for missing data by interpolation and regression; correction of artefacts by smoothing the data; computation of the Cardiac Reserve to standardise heart rate; ratio of energy expenditure divided by lean mass to standardise energy expenditure. The Finder2E software offers the possibility to create “groups”, i.e., sets for physiologically homogeneous volunteers (categorised by age, sex, BMI, activity level, etc.) and create statistical result sheets and charts on data including energy expenditure, METs, accelerometer, cardiac reserve… for each short time interval recorded in the individual schedules.  

**RESULTS**  
The result is a user-friendly software that provides easy manipulation of data and permits easy manipulation of population created using physiologic data. The main window gives instant access to the main functionalities previously introduced: creation of a new project and of groups of volunteers with the statistical results by individual and by group. It is possible to draw curves linking two parameters included in all files recorded.  

**DISCUSSION AND CONCLUSION**  
In our opinion, Finder2E is the first step for providing fully automatic data processing software for energy expenditure and physical activity analysis. This software provides support for researchers in the field of energy expenditure since it considerably reduces the time required for data extraction and statistical analysis.

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**P2-09**  
**ACTIHEART VS. SENSEWEAR ARMBAND FOR PREDICTION OF ENERGY EXPENDITURE IN CONTROLLED AND FREE-LIVING CONDITIONS**  
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**INTRODUCTION**  
Evaluating variations in free-living energy expenditure during the day and on a day-to-day basis is of major interest in clinical trials as well as for individual use. Several monitors are available today for research on energy expenditure (EE) prediction. The aim of our study was to compare the accuracy of EE estimation of two of these devices (Actiheart and Armband), compared to measurements using calorimetric chambers for the assessment of changes of energy expenditure during the day, and the doubly-labelled water (DLW) technique for the evaluation of free-living total energy expenditure.  

**METHODS**  
Two groups of volunteers participated in this study. The first group was composed of 49 normal weight volunteers, 23 men and 26 women, who were confined to a calorimetric room for 24 h. Energy expenditure was measured during physical activities of varying intensity. The second group was composed of 55 normal-weight volunteers (27 men and 29 women) in free-living conditions. All of them wore both monitors (Actiheart and Armband) at the same time for 24 h (calorimetric room) and 10 days (in free-living conditions). “Finder2E” software, developed in-house, was used for data mining and for calculation of energy expenditure using Actiheart and Armband algorithms, either over short time intervals (in the calorimetric room) or during the test period (in free-living conditions). The error of EE estimation (%) was calculated as the ratio between the absolute value of the difference between prediction and reference measurements to the reference measurement. A paired t-test was performed to compare the levels of errors resulting from the two monitors.  

**RESULTS**  
In the calorimetric room, the mean error for estimating EE during the awake period tended to be higher for Actiheart (9.9±6.0%) compared to the Armband (7.2±5.0%) (t=-1.92, p=0.06). The Actiheart error was similar in women (8.0 vs. 7.0%, t=-0.7, p=0.49), whereas it was higher in men (10.0 vs. 7.3%, t=-2.7, p=0.03) compared to the Armband. Analysis by activity showed that Actiheart more effectively predicted EE during standing, walking 4 km/h-1, exercising with a stepper and rest after stepper activity. In contrast, the prediction of EE during post-absorptive rest and sleeping was improved with the Armband. In free-living conditions, the mean error was significantly higher for Actiheart (13.2±10.7%) compared to the Armband (8.3±5.5%) (t=3.5, p=0.001). The Armband underestimated EE in the high value range (> 3100 kcal/d) and vice versa for Actiheart.  

**DISCUSSION AND CONCLUSION**  
The measurements of energy expenditure using Actiheart may be altered by either the delicate procedure for skin preparation or the positioning of the device or of the algorithm. Thus, the error of energy expenditure predicted by Actiheart during sleeping was higher. Since this period is long, the sleeping energy expenditure error accounts for a significant part of the total error. An adaptation in the algorithm for low intensity activity and low heart rate might improve prediction accuracy.

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**P2-10**  
**REPRODUCIBILITY OF HOME-BASED 24-HOUR AMBULATORY MONITORING OF MOTOR ACTIVITY IN PATIENTS WITH MULTIPLE SCLEROSIS**  
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**INTRODUCTION**  
Physical Activity is reduced in patients with multiple sclerosis (MS) and evidence is accumulating that increasing physical activity is beneficial in individuals with multiple sclerosis. The objective of the current study is to determine the reproducibility of 24-hour monitoring of motor activity in patients with MS.  

**METHODS**  
In a test-retest design, six research assistants visited the participants twice within a week in the home situation. Participants were recruited as a convenience sample of 43 ambulatory patients (mean age 48.7; standard deviation (SD) 7.0 years; 30 women; median expanded disability status score (EDSS) 3.5; Inter quartile range (IQR)
RESULTS
Test-retest reliability expressed by the ICCagreement was 0.77 for dynamic activity, 0.74 for transitions, 0.77 for walking, 0.71 for static activity, 0.67 for sitting, 0.62 for standing, and 0.55 for lying. Bland and Altman analysis indicated no systematic differences between the first and second assessment for dynamic and static activity. Measurement error expressed by the SDC was 1.23 for dynamic activity, 0.68 for transitions, 0.99 for walking, 1.52 for static activity, 4.68 for lying, 3.95 for sitting, and 3.34 for standing.

DISCUSSION AND CONCLUSION
The current study shows that with 24 hour monitoring a reproducible estimate of physical activity can be obtained in ambulatory patients with multiple sclerosis.

P2-11 VALIDATION OF ACTIVPAL™ ACTIVITY MONITOR AS A MEASURE OF STEP COUNT DURING THE TIMED UP-AND-GO (TUG) AND TEN-METRE WALK (TMW) TESTS
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INTRODUCTION
The activPAL™ is a commonly-used activity monitor, but there is a lack of published research establishing its validity in people with stroke. Prior to testing the validity of activPAL™ in stroke, a pilot study with healthy participants was undertaken. Activities comprised sitting, standing, and walking, as specified in the Timed Up-and-Go (TUG) and Ten-Metre Walk (TMW) test protocols, which are reliable and widely-used in stroke rehabilitation. The aim of the study was to evaluate the test-retest reliability and concurrent validity of activPAL™ in measuring step count during TUG and TMW, using video observation as criterion standard.

METHODS
Fifteen healthy Queen Margaret University students (13 females, 2 males; age 22.7±2.1 years) were video-recorded in the laboratory undertaking six trials of TUG and TMW with activPAL™, which recorded continuously for the entire day’s data collection. Test order was randomised using electronic die and repeated the following week. Results of independent video observation of step count by three researchers were compared to activPAL™ data. Inter-observer and test-retest reliability were calculated using intraclass correlation coefficients (ICC) with standard error of measurement (SEM). Concurrent validity was determined using Bland and Altman 95% limits of agreement (LOA).

RESULTS
Inter-observer reliability of video observation was perfect (ICC2,1=0.99) with an acceptable level of precision for TUG (SEM=0.13) and TMW (SEM=0.17). For TMW, test-retest reliability of activPAL™ was substantial (ICC2,1=0.77) with an acceptable level of precision (SEM=0.73 steps). Regarding concurrent validity, level of agreement was low between activPAL™ and video observation: mean step count difference between activPAL™ and observation was -3.34 steps (upper LOA=0.94 steps; lower LOA=-5.74 steps). For TMW, reliability and validity of activPAL™ could not be determined as no step count was registered. Mean completion times for TUG and TMW were 9.33s and 11.87s respectively.

DISCUSSION AND CONCLUSION
The results from this study indicate that the activPAL™ was not valid in measuring step count during TUG and TMW. Given that activPAL™ requires a 10-second sampling period to register an activity, activPAL™ data require interpretation with caution where activity durations approximate the sampling period. High reproducibility of data from video observation corroborates its use as criterion standard.

REFERENCES

P2-12 A BETTER INTER-INSTRUMENT RELIABILITY OF UNIAXIAL VS TRIAXIAL ACCELEROMETER IN FREE LIVING CONDITIONS
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INTRODUCTION
The most popular accelerometers in physical activity research are the Actigraph uniaxial accelerometer (AGR, Model GT1M, Actigraph, Shalimar, CA) and the RT3 triaxial accelerometer (Stayhealthy Inc, Monrovia, CA). When a large population is evaluated at the same time, the use of several accelerometers is necessary. To be able to compare data between subjects or repeated measures, accelerometers have to be highly reliable. To date, only one study assessed the inter-instrument reliability of Actigraph accelerometer in free living conditions (FLC), and none on the RT3 accelerometer [1]. Also, to the best of our knowledge, no study compared inter-instrument CV of uniaxial and triaxial accelerometers in FLC. Therefore, the purpose of the present study was to evaluate the inter-instrument reliability of RT3 and Actigraph accelerometers at different levels of PA in FLC.

METHODS
Fifteen healthy adults, aged 22 to 33 year-old, participated in this study. On the test day, the participant arrived at the laboratory. The research team explained instruction on an appropriate use of the two accelerometers. Participants then attached eight Actigraph accelerometers to the level of the back with an elastic belt and adjustable buckle, and five RT3 accelerometers to the back with, also, an elastic belt. The same accelerometers were used for all the participants. Accelerometers were worn during 24 hours in free living conditions. All time spent in motorized vehicles was removed in the statistical analysis. The next day, the participant came back to the laboratory to return accelerometers. Inter-instrument coefficient of variation (CV) for each intensity was assessed using the formula: CV = standard deviation of the measure × 100/mean of the measure for each intensity. The U-Mann & Whitney test was used to compare the difference between the two accelerometers. A p value of .05 was chosen for significance.

RESULTS
Participants were accelerometers for an average of 768 ± 164 min. For both accelerometers, the reliability increased when PA intensity increased. Inter-instrument CV of Actigraph (3 to 10.5%) was lower than those of RT3 (12.6 to 35.5%) at each PA level (p<0.05). Therefore, the Actigraph shows a better inter-instrument reliability compared to the RT3 accelerometer at each PA level.

DISCUSSION AND CONCLUSION
In free-living conditions, a good inter-instrument reliability is needed when assessing PA in large population. This study shows some limits in assessing sedentary and light PA levels, particularly for the RT3 accelerometer. Even if triaxial accelerometers are very precise to assess PA in FLC, the assessment of sedentary behavior may be inaccurate because of the poor reliability.

REFERENCES

P2-13 CONCURRENT VALIDITY OF A PARENTAL-REPORT QUESTIONNAIRE TO ASSESS PRESCHOOLERS’ PHYSICAL ACTIVITY
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INTRODUCTION
The interest in physical activity (PA) to prevent pediatric obesity has increased during the past decade. However, to start with obesity preventative efforts, adequate measurements of PA are needed. Although accelerometers have been put forward as an adequate method to assess preschoolers’ PA, survey measures of PA can be an interesting alternative because they have the ability to provide contextual information, are inexpensive and less time-consuming. A self-report measure of PA is impossible in preschoolers but a standardized validated proxy-report questionnaire to assess preschoolers’ PA is currently lacking [1]. Therefore, this study aimed to compare an objective measure with a parental-report measure of preschoolers’ PA.
**METHODS**
Pa was objectively assessed in 188 Belgian preschoolers (3-6 year) over 2 weekend and 2 weekdays using the GT1M ActiGraph. Concurrently, parents filled out a questionnaire and reported on their preschoolers’ PA during a usual week. Outcomes of the questionnaire were daily minutes spent in (un)structured and total PA (i.e. summation of structured and unstructured PA). Accelerometer data (min/day) were used as the criterion measure of daily PA. Spearman rank correlation coefficients were used to test the relationship between the parental-reported and accelerometer-determined PA. Painold-Samples T-Test was used to test parents’ over- or underestimation of daily PA.

**RESULTS**
104 preschoolers provided data on both measures of total PA (age: 4.50±0.98; 47% boys). Accelerometer-determined levels of daily PA were not significantly related with parental-reported PA (r=0.008; p=0.95). There were also no significant relationships between daily levels of objectively assessed PA and daily levels of parental-reported (un)structured PA (respective r=0.047 and r=0.049; both p>0.05). Parents significantly overestimated their preschoolers’ daily PA (178.8±101.9min/day versus 93.7±28.85min/day; t=8.028; p<0.001).

**DISCUSSION AND CONCLUSION**
The parental-report questionnaire used in this study appeared to be invalid to measure preschoolers’ PA. Although it is tempting to think that parents are able to adequately recall their preschoolers’ PA, this study showed that parents overestimated their preschoolers’ daily PA. The accelerometer has previously been indicated as an appropriate criterion measure to assess PA in young children. However, the results might be influenced by the fact that parents had to report on a usual week and not on the time frame during which the criterion measure was assessed [1].

To conclude, the parental-report questionnaire used in this study did not adequately assess preschoolers’ PA. Further research is required to develop and validate alternative measurements to assess preschoolers’ PA (e.g. activity diary, combined parent- and teacher-report questionnaire).

**REFERENCES**

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**P2-15 MEASURING NEURAL RESPONSES DURING MILD EXERCISE**

**INTRODUCTION**
Non-invasive methods of recording human electro-cortical brain dynamics during normal daily activities would have far-reaching clinical benefits. While this is not yet possible due to limitations in our understanding of the neural processes involved in complex physical movement and measurement of such processes, the literature does suggest a strong link between gait and cognition. Attention is seen to play a central role in gait and locomotion. This study investigates if clinically useful electrophysiological measures of attention can be collected using an auditory task in ecological/non-clinic environments.

**METHODS**
Electrophysiology (EEG, EOG and EMG) recordings were taken from 7 healthy subjects (3 male, 4 female, aged 20-32 years) while presented with an auditory odd-ball task. Data was recorded in different experimental conditions: static (seated) and dynamic (fixed cycling) conditions. Recordings were also taken for two subjects during treadmill walking. Both cycling and walking occurred at a self-selected comfortable pace (fixed cycling) conditions. Recordings were also taken for two subjects during treadmill conditions.

**RESULTS**
The ICCs between both devices were r=0.86 (0.63-0.95; p=0.000) for walking, r=0.85 (0.63-0.95; p=0.000) for brisk walking, r=0.77 (-0.02-0.94; p=0.000) for crossing a bridge, r=0.58 (-0.81-0.88; p=0.000) for walking up a bridge and r=0.85 (0.61-0.94; p=0.000) for walking down a bridge.

**DISCUSSION AND CONCLUSION**
These results indicate that the kmsMove shows good validity in EE calculation during different walking intensities. There are only difficulties in assessing EE during uphill walking while downhill walking is assessed relatively precisely.

**REFERENCES**
DISCUSSION AND CONCLUSION
The P3 is believed to underlie the neural mechanisms required to respond to changing demands, specifically attention and memory interaction plays a key role. Here recording of attentional resources in non-clinical environments has been shown to be possible for an auditory oddball task. It was found that P3 latency did not vary significantly across the three experimental conditions. This is consistent with findings that performance of a cognitive task during a relatively simple motor task does not present a significant change in P3 latency in healthy young adults. This opens up the possibility of recording electrophysiological parameters during motion for patients with gait and movement disorders.

REFERENCES

P2-16 SENSOR DESIGN: WHAT DO PATIENTS WANT?
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INTRODUCTION
Obtaining data in real-life environments using wearable technology can be of great clinical relevance. An interest in monitoring individuals in home and community settings is not new and is one of the factors that originated in the field of telemedicine [1]. However, user acceptance is still an area that is often overlooked, despite the fact that it greatly influences the utility of wearable systems in health care. A systematic review was conducted to look at patient’s preferences, with a view to generating a guideline for body-worn sensor design.

METHODS
Studies were limited to peer-reviewed journals and conference proceedings. Any paper that directly or indirectly focused on the patient’s attitude towards body-worn sensors systems was included. MEDLINE and Pubmed were used to retrieve papers and a total of 557 results were found with keywords and MESH headings that included synonyms of wearable sensor and patient preferences. In total of 49 potentially useful individual papers were identified based on title and abstract of which eight papers were selected after detailed screening.

RESULTS
Patient groups studied were (trial) elderly, geriatric, stroke, spinal cord injured, cardiac and COPD patients. The sensor systems used varied in technical specifications and were used to assess a range of different parameters. Patients showed high levels of acceptance if the system was deemed “low-invasive” and did not affect their “normal” behavior. Technology that could prolong independence tended to be highly regarded by users, while privacy of health data gathered was not regarded as very important for patients contrary to popular belief. Several studies showed that patients are keen on (visual) feedback to ensure the device is still working. Comfort of wearing the device, as well as how well it blended in with their normal clothing was another important aspect. Patients felt quickly stigmatized by devices and some would at times even rebel against the use of health technologies. Integration of wearable sensors into objects patients are familiar with seems to be essential.

DISCUSSION AND CONCLUSION
Despite the variation in measurement outcomes and the patient populations of the studies included in this review, several generic preferences could be determined for wearable sensor systems. It is key to realize that highly sophisticated technology and data analysis techniques become irrelevant if user do not wear the sensor systems [2]. User requirements should always be on the forefront during the development of wearable medical devices to avoid time consuming and costly redesign.

REFERENCES

P2-17 MOBILE SYSTEM FOR ESTABLISHING THE LACTATE THRESHOLD BY ANALYSING THE RESPIRATORY AIR
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INTRODUCTION
The lactate threshold is used to predict adequate work intensity during endurance performance and to evaluate training [1]. The threshold is commonly measured using blood samples.

A low-cost sensor system prototype developed by the research group allows measuring of the threshold noninvasively. The system can estimate the threshold by analyzing the amount of Carbon dioxide, CO2, in respiratory air [2]. A CO2-sensor is placed in the airflow of the respiratory air in a face mask. In an earlier study, it has been concluded that the threshold identified using the sensor system prototype shows good correlation (r=0.74) to lactate thresholds established with the D-max method from lactate levels in blood samples [3].

The aim of the present study was to develop a portable sensor system prototype that can be used when performing different sport activities and without assistance from a test leader.

METHODS
A mobile version of the described sensor system was developed. It is based on a commercially available mobile phone, to which a CO2-sensor and a pulse belt reader (Polar, Finland) were attached. Custom software was developed for the phone.

A person can initiate a threshold test by starting the software. The software constantly records CO2 and heart rate values, until the test is stopped by pressing a button on the software’s user interface. The software then processes the recorded sensor data according to the approach described in [2], and displays the calculated threshold.

Afterwards, the test results can optionally be uploaded to an Internet server to share them with a remote trainer.

The mobile system was tested on four volunteers that performed a threshold test on an ergometer bike.

RESULTS
The mobile system was able to measure the threshold for all persons involved.

DISCUSSION AND CONCLUSION
The mobile system with automatic sampling of heart rate simplifies threshold measurement. A key advantage is that the system allows the person to move freely during the test. Furthermore, the mobile phone provides rich visual and acoustic user interaction, and allows to easily publish results on the Internet.

A drawback of the current system is its weight of about 590 grams in total. However, this issue can be addressed by re-designing the system for low weight.

The mobile phone can be used to wirelessly retrieve data from a large range of additional sensors. In the future, this will allow collecting data on the test conditions, such as temperature and humidity.

REFERENCES
**INTRODUCTION**

The physical inactivity of huge parts of the population becomes more and more problematical for the health care systems in western countries. Therefore a web-based activity monitoring tool was developed, that uses a triaxial acceleration sensor in combination with an altimeter. An important advantage of that combination is that it allows to easily detect the potential energy and activities like going up- or downstairs. Via the integrated gsm module data can be transmitted to an external server for further analysis.

**METHODS**

g.ActiLab combines a triaxial piezoelectric acceleration sensor (resolution: 6.25 mg; max: 18 g), an altimeter (resolution: 0.2 m), a GSM module, a flash memory, and a display in one device. For measurement the device is mounted dorsal on the hip.

15 subjects (mean age 26.5±6.8) participated in the study. Six tasks were performed: walking with 4 km/h and 6 km/h and running with four different paces (8, 10 km/h, 12 km/h, 14 km/h).

For evaluation an ergospirometry device (Oxycon Mobile, CareFusion, USA), that yields high accuracy but is uncomfortable to wear, served as reference system. In parallel the data was measured by using the Oxycon Mobile, g.ActiLab and another accelerometer based device: GT3X (ActiGraph, USA). The metabolic equivalent (MET, [1]) was calculated and the values of the two accelerometer based devices were compared to the reference system.

**RESULTS**

Table 1: Difference of the MET in comparison to the reference system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SAM</th>
<th>DAM</th>
<th>PAL</th>
<th>Rel. Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of gait cycles</td>
<td>2570±1120</td>
<td>n. a.</td>
<td>1957±932</td>
<td>16%</td>
</tr>
<tr>
<td>Percent lying/sitting</td>
<td>n. a.</td>
<td>71.7±16.3</td>
<td>70.4±16.8</td>
<td>2%</td>
</tr>
<tr>
<td>Percent standing</td>
<td>n. a.</td>
<td>19.0±11.7</td>
<td>19.8±12.1</td>
<td>5%</td>
</tr>
<tr>
<td>Percent stepping</td>
<td>n. a.</td>
<td>9.3±5.1</td>
<td>9.7±5.0</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 1 shows for the two systems and each velocity the mean difference to the reference value delivered by the ergospirometry system. The differences are calculated (in %) according to the following formula:

\[
\text{ΔMET} = \frac{(\text{MET}_{\text{sys}} - \text{MET}_{\text{ref}})}{\text{MET}_{\text{ref}}} \times 100
\]

Overall, g.ActiLab achieves higher accuracy than GT3X. Only for slow walking (4 km/h) and slow running (8 km/h) the accuracy is worse than with the GT3X.

**DISCUSSION AND CONCLUSION**

In the proposed paper we will discuss in detail the technology, comparison of results, and analysis tools that are useful for medical doctors. It is proofed that the proposed solution works fine for activity estimation.

**REFERENCES**


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**G.ACTILAB: A WEB-BASED SYSTEM TO MONITOR PHYSICAL ACTIVITY**

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1g.tec Guger Technologies OG, Schiedlberg, Austria

**INTRODUCTION**

We applied all three devices in a group of normal subjects during the working hours content would make it a good compromise between the other two devices. Therefore, the PAL was worn on the front of the right thigh and reported the number of steps and time spent lying or sitting, standing and stepping.

**RESULTS**

Subjects wore the devices for an average of 7±1 hours. The number of daily gait cycles and percent activities reported by the three devices is given in Tab. 1. The PAL counted only 1507±531 gait cycles and underestimated the SAM numbers by 1-39%. The distribution of activities recorded with the DAM and the PAL compared well and stayed below 5% difference.

**DISCUSSION AND CONCLUSION**

The PAL recorded a lower number of gait cycles than the SAM which was previously reported to be highly reliable and accurate (e.g. McDonald, Karabult). This effect might be due to a threshold in the PAL software that does not count step activities shorter than 20 continuous steps. The percentage of activities was highly comparable between DAM and PAL with the PAL reaching comparable values. Therefore, the PAL appears to be a good solution for step and activity pattern assessments with only one device if the additional level of information provided by either the SAM or the DAM is not deemed necessary.

**REFERENCES**


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**COMPARISON OF STEP COUNT AND ACTIVITY ASSESSMENT WITH THE ACTIVPAL (PAL TECHNOLOGIES), DYNAPORT (MCROBERTS) AND STEP ACTIVITY MONITOR (ORTHOCARE INNOVATIONS)**

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**INTRODUCTION**

In our lab, we usually assess activity patterns with the DynaPort Activity Monitor ('DAM' McRoberts) and step numbers with the Step Activity Monitor ('SAM'. Orthocare Innovations) [1-3]. The ActiPal ('PAL', PAL Technologies) so far has only been used sporadically so that we were interested to find out whether its combined information would make it a good compromise between the other two devices. Therefore, we applied all three devices in a group of normal subjects during the working hours to record their number of steps and activity patterns. The aim of the project was to assess the differences between the results obtained with three devices in order to determine their applicability and potential source of error.

**METHODS**

Currently, 7 healthy subjects (4 male, 3 female; 41±13 yrs., 176±7 cm, 68±12 kg, BMI 22±3) were included and agreed to participate (aiming to include >20). Subjects were asked to wear the SAM, DAM and PAL according to manufacturers' instructions for one day during the working hours. The SAM was worn around the right ankle where it recorded the number of gait cycles in one-minute intervals. The DAM was worn around the waist and a thigh sensor was worn on the left leg; it was used to determine the time spent in lying, sitting, standing posture and locomotor activities. The PAL was worn on the front of the right thigh and reported the number of steps and time spent lying or sitting, standing and stepping.

**RESULTS**

<table>
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**REFERENCES**


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**A UBQUITOUS SYSTEM FOR AMBULATORY ASSESSMENT OF PHYSICAL ACTIVITY IN EVERYDAY LIFE**

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**INTRODUCTION**

Nowadays many people are aware of the importance of maintaining sufficient levels of physical activity. In fact, it has been scientifically proven that regular physical activity not only reduces the risk of cardiovascular disease, but also certain cancers and Diabetes. Furthermore, it can also improve musculoskeletal health and reduce symptoms of depression. On the flip side, physical inactivity is estimated to cause around 21–25% of breast and colon cancers, 27% of diabetes and about 30% of ischemic heart diseases [1].

**METHODS**

One approach to encourage people to be more active is to use technical aids that support and motivate them. An important aspect of achieving this is to inform people about their personal activity behavior. Useful parameters are the step count and the calories burnt. The well known recommendation of 10,000 steps a day is still up to date [2]. Ordinary pedometers have some significant disadvantages. For instance, only a single number summary at the end of the day is recorded and there is no possibility to see a daily profile or a trend analysis. Another disadvantage is that it is difficult to share your experience with others for comparison. Such community experiences could help to keep motivated, and by this improve the activity behavior.
RESULTS
We developed an accelerometer-based system that can monitor steps and estimate the energy consumption of a person. It has form factor and ease of use of a USB flash drive. The device size is 31 x 14 x 4 mm and it is integrated in a wristband, so it will not intrude on the user’s regular everyday activities. The device can run for one entire week without recharging. While plugged in to a computer USB port, the battery is automatically charged with the USB power. Recorded data is transmitted automatically to a web page which displays the results in graphs like the activity history. We currently enhance the web portal by web 2.0 elements, like social networks. Competitions will be possible where groups can compete.

DISCUSSION AND CONCLUSION
Our system helps to motivate and encourage people to increase their physical activity in everyday life. It is very flexible and extensible; it can be adjusted depending on the concrete application. Possible scenarios are health programs of health insurance funds or work health. Furthermore, the reasonably priced system can be used in large-scale research studies. Aside from the described usage scenarios, there could be other applications we would like to discuss.

REFERENCES

P2-22 WIRELESS-PORTABLE SYSTEM FOR LONG-TERM MONITORING OF UPPER-LIMB ACTIVITY
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INTRODUCTION
It has been pointed out that there is no optimal technique to measure upper-limb movements [1]. Furthermore the selection of the outcome measures has been debated. Therefore an “ideal” instrument should measure on the level of activity or role fulfilment that reflects function on a individual’s normal day. If activities of the upper-limb are going to be studied, it is useful to study them in a free-living environment and the instrument should not interfere with the subject’s activities. This paper describes the design and implementation of wireless-portable system, which is able to detect the posture and movement of the upper limb in a free-living environment.

METHODS
The system is composed of two parts, a storage unit and a set of acquisition units. The storage unit controls and receives all the information from the different acquisition units. This unit uses a PIC microcontroller (PIC18LF2550), a memory card (SD) and a wireless transmitter/receiver (nRF2401A). It commands all the acquisition units and stores the information. Each acquisition unit has a unique digital identifier and it is composed of a motion sensor, a microcontroller (PIC16F888), and a wireless transmitter/receiver. The motion sensor is based on the Strathclyde Upper-Limb Activity (SULAM)[2].

RESULTS
The proposed system can have several acquisition units associated to one storage unit, which creates a sensor network. This sensor network is dedicated to assess the kinematics of a single subject and it is possible to have more than two systems working in the same room without causing interference between each other. The systems allowed adding extra motion sensor to the original SULAM in order to assess compensatory movements (one on the trunk and one on the leg).

DISCUSSION AND CONCLUSION
A hardware technology consisting of an electro-hydraulic activity sensor (SULAM) and a wireless transmitter/receiver was implemented to transmit data from multiple motion sensors. The system is compact and it does not interfere with the subject’s normal activities. The results represent and important first-step in the development of a wireless-portable system to assess upper-limb activity, which could be used to evaluate and/or monitoring upper-limb rehabilitation.

REFERENCES
In our study we adopted the mobile tri-axial accelerometer actibelt® \( ^2 \) to monitor the activity of dogs (which has to fight against mostly the same diseases as men. In this context our aim was to have a mobile device working in an uncontrolled environment to measure the activity of dogs (which is already working for man \( ^3 \)) and to test its usability in e.g. an animal nutrition supplementation study.

Methods

For at least in the last 15,000 years and possibly up to 100,000 years, dogs and humans were sharing living space and food sources. A beneficial relationship was developed which probably started as a hunting partnership. They were both skilled in endurance running and in the end led to the state in which dogs are today known as “man’s best friends” \( ^1 \). A dog is the animal which has to fight against mostly the same diseases as men. In this context our aim was to have a mobile device working in an uncontrolled environment to measure the activity of dogs (which is already working for man \( ^3 \)) and to test its usability in e.g. an animal nutrition supplementation study.

**INTRODUCTION**

For at least in the last 15,000 years and possibly up to 100,000 years, dogs and humans were sharing living space and food sources. A beneficial relationship was developed which probably started as a hunting partnership. They were both skilled in endurance running and in the end led to the state in which dogs are today known as “man’s best friends” \( ^1 \). A dog is the animal which has to fight against mostly the same diseases as men. In this context our aim was to have a mobile device working in an uncontrolled environment to measure the activity of dogs (which is already working for man \( ^3 \)) and to test its usability in e.g. an animal nutrition supplementation study.

**RESULTS**

After a feasibility study with a female Galgo Español including long term measurements and outdoor field measurements, we have tested the usability with another 30 different dogs (21 female/ 9 male dogs; mean age: 10.5+/-2.3 years; mean weight: 24.8+/-6.53 kg). 28 of them recorded three one-week measurements. One actibelt® had a hardware failure and one dog dropped out of the study. The mean duration was 6.33+/-2.37 days. After familiarization with the new type of dog collar, the dogs were comfortable with it and no longer disturbed by wearing a heavier collar as usual. This made it possible for us to compare the acceleration signals with the gold standard gait analysis methods.

**DISCUSSION AND CONCLUSION**

A mobile accelerometer integrated in a dog collar is a useful way to record dog activity, especially in an uncontrolled environment. It seems feasible to adapt already existing algorithms for step detection in human gait analysis to count steps (Fig. 1). The need to develop objective outcome measures for “non-human persons” such as dogs that can neither be interviewed nor fill in questionnaires may help to improve trial design in the elderly.

**REFERENCES**

\[ ^1 \] Lindblad-Toh K et al, Genome sequence, comparative analysis and haplotype structure of the domestic dog, Nature 2005; 438: 803-819

\[ ^2 \] Daumer M et al, Biomedizinische Technik Biomedical Engineering 2007; 52(1): 148-55

second stage the signals are translated into electrical signals (conversion). The third stage is responsible for signal amplification (gain), since they usually are about uV or mV before being taken to a fourth stage where filtering of the signals and the adequacy of these to improve and discard irrelevant information (processing and simplification). At this point the signals and can be translated into stimuli, usually visual or auditory perception and easily by patients (conversion) which corresponds to the fifth stage of the system. Finally, the information reaches the patient in real time (presentation) and meets the goal of completing the feedback to the patient.

RESULTS
We developed a prototype system capable of acquiring the myoelectric signals and convert them into visual and auditory stimuli through analog and digital processing. Which aims to improve the methods currently used for the rehabilitation of patients with any type of motor dysfunction in upper extremity.

DISCUSSION AND CONCLUSION
Development of the device allows patients to carry out therapies with minimal help, while compensating for the lack of therapies that require specialized personnel and provides the level of interaction, visualization and cognitive stimulation for the rehabilitation of patients with motor dysfunction upper extremity as a consequence of brain injury.

REFERENCES

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P2-26 GAIT AND BALANCE QUALITY ASSESSMENT TOOL USING THE ACTIBELT® PLATFORM
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1SLCMR e.V. - The Human Motion Institute, Munich, Germany; 2Trium Analysis Online GmbH, Munich, Germany

INTRODUCTION
The devices currently used for the clinical assessment of balance and gait quality are cumbersome, can only be used in a gait laboratory and the cost can be prohibitive. However, recent developments in micro-technology make it possible to measure activity with miniaturized and relatively inexpensive mobile accelerometers. We aimed to develop a set of standardized tests enriched by parallel use of accelerometry that a) are known and may be used in a wide range of diseases and/or b) that are associated with fall risk.

METHODS
In our study we used a tri-axial accelerometer – actibelt® [1] integrated in a belt buckle, and therefore placed near the body’s center of mass (COM). We developed an acquisition protocol to perform a set of clinical test in such a way that we could subsequently analyze the data automatically. The sequence of tests was developed in the context of a European project (VPHOP) to assess functional mobility in osteoporotic patients. The battery of tests was agreed upon by an interdisciplinary panel of clinicians and consists of a series of rapid functional tests specially selected to assess risk of falling (i.e., Romberg, iTUG, 10 m walk). We developed a peak detection algorithm based on the “DMW”-algorithm [2] to detect the start and the end of the individual tests. The protocol was tested, during the Osteologie 2010 congress in Berlin, in 25 healthy volunteers who attended the convention. Immediately after the test performance, the data was uploaded to the SLCMR internal server where the results were automatically generated. The analysis output includes: number of steps, asymmetry index (SASI), estimated step length and mean speed. Spearman rank correlation and Wilcoxon non-parametric tests were used to assess the correlation between demographic data and accelerometer parameters.

RESULTS
Data collected using the aforementioned protocol on 40 healthy individuals (17 female, 23 male; mean age 36.4+/–13.9 years) were available for analysis. They performed the 10 m walk test (2 trials) and the Tandem Walk test. Mean values were calculated: mean walking speed = 4.14+/–0.52 km/h, mean step length = 0.68+/–0.08 m. Age was significantly associated to the SASI in the coronal plane (p = 0.018), for adults older than 45 y the mean SASI in this plane was 0.41 while for individuals < 45 y the mean SASI was 0.29. Gender and step length were also significantly associated – (male: 0.73+/–0.07 m; female: 0.63+/–0.06 m; p < 0.001). The peak detection algorithm was tested over 337 taps and these results were obtained: precision = 99.59%, recall = 96.96%, F-measure = 95%.

DISCUSSION AND CONCLUSION
We have developed a framework to automatically detect and evaluate 11 standardized test that play a roll in many chronic disabling diseases, such as multiple sclerosis and osteoporosis. There is evidence that waist-attached accelerometers are best located near the body’s COM, providing information on subject body movements and seem to be better suited for this purpose when compared to sensor locations at the wrist, knee or to uncontrolled locations. We see the potential that these “rapid clinical tests” could become a standard in the clinical assessment in gait and movement disorders. Four European centres are currently using this protocol in the context of a bone fracture risk study.

REFERENCES
P2-28 MAPPING HUMAN MOTION ON 3D SURFACES

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INTRODUCTION
Tracking of physical activities has become more and more popular during the last decade. Especially GPS-enabled mobile phones offered access to this technology to a broad class of customers. Unfortunately GPS has to struggle with various disadvantages, such as high energy consumption, weather dependent resolution, very low resolution of height differences and still relatively high costs.

MATERIALS AND METHODS
A server software was created that can process actibelt® measurements and display them in a Google Maps applet embedded into a web page. The main processing happens in a Python module written in C, based on some of the previously used actibelt® measurement analysis algorithms in R. The visualization is done partly in Python and HTML.

RESULTS
The actibelt® [1] enables continuous recording of physical activity and does not depend on strong/high quality signals from satellites. Furthermore, battery power allows operating times of more than 25 days of continuous recording (the storage of “actibelt RCT” of 512MB is currently the limitation). In comparison with GPS devices it does not assume stops on low walking speeds (below around 2 km/h) but is able to detect stops correctly, as well as walking/running speeds and approximate distances. In contrast to common GPS devices the barometer on “actibelt® BLU” devices can be used to measure height profiles of tracks correctly. All GPS devices tested in this study failed to even record a height profile which was at least approximately correct.

Figure 1: Elevation step frequency and activity counts of a measurement

DISCUSSION AND CONCLUSION
Mapping mobile accelerometry data on 3D surfaces appears to be an interesting alternative to GPS Tracking. Most individuals doing regular training will frequently take the same 2-5 routes, which they will have to record once manually and then recall for each time a workout is performed. The high-quality recording of the height profile should allow remarkable improvements in estimating energy consumption compared to a GPS record of the same workout. Future versions are planned to include an auto-map algorithm, based on the approximate distance, and the height profile recorded, which is matched against Google's database using dynamic time warping.

REFERENCES

P2-29 PEDOMETER STEP COUNTS AND SELF REPORTED OCCUPATIONAL SITTING AND WALKING

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INTRODUCTION
Given the large amount of time adults can spend at work, and the potential implications for health, there is increasing interest in occupational sedentary behavior (i.e. sitting time) and physical activity. Pedometer step counts can provide an objective indicator of these behaviors, but such data collection may not be pragmatic for large epidemiological studies. The utility of self-reported data is, however, unclear. This study aimed to explore the association between self-reported data for occupational sitting and walking, with pedometer data.

METHODS
Volunteers were recruited from an Australian state department of education, and included staff in administrative, teaching, professional and management positions. As part of a self-administered questionnaire, participants indicated the frequency of sitting and walking during their work. Responses were scored using a five point Likert scale (none of the time to all of the time) and collapsed into three categories of low, sometimes, and high. Participants wore a Yamax Digi-walker SW200 pedometer for five consecutive working days, and recorded their total step counts on each day. Data from participants who wore the pedometer for at least three of five working days and at least 10 hours/day were averaged to derive a weekday step count. Univariate associations were examined using ANOVA and linear regression. Data were analysed using multivariable linear regression, with adjustment for age, BMI (measured) and leisure time physical activity (self reported).

RESULTS
Of the 94 volunteers, 86 provided pedometer data, and 82 met the inclusion criteria. Weekday step counts ranged from 2738-18,357 with a mean of 9594 (SD 3441). Univariate analyses indicated a significant association between weekday step counts and each of occupational sitting (β=0.008), occupational walking (β=0.002), age (p=0.013), BMI (p=0.016), and leisure time physical activity (p=0.013), and non significant associations with health or employment status. Multivariable analyses indicated that people reporting high sitting at work had significantly lower weekday step counts than those reporting low sitting (β=−2939; 95%CI -4893, -277; p=0.023). Those reporting high walking at work had significantly higher weekday step counts than those reporting low walking (β=2939; 95%CI 985, 4893; p=0.003).

DISCUSSION AND CONCLUSION
Self report data on the frequency of sitting or walking at work can differentiate between the lowest and highest levels of behavior, but may not be sensitive to less extreme differences. Further work is needed with more heterogeneous samples and direct concordance between time spent at work and pedometer data.

P2-30 MEASURING THE PHYSICAL ACTIVITY/INACTIVITY OF ADULTS WITH DOWN SYNDROME

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INTRODUCTION
Adults with Down syndrome have low levels of physical activity, and are more likely to experience health problems such as cardiovascular and obesity. Previous research has focused on exercise interventions to promote the physical activity of adults with Down syndrome, yet current physical activity recommendations are more relevant to lifestyle physical activity.

METHODS
Lifestyle physical activity/inactivity of four community-based adults with Down syndrome was objectively measured over a 7-day assessment period, using an activity...
RESULTS
Three of the participants were Special Olympics athletes and attended regular sports activities/training sessions, yet prolonged walking in the person’s local area was the only activity identified whereby participants were able to achieve more than 10,000 steps per day, and over 30 minutes of moderate intensity activity. Participants were sedentary in the absence of structured activity, and reported that they require assistance and support to access and participate in physical activities.

CONCLUSION
Walking is key to increasing the physical activity of adults with Down syndrome. Further research on establishing more suitable physical activity measurement guidelines is recommended.

REFERENCES

P2-31
ACCELEROMETRY CUTOFFS AND OLDER ADULTS: A SYSTEMATIC REVIEW

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INTRODUCTION
Most accelerometer research is in children and adults. Literature on accelerometer in older adults is limited and many studies rely on validity studies completed on younger adults to determine cutpoints for exercise intensity. The purpose of this study was: 1) to review the literature to identify studies that used Actigraph accelerometers to assess moderate-to-vigorous physical activity (MVPA) in older adults; and 2) to determine the effect of changing reported cutpoints on meeting guideline recommendations for MVPA.

METHODS
We completed an electronic literature search for accelerometers, physical activity, and older adults. We limited our search to English language and adults aged 65 years+. We included studies that used ActiGraph accelerometers (Pensacola, FL) at the waist and cutpoints for exercise intensity. Data extracted identified the study design, participant characteristics and accelerometer methods. We then analyzed accelerometer data (GT3x) from active older women (65–75 years) using different cutpoints from the literature to determine meeting guidelines as a ≥ 30 minutes MVPA/day. Data were a sample from an RCT to test the effect of frequency of resistance training. Participants wore accelerometers for 1 week (1 minute epoch with inclusion of at least 4 days with ≥ 10 hours/day).

RESULTS
There are a limited number of articles that have used accelerometer in older adults. The majority of cutpoints for MVPA used for this age group ranged between 1952 to 2020 counts/minute. We identified two other cutpoints that included older adults in their calculation and used these three cutpoints (Swartz=574 counts/minute [1], Copeland=1041 counts/minute [2], Freedson=1952 counts/minute [3]) to analyze our data. 114 participants had valid data and their mean age was 69.6(2.9) years and mean BMI was 26.6 (5.0) kg/m2. The following amount of MVPA was obtained from the different analyses: Swartz=84.7(41.8) minutes/day, Copeland=47.2(20.0) minutes/day and Freedson=23.9(20.6) minutes/day. These values result in 108(95%), 73(64%) and 38(33%) participants meeting MVPA guidelines respectively.

DISCUSSION AND CONCLUSIONS
Accelerometers provide valuable information regarding physical activity, but the analysis of data can alter observed findings. The majority of studies have used similar cutpoints which allows for comparison, however, these cutpoints are not age or ability specific and may not accurately represent the amount of MVPA for all older adults.

REFERENCES

P2-32
ACCELEROMETER DERIVED MOVEMENT PATTERNS DIFFERENCES ACROSS AGE

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INTRODUCTION
Pattern recognition classification algorithms have successfully identified energy cost differences for each type from hip-worn accelerometers (ACC) [1,2]. These algorithms evaluate attributes of the acceleration signal during high frequency sampling. ACC output similarities and differences across activity types are well characterized [3]. An often overlooked area of potential difference lies in movement pattern disparities across age. The purpose of this study was to examine movement pattern differences across age during treadmill (TM) walking and activities of daily living (ADL).

METHODS
Participants (N=118) underwent measures of stature, mass, and percent body fat (%BF) and were classified into 3-groups (Gp1, 18-39yrs, n=48; Gp2, 40-59yrs, n=39; Gp3, 60-79yrs, n=31). Each participant completed 7-TM walking activities (26.8-107.2 m/min in 13.4 m/min increments), and 5-ADLs (1: computer, 2: sweeping/mopping, 3: vacuuming, 4: moving boxes, and 5: walking/intermittent stair climbing) for 4-7 min each. During activities a tri-axial ACC (Actigraph GT3x) was worn on the left ankle (LA), left hip (LH), and left wrist (LW). Each ACC was initialized to record in 1-4 epochs, with mean counts derived from averaging the last 2-min of TM and 4-min of ADL activity. ANOVA and GLM were used for unadjusted and adjusted (stature and %BF) age group comparisons on movement patterns.

RESULTS
All groups significantly differed by age (p<0.001), height (p<0.05), and %BF (p<0.001). The magnitude of mean acceleration significantly increased in unadjusted and adjusted analyses (p<0.001) across TM walking speeds for the LA, LH and LW. During these activities there were no significant differences in ACC output within each TM walking speed across all age-group categories. The magnitude of mean unadjusted and adjusted acceleration significantly differed across each ADL within each age group category (p<0.05). For ADLs 2, 3, 4, and 5, ACT output was significantly lower (p<0.05) in age Gp3 compared with Gp1 and 2, in the magnitude of 5-13% lower for LA, 3-11% lower for LH, and 7-24% lower for LW.

DISCUSSION AND CONCLUSION
ACC derived movement patterns during paced activities did not differ across age group classifications. During self-paced ADLs, ACC movement was decreased in the old, with differences becoming more pronounced with higher energy cost activities. Findings suggest that with older age movement patterns during ADLs become unique from other ages, where individual’s likely self pace as a function of individual physiological attributes.

Future work is warranted to evaluate predictive capabilities of advanced modeling approaches as a function of age and physiological function.

REFERENCES
**P2-33** HOW RELIABLE AND VALID ARE TIME USE SURVEYS FOR ASSESSING PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR?

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**INTRODUCTION**

National time use surveys have been collected in many countries since as early as the 1960s. Time use surveys potentially provide higher quality, more detailed sedentary and physical activity behavior national prevalence estimates than traditional self report surveillance systems. This study determined the reliability and validity of time use surveys for assessing sedentary and physical activity behaviors [1].

**METHODS**

Participants (n=134) were recruited from Australian worksites and completed a 2-day time use diary twice, 7 days apart. Participants also wore an Actigraph GT1M accelerometer over the whole study period, which determined time spent in sedentary, light and moderate/vigorous activity intensities. The time use activity codes were reclassified into the same three activity intensity categories based on the physical activity compendium, with the exception of occupational time use codes, which are difficult to classify into intensity categories. The first and second time use diaries were compared for test-retest reliability. Both time use diaries were also compared with the activity monitor to determine the time use survey's validity.

**RESULTS**

Participants with similar activity patterns during the 2 diary periods showed reliability intraclass correlations of 0.74 and 0.73 for non-occupational sedentary behaviour and moderate/vigorous physical activity, respectively. Comparison of the diary with the accelerometer showed Spearman correlations of 0.57–0.59 and 0.45–0.69 for non-occupational sedentary behaviour and moderate/vigorous physical activity, respectively.

**DISCUSSION AND CONCLUSION**

Time use surveys appear to be more valid for population surveillance of non-occupational sedentary and health enhancing physical activity behavior than more traditional surveillance systems, which generally only show Spearman validity correlations in the 0.2-0.3 range. National time use surveys could potentially be used in many countries to retrospectively study non-occupational sedentary and physical activity behaviors over the past five decades.

**REFERENCES**


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**P2-34** NOVEL ANALYTIC METHODS TO ESTIMATE PHYSICAL ACTIVITY FROM ACCELEROMETER DATA: AN OPENSOURCE WEB-BASED TOOL

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**INTRODUCTION**

Accelerometers have become a relatively common way for clinical researchers to objectively measure physical activity. In turn, sophisticated statistical methods have been developed to estimate various aspects of physical activity from accelerometer data. The computer programming required to implement these methods is substantial, which poses a barrier to their use by clinical researchers. To address that barrier, we have created an easy-to-use freely available and open source website that implements the neural network developed in Staudenmayer et al. to estimate energy expenditure (METs) from 1-second epoch single-axis Actigraph accelerometer data [1]. It also processes the data to estimate the number bouts of physical activity, the amount of sedentary time, the number of transitions between activity levels, and other aspects of physical activity. Multiple Actigraph files can be processed simultaneously. Other options include the capacity to upload a log of the times the device was switched on and off, to modify criteria used to determine “non-wear time”, and to analyze specific parts of a day. The website creates downloadable spreadsheets that contain the estimates.

**DISCUSSION AND CONCLUSION**

The website we have created allows for easy application of a new statistical method to estimate METs and several other aspects of physical activity from 1-second epoch single-axis Actigraph data, and it provides a number of options for customizing the analysis. This tool reduces the programming burden on clinical investigators, and it makes it easier for a larger community of researchers to use the latest methods. The software is available free of cost and is open source. It can be extended in the future as additional methods are developed. The software can also be modified and used as a template by other groups who want to make their methods easily accessible to others.

**REFERENCES**


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**P2-35** ENERGY EXPENDITURE MEASUREMENT COMPARISON DURING CYCLE ERGOMETRY: LIFECYCLE, SENSEWEAR PRO ARM, AND LEG, INDIRECT CALORIMETRY

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**INTRODUCTION**

Cycle ergometry is a common activity in fitness facilities with many ergometers providing a visual estimate of energy expenditure (EE), which most users believe to be accurate. Simple step counters and accelerometry based physical activity monitors may not measure stationary cycling EE accurately due to where they are positioned on the body and/or the rotary nature of the cycling activity itself. The SenseWear armband (SWA) combines physiological measures with accelerometry for estimating EE. However, studies have found SWA to underestimate cycling EE when compared to indirect calorimetry (IC). This may be due to SWA placement (on the arm), characteristics of the group tested (children, untrained, males, overweight), situation (lab), and/or the SWA Pro2 and software (version 1 or 4) used [1,2,3]. Our study sought to explore some of those factors by assessing cycling EE in a fitness facility setting as measured concurrently by a commercial Lifecycle 95C ergometer (LCE), portable IC (MetaMax) and two SenseWear Pro3 armband units placed on the arm (SWA-Arm) and the lower leg (SWA-Leg) in healthy, young, fit males and females.

**METHODS**

Ten (5 males: 21.8 ± 0.8 yrs, 183.5 ± 8.5 cm, 84.0 ± 5.5 kg; 5 females: 21.2 ± 1.3 yrs, 167.7 ± 7.6 cm, 61.3 ± 5.5 kg) volunteer Kinesiology students participated. They cycled on the LCE performing a 5 minute warm-up, 20 minutes at a constant load set to elicit 65-70% of age-predicted HRmax, and a 5 min cool-down. The same LCE was used for all tests with the subject’s weight entered for the EE kcal display. SWA Version 6.1 software was used.

**RESULTS**

Table 1 – The kcal energy expenditure (mean ± SD) of the four measurement methods for the 20 minutes of constant load, steady-state cycle ergometry exercise.

<table>
<thead>
<tr>
<th></th>
<th>IC Metamax</th>
<th>Lifecycle 95C</th>
<th>SWA-Leg</th>
<th>SWA-Arm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>278.9 ± 26.4</td>
<td>193.4 ± 13.8</td>
<td>196.0 ± 23.7</td>
<td>182.2 ± 25.7</td>
</tr>
<tr>
<td>Females</td>
<td>228.9 ± 30.2</td>
<td>156.4 ± 16.6</td>
<td>147.4 ± 16.5</td>
<td>119.6 ± 12.7</td>
</tr>
</tbody>
</table>

Factorial ANOVA procedures (p≤0.05) and Bonferroni post-hoc comparisons revealed that the IC EE was higher than all other measurement methods. EE for LCE and SWA-Leg were similar, LCE EE was higher than the SWA-Arm, and EE from the SWA-Leg and SWA-Arm were similar. An expected sex difference in EE due to body mass was found, however, a significant sex by method interaction was observed.

**DISCUSSION AND CONCLUSION**

The magnitude of underestimation of all methods compared to the MaxMetax IC was surprising and has implications for exercisers and researchers alike concerning the accuracy of the EE estimates they use. Our results support previous findings of underestimation of cycling EE by the SWA but suggest that by simply placing the SWA
on the lower leg during cycling may reduce that difference. Further research with a larger sample and different exercise intensities appears warranted.

REFERENCES

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P2-36

VALIDATION OF TOTAL ENERGY EXPENDITURE OF SUUNTO HEART RATE ANALYSIS WITH DOUBLY LABELED WATER METHOD

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INTRODUCTION
Heart rate (HR) monitoring is an accepted objective method to estimate energy expenditure in free living subjects [1]. There are several heart-rate (HR) monitors available on the field; however most of them have not been tested in terms of its accuracy. The purpose of this study was to validate total energy expenditure estimated from Suunto HR (Suunto Oy, Finland) analysis with the doubly labeled water (DLW) method.

METHODS
The study subjects were from mother-father-daughter trios (14 mothers, 15 fathers, 15 girls), aged 18-59 years, with a mean body mass index (BMI) of 26.3 (kg·m⁻²). Total energy expenditure (TEE) was estimated from a 24 h heart rate log by Suunto HR analysis and by DLW. The correlation between TEE values estimated by different methods was calculated using Pearson correlation. The TEE values were compared to each other as the mean of the difference ± 1.96 SDs across the family members by Bland and Altman analysis [2]. T-test was used to evaluate the mean differences.

RESULTS
Compared to DLW, no significant differences in TEE were found between DLW (2043±301 kcal/day for mothers, 2618±423 kcal/day for fathers, and 2102±299 kcal/day for daughters, respectively) and HR analysis (1989±285 kcal/day for mothers, 2665±641 kcal/day for fathers, and 2285±461 kcal/day for daughters) within family members and in the study population. HR analysis provides 2.1% lower values for TEE in mothers, 1.8% higher values in fathers and 8.8% higher values in girls. The correlation between the two methods was r=0.648 (p<0.001) for the total sample. The Bland and Altman method showed good agreement between the two methods.

DISCUSSION AND CONCLUSION
Suunto HR analysis provided valid estimation of the total energy expenditure in both adult males and females. Using HR is an easy and cost effective way to estimate total energy expenditure.

REFERENCES

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P2-37

ESTABLISHING A THRESHOLD FOR THE NUMBER OF MISSING DAYS USING 7-DAY Pedometer DATA

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INTRODUCTION
Increasingly, objective physical activity monitoring devices (e.g., pedometers and accelerometers) are used to measure individuals’ habitual physical activity [1] for surveillance, screening, research, and evaluation purposes. Due to the nature of this type of data collection, researchers are often left with large amounts of missing data. Individual information centered (IIC) approach [2,3] to missing data recovery (i.e., replacing missing values by the mean of the remaining days of the participant) is an alternative and superior method which relies on an individual’s own pattern of physical activity. Few studies, however, have examined the impact of the amount of missing values/days on overall step counts. The purpose of this study was to examine the threshold of the number of missing days where recovery using IIC remains effective.

METHODS
Data for this study came from Kang et al. [2] where a total of 86 participants, aged from 17 to 79 years old, had 7 consecutive days of complete pedometer (Yamax SW 200) wear. Missing datasets (1 day missing to 6 days missing) were created by a SAS random process 10 times each. All missing values were replaced using the IIC approach. A 7-day average was calculated for each dataset, including the complete dataset. One-way repeated measures ANOVA was used to determine the differences between 1 through 6 missing datasets and the complete dataset. Mean Absolute Percent Error (MAPE) was also computed.

RESULTS
Mean (SD) daily steps counts for the complete 7-day dataset were 7979 (3084). Mean (SD) values for the 10 samples for 1 through 6 days missing datasets were 8072 (3218), 8066 (3109), 7968 (3273), 7741 (3050), 8314 (3529), and 7871 (4431), respectively (p > .05). The lower MAPEs were estimated for 1 day missing (4.3%), 2 days missing (6.9%), and 3 days missing (9.5%) while all others were greater than 10%.

DISCUSSION AND CONCLUSION
The results of this study show that the 1 through 6 days missing datasets, with replaced values, were not significantly different from the complete dataset. Based on the MAPE results, it is not recommended to replace missing step counts for 4 + days missing (MAPE > 10%). Further research is suggested to analyze missing step-count data for situations other than 7-days.

REFERENCES

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P2-38

ASSESSMENT OF L5/S1 MOMENTS DUE TO TRUNK MOTION USING AN INERTIAL SENSORS

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INTRODUCTION
Awkward trunk posture/motion causes high muscular spinal moments and is an important risk factor for the development of back pain. Inertial sensors (ISs), measuring 3D accelerations and angular velocities, could be used for the ambulatory assessment of this spinal loading. A previous study [1] investigated the optimal sensor placement for the determination of trunk inclination. The aim of the present study was to investigate how well dynamic L5/S1 moments due to trunk motion (ML5/S1) could be estimated using the 3D accelerations measured by an IS. In addition, the optimal sensor position for measurement of ML5/S1 was investigated.
METHODS

M\textsubscript{ML5/S1} was assessed in 10 subjects during a manual lifting task (Figure 1). Gold standard M\textsubscript{IS} was obtained by calculating the moment caused by the motion of the three major trunk segments (abdomen + thorax + head) using inverse dynamics. Segments motions were recorded using OptotracTM marker clusters. IS M\textsubscript{ML5/S1} was estimated using the IS accelerations projected on a plane in the IS coordinate system, representing the transverse plane of the trunk. This plane was defined during an upright reference posture at the start of the each trial (in this posture: trunk transverse plane = the global horizontal plane). IS M\textsubscript{ML5/S1} was obtained by multiplying this acceleration, consisting of acceleration due to actual motion and gravity, by the trunk mass and by a fixed moment arm from the L5/S1 joint to the combined centre of mass of the trunk. To test which position of the IS on the trunk was optimal for measurement of M\textsubscript{ML5/S1}, lifting trials were repeated and, in between trials, the IS was moved from the top of the sacrum (posterior superior iliac spines) towards C7.

RESULTS

Figure 2 shows the RMS error between the gold standard and IS M\textsubscript{ML5/S1} as a function of sensor location. Averaged over subjects, the RMS error was smallest for IS placement at about 20-30% of the distance from the sacrum to C7. The RMS error at this location was around 10 Nm which was about 8% of the peak M\textsubscript{ML5/S1}.

DISCUSSION AND CONCLUSION

M\textsubscript{IS} could be assessed with reasonable accuracy when the IS was placed at about 25% of the distance from the sacrum to C7. This location is consistent with the previously reported optimal location for the measurement of trunk inclination [1].

REFERENCES

A NOVEL GYROMETER BASED ASSESSMENT OF THE CLINICAL ORTHOPAEDIC SINGLE LEG STANCE ‘TRENDELENBERG TEST’

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INTRODUCTION
The Trendelenburg test has been widely used by orthopaedic surgeons to assess qualitative muscle performance of a patient’s hip abductors[1]. During the test, patients stand on one leg while the examiner observes the movement of the pelvis in the frontal plane. With impaired strength of the stance side hip abductors, the nonstance ilium drops below the stance side ilium (pelvic drop) resulting in a positive test. There is a large variety in the way the test is performed and interpreted[2]. We investigate the use of a gyrometer in the assessment of Trendelenburg test which dynamically measures the true angle of pelvic tilt/drop with respect to the ground.

METHODS
A gyrometer (300deg/s) was attached onto the sacrum in healthy subjects (n=12, M/F=5/7, age=35±11, BMI=25±4, UCLA=8±2). All subjects were asked to raise one leg with 30° flexion in the hip joint with foot flat to the floor and to maintain this position for 15 seconds with both hands resting on a researcher for balance. The gyrometer signal was analyzed using our own developed algorithms in MATLAB. Pelvic angle [deg] is defined as the mean of total pelvic tilt/drop during 15 seconds single leg stance.

RESULTS
Different phases of the Trendelenburg test were identified and quantified using the gyrometer signal: 1. bipedal stance; 2. rising left leg and stabilization; 3. single leg stance phase; 4. placing leg back on the ground; 5. bipedal stance (figure1). While standing on one leg, subjects showed either pelvic tilt up to 6° or pelvic drop not more than 2° (figure2). Both legs showed similar results (legs n=26, pelvic tilt=1.6°±0.5).

DISCUSSION AND CONCLUSION
Our results show that it is possible to use gyrometers to measure pelvic obliquity in the within healthy subjects. In our data we showed that a pelvic drop up to 2° can be considered as normal. We observed different leg raising strategies in which subjects who hold the non stance foot posterior to the stance foot were more likely to show a pelvic drop. A small difference was also observed between legs on the same subject. The additional use of a gyrometer enabled more accurate and objective dynamic assessment of the Trendelenburg test measuring the true pelvic angle. We conclude that gyrometer based assessment of Trendelenburg test could improve test validity. Further evaluation within patients should be conducted to prove the additional value.

REFERENCE

THE EFFECT OF EPOCH LENGTH ON THE TOTAL REPORTED DURATION OF WALKING

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INTRODUCTION
Accelerometer-based activity monitors, which report their outcome as counts accumulated over a fixed time-period (epoch), are currently the most common form of measuring objective physical activity. More recently, accelerometer-based activity monitors which report outcome as time spent in postural and activity categories, have been used. These monitors report duration to a much finer resolution. The effect of epoch length on the reported duration of activity when comparing these two classes of activity monitors has not been explored.

METHODS
Eleven healthy adults (5 male, age 29±6 years, BMI 23.4±2.9kg.m-2) wore two activity monitors (Actigraph and activPAL) simultaneously during a short controlled series of activities (five short periods of standing (30s); 45s; 60s) with periods of standing (15s-45s) between, and spending an hour away from the university campus as they wished (n=9).

The Actigraph monitor (GT3X) was set to collect data in 1 minute epochs, and counts were categorised as not walking (<600) or walking (≥600). The activPAL activity monitor presents data as one of three postural categories (sit/lie; stand; walk) in durations to the nearest 0.1s. For the controlled tests, total duration of walking was compared to the known walking content of the test (1-sample t-test). For both tests, total duration of walking was compared between monitors (paired t-test).

RESULTS
In the controlled tests, the activPAL always recorded 5 separate walking events. Total duration of walking events 177±5s was not significantly different to the known value 180s (p=0.6), and no single walking event was more than 5s different from the values specified in the protocol. For the Actigraph the number of walking periods identified were fewer than those undertaken (1-4). The total duration of walking was 284±61s, which was significantly higher than the known value (p<0.001), and the activPAL (p<0.001).

Outdoors, participants spent the majority of their time walking (38±10 minutes). The mean absolute difference in walking duration between the Actigraph and the activPAL was 4±1 minutes. The difference in duration between monitors was not significant (p=0.6), but could represent up to a 24% difference on an individual basis.

DISCUSSION AND CONCLUSION
Despite the relatively low levels of walking recorded during the study, there were differences in the duration of walking recorded between the monitors of up to 24%. The difference between monitors was not statistically significant, but has the potential to be a threat to direct comparisons in the duration of walking over longer periods of monitoring.

ACCELEROMETRY WEAR TIME EFFECTS ON SEDENTARY BEHAVIOR AND PHYSICAL ACTIVITY INTENSITY

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INTRODUCTION
Data processing procedures and output comparisons for accelerometry (ACC) have been explored [1] but not specifically in older adults (OA). Accordingly, the purpose of this study was to compare sedentary behavior (SB) and physical activity (PA) estimates in OA across different wear time processing decisions.

METHODS
Three hundred and forty individuals (63.9±7.7yrs) wore a belt-mounted 7164 Actigraph ACC for seven consecutive days during waking hrs. ACC derived counts/min were
categorized into accumulated time spent in SB (≥49cts/min), moderate general (MG; 760-1651cts/min), moderate walking (MW; 1952-5724cts/min), vigorous (≥5725cts/min), and moderate + vigorous activity (MVPA; ≥1952cts/min) [2]. Error scores for SB and PA averages were determined by subtracting estimates obtained from 6, 8, and 12 hrs of wear time from the criterion of 10 hrs. Differences between mins/d of SB and PA were determined with a one-way MANOVA adjusting for alpha level. One sample t-tests with adjustment for simultaneity were run to see whether error scores were significantly different from zero.

RESULTS

The range of SB and PA across all wear times was 551.7-562.5 SB mins/d, 71.4-73.4 MG mins/d, 22.3-32.2 MW mins/d, 1.2-1.5 vigorous mins/d, and 23.6-24.1 MVPA mins/d. The one-way MANOVA revealed the error scores for different wear times differed from one another for SB and PA averages (p < 0.001). One-sample t-tests on the error scores revealed that SB and MG estimates were significantly different from zero for 6, 8, and 12 hrs of wear time (+1.3 to -3.8mins/d) and +0.1 to -0.7mins/d, respectively, 6 and 12 hrs and 8 hrs of wear time for MW (+0.2 and -0.15mins/d) and MVPA (+0.2 and -0.2mins/d), respectively. There were no differences in wear time for vigorous PA. There were significant differences in the number of useable days between 6, 8, and 12 hrs of wear (6.7-6.3d) when compared to 10 hrs wear time (6.5d).

DISCUSSION AND CONCLUSION

This study demonstrated that statistical differences occurred in mean estimates of SB, various PA intensities, and total days of wear when 6, 8, and 12 hrs of wear time was compared to 10 hrs. Despite the statistical differences, the actual differences were not clinically meaningful. Findings suggest that ACC wear time may not have as strong an influence on the absolute amount of SB or PA accumulated by OA. Future evaluations should include examining whether various other data processing algorithms or weightings of SB and PA have any effects on these outcomes.

REFERENCES


P2-45 ARE WE MISSING STEPS? A COMPARISON OF PEDOMETER COUNTS AND 24-OUR MOTION SENSOR COUNTS IN OLDER ADULTS

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INTRODUCTION

Pedometers are popular research devices for measuring physical activity in real-life settings. Although strategies are used to avoid non-wear, little is known about the effect of non-wear on daily step counts. The purpose of this study was to investigate the effect of non-wear on pedometer estimates of physical activity, by comparing step counts from a traditionally worn pedometer (NL-1000, New Lifestyles Inc, Lee’s Summit, Missouri, USA) to step counts from a permanently-worn motion sensor (activPAL monitor, PAL Technologies Ltd, Glasgow, Scotland).

METHODS

Twelve men and 25 women aged ≥ 65 yrs (M = 70 yrs, SD = 5 yrs) were instructed to wear the NL-1000 during all waking hours and were fitted with the activPAL, which was worn continuously. The NL-1000 records and stores step counts over the previous 7 days, and is worn on the waist band above the anterior midline of the thigh. The activPAL stores data for up to 8 days and is attached to the anterior surface of the thigh using a waterproof coating. By checking date recordings, we determined there were 236 overlapping days (i.e. when both monitors were worn). Outliers (steps/day < 1,000 and > 30,000; n = 14, or 3% of all data points) were removed from the analysis, leaving 225 pairs of overlapping data. Mean pedometer step counts were compared to the activPAL via one-way dependent ANOVA. The mean difference was also compared using Cohen’s d to evaluate the effect size.

RESULTS

Pedometer and activPAL steps were normally distributed (skewness = 0.43 and 0.59, kurtosis = 0.16 and 0.46). The ANOVA showed that mean activPAL steps (M = 8,165, SD = 3,254) were significantly higher than NL-1000 steps (M = 6,236, SD = 2,972; F1,224 = 246.7, p < .001). Cohen’s d was 0.62, indicating a moderate-to-large effect size. Additionally, the correlation between measures (r = .83) was relatively high, indicating that participants’ relative order was similar regardless of pedometer non-wear.

DISCUSSION AND CONCLUSION

When worn following standard instructions regarding continuous wear, steps obtained from a wrist-worn pedometer appear to grossly underestimate steps taken over a 24-hour period by approximately 2,000 steps, as measured by a permanently-fixed activity monitor. This has potentially profound implications for the use of pedometers in population surveillance and physical activity interventions. Additional strategies may be necessary for either reducing non-wear time or monitoring non-wear time, in order to obtain accurate estimates of 24-hr physical activity.

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P2-44 THE COMBINED ASSESSMENT OF PHYSICAL ACTIVITY, SEDENTARY BEHAVIOUR, SLEEP AND DIET: A FEASIBILITY STUDY

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INTRODUCTION

With evidence suggesting that physical activity (PA) [1], sedentary behaviour (SB) [2], sleep and diet [3] all influence a number of adverse health outcomes at least partly independently of each other, it is important to adopt a lifestyle approach when assessing the influence of these behaviours on health. However, any approach used to investigate these factors should place minimal burden on participants to yield high compliance. The aim of this study is to assess the feasibility of measuring these health behaviours concurrently.

METHODS

A sample of 78 adults had their PA and SB monitored using an ActiGraph GT1M accelerometer and a daily activity diary. Time spent in bed and sleep duration were recorded using a sleep diary. The majority of the sample (n = 59) were asked to wear the accelerometer, complete the activity diary and sleep diary for 7 days. A sub-group (n = 19) completed the study for 9 days and had their dietary intake assessed using a food frequency questionnaire (FFQ). A repeated measures ANOVA investigated the presence of activity to each measure over the monitoring period.

RESULTS

The completion rate for this study was 95%. Of those who completed the study, 93% wore the accelerometer for 7 days. Of the 19 participants who were asked to wear the accelerometer for 9 days, 95% complied. Of the 74 participants who complied to the accelerometer protocol, 100% completed the daily activity and sleep diaries. There were 18 completed FFQs from the 19 who were asked to complete them. There was positive feedback from the participants upon completion of the study, with many reporting that they were happy to complete the different aspects of the method. The repeated measures ANOVAs revealed no significant differences between the time spent in SB, sleep duration, or each dimension of PA between the different monitoring days (all p > 0.05).
P2-46  DIRECT OBSERVATION AND PEDIOMETER TO MEASURE PHYSICAL ACTIVITY BOUTS AMONG PRESCHOOL CHILDREN

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INTRODUCTION
Based on the U.S. physical activity guidelines [1] children should do 60 minutes or more of physical activity daily. Among preschool children it is assumed that the activity bouts are very short.

The aim of our study was to quantify the frequency, duration and intensity of physical activity bouts among preschoolers during their normal daily routine.

METHODS
We used data from 7-day pedometer records and from direct observation to ascertain the frequency of bouts, the length of activity bouts expressed in seconds and the intensity of activity during those bouts expressed in steps/min. Fourteen girls and 16 boys (6 ±0.5 years) were included in the study. Step counts measured by Omron Walking style Pro were available from 29 kinds. Of those eight were also directly observed during on average 2.2 ±0.7 hours using a stopwatch. The direct observation took place during the morning when the kids attended the kindergarten.

RESULTS
During the direct observation 87% of the time kids were sitting. On average 18±5 activity bouts/h were observed and one bout lasted on average 24.1 ±10 sec. The kids made on average 14.7±7 steps/min and accumulated on average 883±441 steps/h. Based on the pedometer data six girls and six boys met the physical activity recommendations by accumulating at least three times/week more than 13874 steps/day [2].

DISCUSSION AND CONCLUSION
In general the active time was much shorter than the sitting time during the direct observation and the physical activity bouts were very short. Compared to other studies with preschool children [2, 3] the steps/min were very low. One reason for that could be that direct observation combined with making notes is difficult in a kindergarten setting.

Most of the children did not meet the recommended activity level. A focus on physical activity promotion during the time in the kindergarten could support children to achieve the physical activity recommendations for health benefits. Other measurement equipments such as GPS could be useful to learn about the locations where children are physically active.

REFERENCES

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P2-47  OLDER ADULT OFFICE WORKERS: ACTIVE YET SEDENTARY

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INTRODUCTION
The waking day present multiple opportunities for inactivity: at work, during transport and during many leisure time pursuits [1]. Sedentary behaviour is now gaining credence as a threat to public health in the 21st century, similar to inactivity, and interventions are required to curb this threat [2]. Before this, sedentary levels must be assessed and the interaction with physical activity established. The aim of this paper is to describe the sedentary levels and physical activity levels of a group of office workers.

METHODS
7 day free-living accelerometry was collected from a convenience sample of older adults (5 male, 12 female) using the ActiVital™ (PAL Technologies Ltd, UK). Each participant had at least 5 days of full 24 hour data. Sitting/lying, standing, stepping and cadence data were taken from the accelerometer output. BMI and blood pressure were measured using standard procedures and cardiovascular (CV) fitness was estimated using a Modified Bruce submaximal treadmill test. Due to the nature of the data Spearman correlations were used with Bonferroni adjustments.

RESULTS
This group of older adults (58 years, 27.2kg/m2) spent 18.2 (±1.1), 3.7 (±0.6) and 2.1 (±0.6) hours sitting/lying, standing and stepping respectively per 24 hour day. When estimated time in bed was taken into account, 10.1 (±1.1) hours were spent sedentary during waking hours. This sedentary time was not significantly correlated with CV fitness, BMI or blood pressure (p>0.05). In relation to physical activity levels, participants accumulated 11293 (±3500) steps per day. Total steps taken were significantly correlated with steps taken at cadences between 110 and 140 steps/minute (.534 and .703, p<0.002). Time spent sedentary was negatively correlated with all step cadences (−.119 to −.68).

DISCUSSION AND CONCLUSION
Combining sedentary and physical activity results indicates that this group of older adults are sufficiently active [3] yet quite sedentary. Those who accumulated more steps per day accumulated them at intensities which would be considered moderate intensity walking. Those who were found to be more sedentary accumulated lower numbers of steps at all cadences not just at higher intensities.

Taken together, these data indicate that older adults can be physically active yet be extremely sedentary throughout the day. Physical activity measurement alone is insufficient to examine health related human movement behaviour, and richer data can be obtained via collection of information on body posture. Results suggest a relationship between sitting behaviour and the intensity of physical activity that should be explored in future research.

REFERENCES

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P2-48  OBJECTIVE MEASUREMENT OF HABITUAL SEDENTARY BEHAVIOUR AND PHYSICAL ACTIVITY IN PRE-SCHOOL CHILDREN: COMPARISON OF ACTIVPAL WITH ACTIGRAPh MONITORS

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INTRODUCTION
The Actigraph is well established for measurement of both free-living sedentary behaviour and physical activity in youth [1]. The activPAL has not yet been used to measure sedentary behaviour or physical activity in youth but the validity for measurement of both constructs in young children is established [2]. The present study aimed to compare the two monitors in a convenience sample of free-living pre-school children.

METHODS
Twenty-three pre-school children (mean age: 4.5 ± 0.7 years) wore the activPAL and the Actigraph accelerometer simultaneously during waking hours for a mean of 5.6 days and 10 hours/day. Measures of daily mean percentage time sedentary (lying/ sitting and standing with no translocation) and physically active were compared between the two monitors.

RESULTS
Daily mean percentage of time sedentary was 74.6 (±6.8) for the Actigraph and 78.9 (±4.3) for the activPAL. Daily mean percentage of time physically active (light intensity plus MVPA) was 25.4 (±6.6) for the Actigraph and 21.1 (±4.3) for the activPal. Rank order correlations between the two devices were statistically significant (r=0.676, p<0.001). Differences in percentage of time spent sedentary and physically active between the monitors were significant (paired t-test, p<0.001). The Bland-Altman analysis showed that for estimates of percentage of the day spent sedentary there was a difference of -4.3% (±4.8) of daily time (limits of agreement −14.0 to 5.4%) for the Actigraph relative to the activPal.

DISCUSSION AND CONCLUSION
Estimates of percentage of daily time spent sedentary and in total physical activity were broadly similar between the two monitors at a group level. The two monitors should not be considered to be interchangeable, however, as there were larger differences between them at the individual level.
An apparently small difference may be important for some applications, such as population surveillance of physical activity and/or sedentary behaviour and assessment of compliance with guidelines.

REFERENCES

P2-49
OPTIMAL SENSOR PLACEMENT FOR OBJECTIVE PHYSICAL ARM ASSESSMENT
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INTRODUCTION
Monitoring arm elevation and movements in a free-living environment is important for the assessment, diagnosis and evaluation of rehabilitation. Current arm activity monitors used in clinical populations consist of one or multiple sensors placed at different locations of the arm. They assess motion intensity of the arm and/or orientation of the wrist with respect to the shoulder. The optimal placement to assess both motion intensity and arm elevation using a single unit accelerometer is unknown. Therefore the aim of this study was to assess the optimal accelerometer placement to categorize three levels of arm motion intensity and three levels of shoulder elevation.

METHODS
10 participants (5 men) wore three 3-axis accelerometers placed on the wrist, elbow and shoulder (SensorSieve, Maastricht Instruments). Participants performed arm activities for 30 sec. at three levels of arm elevation (fig 1) and intensity (controlled by a metronome) on two separate days. Four thresholds were determined for each accelerometer placement based on the measurement of day one to define nine categories (three levels of arm elevation and intensity). This was done by systematically shifting each threshold by 1% steps until highest percentage of correctly classified samples was attained. Based on these thresholds arm activities performed on the second day were categorized to test the reproducibility. The sensor location that led to the best classification was defined as the optimal placement.

RESULTS
The wrist sensor of one subject failed to record data and was therefore excluded. The percentage correctly classified samples for the first and second day was 46.8±18.6% and 43.2±11.6% for the wrist, 99.8±0.4% and 99.4±0.9% for the elbow and 48.0±19.6% and 43.8±11.9% for the shoulder. Movement intensity was classified correctly by all sensors (day 1 and 2 wrist: 96.4±4.8% and 98.3±1.1%, elbow: 99.9±0.2% and 99.5±0.9%, shoulder: 94.1±5.9% and 95.6±3.7%). Shoulder elevation was only classified correctly by the elbow (day 1 and 2 wrist: 48.0±19.6% and 43.8±11.9%, elbow: 99.9±0.4% and 99.3±0.2%, shoulder: 50.2±11.7% and 41.4±10.1%).

DISCUSSION AND CONCLUSION
The accelerometer placed on the elbow resulted in the best classification and high reproducibility of the elbow sensor (>99%) give confidence that these wearable arm monitors can be used as clinical assessment tool of daily activity and mobility during everyday behavior using ambulatory a accelerometer: the upper limb activity monitor. Behavior research methods 2006;38:439-45.

REFERENCES

P2-50
ASSESSMENT OF STEP LENGTH WITH IMU TECHNOLOGY IN NEUROLOGICAL POPULATIONS
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INTRODUCTION
Objective measurements of gait parameters enable clinicians to accurately diagnose and monitor progression of neurological conditions. Current gold standard gait measurement, optical motion capture, is performed in gait laboratories and is underutilised by clinicians because of lack of funding, time and expertise. A cheaper and simpler alternative might be to combine gyroscope, accelerometer and magnetometer data from inertial measurement units (IMU). Previous work [1] found that step length in typically developed adults (TDA) can be derived from the participant’s centre of mass (CoM), but only if a correction factor of 1.25 is applied. To develop IMU technology further for practitioners to use in clinic, it needs to be established whether the model proposed by [1] can be generalised to neurological conditions.

METHODS
Participants with Parkinson’s disease (PD; n=24), muscular dystrophy (MD; n=19), motor neuron disease (MND; n=7), stroke survivors (n=9) and TDA (n=10) were asked to walk over a 10-metre distance. An IMU was attached over the participant’s projected CoM. Actual walking speed (Vap) was calculated by dividing the walking distance by the time taken to cover the 10-metres. IMU data were processed to obtain vertical excursion of the CoM in the global frame. Step time was taken as the time interval between peak-to-peak CoM excursions during one cycle. Step length was calculated using Zijlstra and Hof’s model [1]. Predicted walking speed (Vip) was derived by dividing average step length by average step time. The correction factor was optimised by manipulating Vip until it matched Vap for each participant. Group correction factors from each neurological condition were compared with TDA. Furthermore, in each neurological group the variability of the correction factor was explored by testing the relationship between Up and Vap with a Pearson’s correlation.

RESULTS
The group correction factor of 1.25 to model gait in TDA was similar in people with PD (p=0.83) and MD (p=0.24) but significantly different in people with MND and stroke survivor (p<0.01). Furthermore, for each neurological condition R² was greater than 0.91.

DISCUSSION AND CONCLUSION
Although a low proportion of variability was observed for each neurological condition, heterogeneity present in calculated correction factor suggests that development of generic group correction factors is unfeasible. Rather, a correction factor for each person should be calculated irrespectively of their clinical condition or disability level, to accurately model step length. These promising findings suggest that future research should determine if clinicians can diagnose and monitor progression of various neurological conditions with IMU technology.

REFERENCES

P2-51
MEASUREMENTS OF TRUNK ROTATION BY USE OF INERTIAL MEASUREMENT UNITS
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INTRODUCTION
In recent years, accelerometer-based systems have provided useful insight into several aspects of human gait [1]. Most results are based on kinematic data and do not utilize all information often provided by these systems, such as orientation data. The aim of this study is to investigate trunk rotation by use of an Inertial Orientation Tracker (MTx, Xsens). Alum et al. [2] used angular velocity data to analyze balance and gait based on roll and pitch. This study will focus on the yaw angle and how it varies with sensor placement and velocity.

METHODS
Healthy subjects are asked to walk on a treadmill. The first part of the procedure is repeatedly employed following the instruction (“Walk as fast as you can without feeling unsafe”). Four different sensor placement configurations are used: lumbar region and pelvis, with the sensor attached to a rigid plate and a soft Velcro belt, respectively. In
the second part of the procedure subjects are asked to walk on a treadmill at 3 different velocities with the sensor attached to the pelvis.

RESULTS

Preliminary results show that the sensor system is quite sensitive to external influences, often resulting in drift. Despite this, preliminary results show that larger deflections are measured on the pelvis (mean yaw angle per step, \( \sigma = 7.98 \)) compared to the lumbar region (\( \sigma = 3.18 \)). When the sensor is attached to the rigid plate, deflections and variances are marginally smaller. Results for the second part of the procedure show that yaw angle increases with velocity (\( \sigma = 4.83 \) (3 km/h)) versus \( \sigma = 7.95 \) (5 km/h)).

DISCUSSION AND CONCLUSION

Before further trials are run, the problems with drift should be eliminated. As expected, the measurable yaw angle is larger on the pelvis than on the lumbar region. The results also indicate that the signals are more irregular when measured on the lumbar region. There was no evident difference between attaching the sensor to a rigid plate and a Velcro belt. Finally, the results show that yaw angle increases with velocity. Future work will focus on how yaw angle deflection varies between subjects and patient groups.

REFERENCES


P2-52 INTRA-RATER RELIABILITY OF A BODY-FIXED SENSOR BASED ASSESSMENT OF SPATIOTEMPORAL GAIT PARAMETERS IN INDEPENDENT-LIVING OLDER ADULTS

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INTRODUCTION

Body-fixed-sensor (BFS) based methods for quantifying functional walking performance can assist in optimizing interventions for supporting independent mobility in older adults. Evaluations of the reproducibility of BFS based gait outcomes in standardized and free-living conditions are needed. This study examines the intra-rater reliability of a standardized, BFS based gait assessment in independent-living older adults of 70-80 years old. Subsequent work will address the reliability in free-living conditions.

METHODS

Three older men and 19 older women (mean age 74.4) without pathological conditions that severely affect walking were included. In two separate weeks, subjects walked back and forth along a 30 m long corridor at a normal, fast and slow speed as well as at a normal speed while simultaneously performing an auditory version of the Stroop task (dual task condition). A sensor unit containing a tri-axial accelerometer and gyroscopes (DynaPort Hybrid, McRoberts, NL) was attached with a waiststrap at the lumbar region. Stride cycles were selected based on instants of foot contacts as determined from forward accelerations. Mean values of back and forth trajectories were determined for walking speed, step duration and length, and for the step length/step frequency-ratio (L/F-ratio). Test-retest reliability was determined using Intraclass Correlation Coefficients (ICCs).

RESULTS

ICCs were mostly above 0.77. Table 1 reports the ICCs and corresponding 95% confidence intervals for the different walking conditions and gait parameters. The group mean walking speed for respectively normal, fast, slow and dual task walking was 1.35, 1.59, 1.09, 1.13 m/s.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Normal</th>
<th>Fast</th>
<th>Slow</th>
<th>Dual Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking Speed</td>
<td>0.81 (0.67-0.93)</td>
<td>0.78 (0.67-0.93)</td>
<td>0.83 (0.61-0.93)</td>
<td>0.72 (0.44-0.87)</td>
</tr>
<tr>
<td>Step Duration</td>
<td>0.85 (0.67-0.93)</td>
<td>0.78 (0.61-0.91)</td>
<td>0.71 (0.42-0.87)</td>
<td>0.69 (0.39-0.86)</td>
</tr>
<tr>
<td>Step Length</td>
<td>0.88 (0.70-0.95)</td>
<td>0.90 (0.71-0.96)</td>
<td>0.93 (0.84-0.97)</td>
<td>0.86 (0.70-0.96)</td>
</tr>
<tr>
<td>L/F-ratio</td>
<td>0.90 (0.75-0.96)</td>
<td>0.86 (0.69-0.94)</td>
<td>0.93 (0.60-0.97)</td>
<td>0.91 (0.79-0.98)</td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSION

The BFS based gait assessment yields reliable results for repeated testing under standardized conditions in independent-living older adults of 70-80 years old. In ongoing studies, the method is further developed and evaluated as part of a home-monitoring system in quantifying daily-life gait performance in different target populations.

P2-53 OBJECTIVE MEASURES AND RECEIVED THE ENVIRONMENT AND ITS RELATION TO THE PHYSICAL IN A TOWN DOWN SOUTH OF EUROPE

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INTRODUCTION

Information that has assessed the relationship between availability of sports facilities and amiable environment with physical inactivity show conflicting results [1,2,3]. This may be due to the heterogeneity of the measures used: objective vs. perceived. The aim of this study is to assess the association between sports facilities, actual and perceived, and physical inactivity in residents in the districts of the city of Madrid, and the relationship between an amiable environment and physical inactivity.

METHODS

Information on physical inactivity and perceived amiable environment indicators in each district -dirt in the streets, air pollution and lack of green space- were obtained from the Madrid Health Survey conducted in a sample of the population non-institutionalized in 2005. The analysis included 6,607 individuals between 16 and 74 years of age. The number of sports facilities by district was obtained from the Sports Facilities Census 2005. The objective indicators - street lighting, road safety and green spaces- come from the Statistical Institute of Madrid. The association between different indicators and physical inactivity was obtained by odds ratio (OR) adjusted for age and individual socioeconomic characteristics.

RESULTS

No relationship was found between the actual number of sports facilities and physical inactivity. The prevalence of physical inactivity was lower in districts with fewer sports facilities perceived. The ORs for physical inactivity in residents of these districts, with respect to those who live in districts with more facilities perceived was 0.63 (95% CI 0.50 to 0.80) in men and 0.45 (95% CI 0.36 to 0.55) in women. The ORs for physical inactivity in residents of the districts worst illuminated face of those who live in more enlightened districts was 1.45 (CI 1.13 to 1.85) in men and 1.56 (CI 1.25 to 1.93) in women. Other indicators of objective measures as well as three indicators of perceived amiable environment showed no relation to physical inactivity.

DISCUSSION AND CONCLUSION

It was only observed relationship between street lighting and physical inactivity. The relationship of the perception of sports facilities with physical inactivity was in the opposite direction than expected. There was no relationship between the actual number of sports facilities physical inactivity, neither between other objective indicators and perceived amiable environmental and physical inactivity. These findings in a city in southern Europe suggest that the availability of sports facilities and an amiable environment are not determinants of physical activity.

REFERENCES

DIFFERENT LEVELS OF PHYSICAL ACTIVITY AND 24-HOUR HEART RATE VARIABILITY IN PERSONS WITH NECK-SHOULDER PAIN

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INTRODUCTION
Musculoskeletal disorders such as neck-shoulder pain constitute a significant problem. Chronic muscle pain is related to a reduction in heart rate variability (HRV), indicating aberration in autonomic nervous system regulation (1). It is important to know how this aberration is related to physical activity (PA) and stress perception. The aim of the study was to investigate the influence of PA on 24-h HRV, self-rated stress and pain intensity in subjects with chronic neck-shoulder pain (NSP) and healthy controls (CON) with different activity levels.

METHODS
Eighteen subjects with chronic neck-shoulder pain and 18 age and gender matched healthy controls took part in the present study. Subjects underwent 24-hour ambulatory monitoring of PA and HRV with IDEEA system. Perceived stress was rated during daily activities. Pain intensity was rated prior to ambulatory recordings. Based on total walking-distance a median split was performed for NSP (median = 3.97 km) and CON (median = 4.04 km) to investigate the impact of PA on HRV, stress and pain. HRV was analysed in time and frequency domains. Mean RR-intervals (IBI), pNN50 and normalized low frequency power (LFnorm) were used to assess ANS regulation during the evening, sleep, morning and day.

RESULTS
Shorter IBI (higher heart rate) was found in NSP compared to CON. A significant difference was found between active NSP compared to active and inactive CON (p<0.05). No difference in IBI was seen within NSP (active vs inactive), nor within CON. NSP showed reduced pNN50 compared to CON, but no difference between groups with high/low PA. However, the largest increase in pNN50 from evening to sleep was observed in active CON. For LF-HRV, no significant difference was found between NSP and CON. A tendency towards a larger reduction in LF during sleep was seen in active CON (p<0.1). Pain intensity was higher in inactive NSP (mean 4.2) compared to active NSP (mean 2.7). There was no difference between NSP and CON in stress level, irrespective of PA level.

DISCUSSION AND CONCLUSION
Elevated heart rate and reduced HRV may support the hypothesis of ANS imbalance in persons with chronic neck-shoulder pain. Although, comparable HRV were seen between active and inactive subjects with pain, the largest HRV was seen in active subjects without pain. More active subjects with NSP showed lower pain intensity. Increasing daily PA may be an effective intervention improving ANS regulation and pain among persons with chronic muscle pain.

REFERENCES

OBJECTIVELY MEASURED PHYSICAL ACTIVITY AND SARCOPENIA IN OLDER JAPANESE ADULTS: LONGITUDINAL DATA FROM THE NAKANOJO STUDY

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INTRODUCTION
A recent cross-sectional study [1] shows significant associations between skeletal muscle mass and yearlong physical activity in older adults, with better health in those taking at least 7000-8000 steps/day and/or spending at least 15-20 min/day at >3 metabolic equivalents (METs). The present study examines these relationships longitudinally.

METHODS
Subjects were free-living Japanese aged 65-84 years (192 men, 244 women). Daily step count and physical activity intensity were measured continuously by pedometer/accelerometer for 5 years. Skeletal muscle mass index (SMMI) was determined by bioelectrical impedance at baseline and each year-end. Sarcopenia was defined as a SMMI/height2 value >1 SD below the mean for healthy young Japanese. Repeated measures analysis of variance assessed changes in month-averaged physical activity scores for each July. One-factor repeated measures analysis of covariance (ANCOVA) assessed yearly changes in SMMI. ANCOVA at 2nd-6th measurements or Cox proportional hazards regression analysis assessed independent relationships between baseline physical activity and year-end value SMMI or the 5-year risk of having sarcopenia, respectively, after controlling for baseline SMMI, age, smoking status and alcohol consumption.

RESULTS
Subjects maintained their physical activity over the 5 years. In both sexes, year-end SMMI values were greater in those with higher baseline physical activity scores, the relationship being more marked for duration at >3 METs than for step count. When data were categorized into physical activity quartiles, final SMMI values were not significantly greater in those men and women exceeding mean counts of 7,800 and 7,600 steps/day and/or mean durations >3 METs of 20 and 17 min/day, respectively. A multivariate-adjusted Cox proportional hazards model predicted that individuals who engaged in >6,600 steps/day and/or <15 min/day of activity at >3 METs over the 5 years were, respectively, 1.4-3.9 and/or 2.0-5.0 times more likely to have sarcopenia than those who participated in >8,500 steps/day and/or >22 min/day of activity at >3 METs.

THE OTHER SIDE OF THE EQUATION: INCREASING PHYSICAL ACTIVITY DOES NOT IMPACT SITTING TIME

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INTRODUCTION
Prospective evidence supports positive associations between sitting time and all cause and cardiovascular disease mortality independent of physical activity levels [1] or leisure time physical activity [2]. In context of widespread physical activity initiatives and campaigns, existing and future physical activity intervention research may benefit from tandem assessment of sitting time to validate whether physical activity promotion messaging should be expanded to also include sitting time recommendations to further reduce disease risk. The aims of this study were to determine whether increasing physical activity is associated with a reduction in sitting time and examine associations between sitting time and cardiometabolic disease risk factors.

METHODS
In a rural setting, sixty-seven apparently healthy adults (43.3±11.8 years; 27.6±5.9 kg/m2) self-reporting less than 90 minutes of physical activity per week completed pedometer-based interventions to increase physical activity levels. Change in physical activity measured by pedometer (HJ720-ITC, Omron, Inc) was the primary outcome, and secondary outcomes were change in multiple cardiometabolic disease risk factors and sitting time. All participants were assessed before and after the 12- or 16-week physical activity interventions. Weekly sitting time was assessed by participant self-report to the nearest half hour. Aims were assessed through linear regression analysis and paired t-tests at an alpha of P<0.05.

RESULTS
Physical activity increased significantly 1,280±2,157 steps per day, however sitting time remained constant (40.8±19.1 hours/week at baseline compared to 41.0±18.0 hours/week at follow-up) and was not associated with change in steps per day (β=0.103, P=0.4). Health promoting improvements in waist circumference (P=0.03), hip circumference (P=0.002), body mass index (P=0.02), diastolic blood pressure (P=0.02), and aerobic fitness (P=0.001) following the interventions were not associated with change in sitting time. At baseline, steps per day (mean 7,887±2,287) was inversely associated with sitting time (β=-0.26, P=0.001). Pre-intervention sitting time was associated with hip circumference (β=-0.99, P=0.01), body mass index (β=-0.04; P=0.05), and fasting insulin (β=-0.19; P=0.01) and inversely associated with HDL concentration (β=-0.31; P<0.01).
**DISCUSSION AND CONCLUSION**
Increasing physical activity levels through pedometer-based interventions improved several cardiometabolic risk factors but did not change time spent sitting. The absence of a physical activity intervention effect on sitting time combined with its association to several cardiometabolic risk factors provides further justification for public health recommendations specific to reducing sitting time in addition to increasing physical activity.

**REFERENCES**

**P2-57**
CORRELATION BETWEEN AEROBIC FITNESS AND PHYSICAL ACTIVITY OF CHILDREN AND PARENTS

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**INTRODUCTION**
A positive relationship between physical activity (PA) and aerobic fitness (AF) is reported for adults, but there is little information in children when considering studies which measured both PA and AF directly [1]. Furthermore, the relationship between PA and AF may differ in normal and overweight subjects. Therefore, we measured AF and PA in children and parents directly and discriminated between normal and overweight subjects.

**METHODS**
8-10 year old children with particularly high and low AF examined in the IDEFICS study were invited together with their parents and siblings. Only two-parent families were eligible. Moderate to vigorous physical activity (MVPA) was measured for seven consecutive days using uniaxial accelerometers (ActiGraph/ActiTrainer, MTI, USA) worn around the wrist and expressed as the average number of minutes per day with at least 3000 counts/min. AF was determined by the maximum oxygen uptake (VO2 max) related to body weight (g m^−1 kg^−1) measured during a maximum bicycle ergometer test. VO2 max was averaged for 15 second intervals. Spearman rank-correlations were computed between VO2 max and MVPA.

**RESULTS**
Correlation coefficients demonstrated moderate associations between AF and MVPA for all 295 subjects (r=0.40, p<0.001) as well as in the subgroups of parents (r=0.41, p<0.001; n=136), children (r=0.40, p<0.001; n=119) and boys (r=0.40, p<0.001; n=64). Stronger correlations were found among fathers (r=0.61, p<0.001; n=67) and among girls (r=0.47, p<0.001; n=55) while the correlation among mothers was weak (r=0.22, p=0.068; n=69). The association between AF and PA differed between overweight and normal weight children (r=0.59, p<0.05; n=90, respectively) but not between overweight and normal weight adults (r=0.39, p<0.01; n=53 vs. r=0.39, p=0.01; n=57, respectively). On average, the accelerometer was worn for 6.1 ± 1.3 days with a measurement duration of at least 10 h/day.

**DISCUSSION AND CONCLUSION**
The correlation coefficients between PA and AF in children were higher than previously reported [1]. This could be explained by a more precise estimation of PA resulting from measurement over seven consecutive days. The pronounced association between AF and PA in overweight children has to be interpreted with caution due to the small number of overweight subjects. However, the increased metabolic demand for overweight children when performing MVPA could result in increased VO2 max. We conclude from the moderate correlations between AF and PA that neither of them should be taken as a surrogate for the other instead, PA and AF should be measured independently.

**REFERENCES**

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**P2-58**
ACCELERATION DISTANCE TO STEADY STATE RUNNING IN CHILDREN

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**INTRODUCTION**
Purposes of this study were to: a) demonstrate a method that determines steady state (SS) gait b) determine the number of trials needed to identify best 30m sprint performance in children and c) determine the distance needed to reach SS.

**METHODS**
From a 3-point stance 44 young skilled soccer players sprinted individually as fast as possible to cones 35 m away. A videocamera recorded the first 10 meters and timing gates recorded the time from start to 30m (T30). The fastest of three trials was used for gait analysis. Each step length in the 10 meter segment was determined from the video using DartFish software. A coefficient of variation (CV) was determined for each successive three step lengths (CV1: step 1-3; CV2: step 2-4, etc) for each child. A CV<0.08 indicated that the child had reached SS. The acceleration distance (ACdist) was calculated by adding the lengths of all non-SS steps. Data were examined by gender (28 boys, 16 girls) and age group (Y=6-7 yr; M=8.9-10 yr) for T30 and ACdist using factorial ANOVAs with significance level set at p<0.05.

**RESULTS**
Results indicated no significant gender effects for either variable but showed a significant age effect between groups. No significant interaction was observed for either analysis. Follow-up one-way ANOVAs by age group indicated that running speed (T30) was significantly faster (p<0.01) and acceleration distance was significantly greater (p=0.01) for the oldest group than the two younger groups which did not differ from one another on either variable. Repeated measures ANOVA was used to examine T30 by age group. Results indicated that of the three trials, the first was significantly faster for the oldest group (p<0.01), the first and second trials were significantly faster than the third for the middle group (p<0.01), and no differences existed between trials for the youngest group. The P90dist were 6.0lm, 4.58m, and 7.04m for the Y, M and O age groups, respectively, with a distance of 6.22 m for the entire sample.

**DISCUSSION AND CONCLUSION**
The coefficient of variation is a sensitive measure to determine SS. One trial ought to suffice when recording children’s 30m running speed, with a second trial recommended if the student stumbles or hesitates. A distance of 6.22 m is sufficient to allow almost all children in the 6–10 year age range to accelerate to steady state.

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**P2-59**
PHYSICAL ACTIVITY LEVELS OF CHILDREN WITH MILD-MODERATE INTELLECTUAL DISABILITIES (MMID): A MULTI-COMPONENT PHYSICAL ACTIVITY INTERVENTION

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**INTRODUCTION**
Physical activity (PA) guidelines recommend children do a daily minimum of 60 minutes moderate-vigorous PA (MVPA) and reduce sedentary behaviour to <2 hours per day [1]. People with intellectual disabilities (ID) are at greater risk of obesity, inactivity and health inequalities than their non-ID peers [2, 3]. However there is a paucity of evidence on PA and sedentary behaviour before the implementation of a multi-component 10-week PA intervention specifically designed for children with MMID in a cross-over control design.

**METHODS**
50 children with MMID from 2 local additional support needs schools participated in the study (Intervention Experimental Group (EG), N= 21, mean (SD) age 9.5 (1.1) yr; Intervention Control Group (CD), N=29, mean (SD) age 9.3 (1.2) yr). Height (Leicester Height Measure) and weight (SECA Digital scales LS880) were measured and BMI calculated. Children wore an Actigraph accelerometer (GT3X or GT1M, ActiGraph, FL) during their waking hours for 7 days. Daily mean PA, % time sedentary and in MVPA were compared between CG and EG at baseline. These measures and comparisons were repeated post-intervention and at follow-up. Within-group comparisons will be made across the three measurement time points to determine the effectiveness of the PA intervention.

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RESULTS
At intervention baseline, Mean (SD) height, weight and BMI were 1.37 (0.1) m, 37.1 (16.7) kg and 18.9 (4.9) for EG and 1.38 (0.1) m, 36.0 (8.4) kg and 18.7 (3.5) for CG (all p<0.05). Mean (SD) daily PA was not significantly different between EG and CG, (527 (129) & 690 (183) cmp.d-1 respectively). Median (range) time spent sedentary was 78.7 (17.0) & 75.4 (20.2)% and in MVPA, 1.6(4.2) & 2.7(9.6)% for EG and CG respectively. These differences between groups just reached statistical significance (p=0.04 in both). Neither EG or CG reached the minimum 60 mins MVPA.day-1.

DISCUSSION AND CONCLUSION
At intervention baseline, children with ID were on average very inactive, spent a significant portion of their waking time sedentary and very little time in MVPA. Neither control nor experimental group met the minimum PA guidelines for health. This further supports the need for the PA intervention. Post-intervention and follow-up data will be available at conference. Comparison of baseline with post-intervention and follow-up measurements can determine if the PA intervention can ameliorate this trend and help children with ID meet the minimum recommended PA for health.

REFERENCES

P2-60 DAILY VARIABILITY IN ACTIVE COMMUTING BEHAVIOURS IN PRIMARY SCHOOL CHILDREN
Rowe DA1, Murtagh S2, McMinn D3, Nelson NM4,5
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INTRODUCTION
Collection of physical activity (PA) data on children poses several measurement challenges, such as reliability, reactivity, and missing data[1]. Several existing sources guide the collection of reliable data across the whole day, but there is no published evidence of the daily reliability of children’s PA taken on the way to and from school. The purpose of this study therefore was to quantify daily variability in active commuting in primary school children.

METHODS
Data were collected on 166 children aged 8-9 yr in five schools in Greater Glasgow. Children wore an Actigraph GT1M (Actigraph, LLC, Pensacola, FL, USA) from Monday until Friday during one week prior to (PRE) and following (POST) a 6-week active commuting intervention or control condition. Data were processed to yield minutes of moderate-to-vigorous PA (MVPA)

RESULTS
Whole day data were relatively normally distributed (skewness and kurtosis <2.0), but a.m. and p.m. commute data were more nonnormal. Prevalence of missing at least one day of data was quite high, ranging from 73 children (44%; whole day, PRE), to 115 children (69%; a.m. commute, POST), with more missing data during the POST period. ICCs ranged from .66 to .82 (PRE) and from .59 to .87 (POST), with an overall mean ICC of .74. As expected, whole day PA was more reliable than a.m. or p.m. commuting PA. Mean scores were generally not significantly different across days (p > .05), with the exception of PRE whole day steps and MVPA (p < .001) and POST whole day steps (p < .05).

DISCUSSION AND CONCLUSION
Similar to other studies with children, the incidence of at least one day of missing data was relatively high in this sample. Despite the young age group, the fact that data were collected over only 4 days, and the relatively brief data frame of a.m. and p.m. data, reliability was acceptable overall. Further analysis would determine whether the use of individual information centered data replacement[3] would be accurate in this population and type of PA data, but the results of the current study are promising in this regard.

REFERENCES

P2-61 THE FIFEACTION STUDY: RATIONALE AND METHODS
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INTRODUCTION
In community and school settings, children’s physical activity provision is largely determined by local government. Data on children’s physical activity habits, preferences and motivations are lacking at the regional level, because of the expense and expertise needed to conduct rigorous assessment. The purpose of this study was to use collaborative expertise within a regional government agency (Fife Council) and research institution (University of Strathclyde) to conduct a population-wide survey of physical activity among children in the Fife region.

METHODS
In consultation with Fife Council’s Active Fife team, researchers from the University of Strathclyde developed a study design that would (a) reach as many children as possible, (b) be scientifically rigorous, (c) be economically feasible, and (d) inform both local policy/provision and research theory. Consultation involved determining the needs of Fife Council, reviewing potential measurement instruments, and developing a research design that could be implemented collaboratively by experienced researchers and local government employees. All methods required consent from parents and children.

RESULTS
In May 2009, the FifeActive study design was finalised, and Fife Council’s Active Fife team was provided with a 1-day training session in data collection methods. The main aims of the study are (a) to collect pedometer-measured physical activity data on 1,000 children in F4, P7, and S1-S3, and (b) to use an online survey to introduce physical activity concepts into the Curriculum for Excellence of all children in P7-S3 in Fife (N = 16,000), thereby also providing data to inform policy and practice. Survey questions include: (a) compliance with recommended physical activity levels; (b) current and desired modes, places and times for physical activity; (c) current modes and experience of sedentary behavior; and (d) a variety of pragmatic determinants of physical activity, based on the heuristic Youth Physical Activity Promotion Model of Welk[1]. By November, 2010, the survey had been completed by over 4,000 children, and pedometer data had been collected on approximately 300 children.

DISCUSSION AND CONCLUSION
The FifeActive study is an example of how local agencies and universities can collaborate to achieve necessary research goals that will inform physical activity provision for children. Major challenges have been achieving a balance between budgetary feasibility and scientific rigour, and ensuring children’s compliance with the pedometer data collection requirements. Two other regional agencies have requested access to the FifeActive study methods and design. It is hoped that using this model widely will generate rich regional level data that are standardized, and therefore comparable, across local regions.

† Funding from NHS Fife

REFERENCES
**P2-62 ACTIVITY-BASED FEEDBACK AS POTENTIAL TREATMENT OF PATIENTS WITH CHRONIC LOW BACK PAIN**

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**INTRODUCTION**
Recent studies on physical activity behaviour showed that individuals with chronic low back pain (CLBP) have deviating activity patterns compared to controls [1]. Based on this, it is concluded that treatment should focus on creating a more balanced pattern. An innovative way to do this is by using technology that is able to provide feedback on the monitored everyday activities of patients with CLBP also called Activity Based Feedback (ABF) treatment. The aim of this study was to get insight in the compliance of patients with CLBP to an ABF treatment when provided for two weeks.

**METHODS**
The design was a prognostic cohort study. Inclusion criteria were age between 18 and 65 years, pain duration >3 months and no other pathologic complaints or immobility. During treatment, patients carried a Body Area Network (BAN) consisting of a movement sensor and a Personal Digital Assistant (PDA). Patients were instructed to deploy the same activity pattern as displayed visually on the PDA (norm value). This norm value is based on the mean activity patterns of 60 healthy controls. Besides continuously visually feedback, patients received time-related personalized feedback every hour about their activity pattern. When the activity level of the patient was more than 10% above the norm value, a discouraging feedback message was given (e.g. take some rest). When the activity level was more than 10% below the norm value, an encouraging feedback message was given (e.g. take a walk). In all other cases, patients received neutral feedback messages (e.g. doing all right).

Compliance has been defined as the change in activity as reaction on the discouraging and encouraging feedback messages. For this, the difference in the activity level 30 minutes before and 30 minutes after each individual feedback message is calculated.

**RESULTS**
Fifteen CLBP patients participated in the intervention. A total amount of 517 feedback messages were given to all patients and used for evaluating compliance. Of those feedback messages, 11% were encouraging and 89% discouraging. During the whole feedback period, patients decreased their activity significantly after a discouraging feedback message (p=.001) and a trend was seen in an increase in activity after an encouraging feedback message (p=.059). The compliance to both feedback messages was significantly highest in the morning (p<.05).

**DISCUSSION AND CONCLUSION**
Patients were able to comply with the feedback messages given, both to the discouraging as encouraging messages. This means that the new ABF treatment seems to have potential to influence activity patterns of CLBP patients. More research is necessary to explore the influence on pain intensity levels.

**REFERENCES**

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**P2-63 EVALUATION OF MUSCLE FATIGUE DURING TREADMILL WALKING IN PATIENTS WITH TYPE 2 DIABETES AND PERIPHERAL VASCULOPATHY**

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**INTRODUCTION**
Combined aerobic and resistance training (RT) has been reported to enhance insulin sensitivity and to improve glycemic control, lipid profile and blood pressure [1]. Based on this evidence the American Diabetes Association guidelines have refined the recommendations on the desired types, amounts, and intensities of aerobic physical activity for diabetic people. So far people with type 2 diabetes should be encouraged to perform RT in the absence of specific contraindications. The aim of this study was to evaluate the effects of RT on muscle fatigue assessed by means of surface electromyography (SEMG) [2], in dynamic conditions, in a group of type 2 diabetic patients with peripheral arterial disease (PAD) and without (T2DM).

**METHODS**
3 groups of subjects participated in the study (age 61.1±5; BMI 25.5±3; 11 control subjects (CS), 11 diabetic patients without PAD (T2DM) and 8 diabetic patients with PAD. Patients were asked to walk on a treadmill for 40 minutes: the session started and ended with a period of 2.5 minutes at 2 km/h and no inclination while central part scheduled 35 minutes at a speed of 4 km/h, with an inclination of 2% (for total 3.3 METS). Foot-switch, knee flexion-extension angle and SEMG signals were recorded (Biaseps Femoris, Vastus Lateralis, Rectus Femoris, Tibialis Anterior (TA) and Gastrocnemius Lateralis) synchronously by means of STEP32 (DemItalia, Italy). The mean frequency of the Power Spectral Density function (MFPSD) was estimated on each SEMG at each gait cycle. Analysis of correlation was performed (SPSS v13, R software, RODBC package, polychor function) between MFPSD and clinical parameters in order to highlight possible correlation between muscle fatigue and various diabetes complications (peripheral and autonomic neuropathy, and PAD).

**RESULTS**
Presence of muscle fatigue was revealed in 5 subjects with T2DM and no PAD (2 with peripheral neuropathy, 1 with autonomic neuropathy, 2 without diabetes complications) and in 4 patients with PAD (1 with peripheral neuropathy, 1 with autonomic neuropathy, 1 with both peripheral and autonomic neuropathy, 1 without diabetes complications). When considering correlation analysis, a nice correlation was found (0.96> R >0.6) between the presence of peripheral, autonomic neuropathy, PAD and the presence of electrical muscular fatigue.

**DISCUSSION AND CONCLUSION**
Preliminary results show that presence of muscle fatigue was revealed in T2DM subjects with and without PAD. However none interrupted the exercise training. This should be considered when planning RT protocols for T2DM subjects. Further studies should be performed including a larger sample of subjects.

**REFERENCES**

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**P2-64 PHYSIOLOGICAL RESPONSES TO COKEOVEN STANDPIPE CLEANING TO ASSESS ENGINEERING INTERVENTION EFFICACY**

Wallace ML1, Oliver ML2, Munro DM2, Sexsmith JR3
1School of Engineering, University of Guelph, Guelph, Ontario, Canada; 2Faculty of Kinesiology, University of New Brunswick, Fredericton, New Brunswick, Canada

**INTRODUCTION**
To chip carbon build-up on the walls and lid of a cokeoven standpipe, workers use high-frequency, high-impact forces under high heat loads while dressed in full body safety gear, including hard hat, face shield, respirator and NOMEX™ suit. Previous work by our lab has established that the physical demands of cokeoven standpipe cleaning are quite high [1] indicating that an engineering intervention is needed; therefore, the aim of this study was to assess the physiological load reduction efficacy of a prototype engineering intervention.

**METHODS**
Three of seven standpipe cleaners volunteered to participate (37.7 ± 8.4 y; 187.8 ± 7.5 cm; 104.6 ± 17.8 kg; 2/3 subjects were smokers). Each subject cleaned three standpipes: one using the old method of cleaning and two standpipes using the engineering intervention (EI). The EI (Figure 1) consisted of a custom made H-shaped frame with several alternately-placed pegs attached in the top half which acted as rigidly-mounted pivot points to help in controlling the 8’-long scraper bar and to provide leverage during scraping. The frame was mounted on a customized Canway Mobile Ladder Stand (Canway Equipment Mfg., Hamilton, ONL), which provided a sturdier, more stable platform with a safety lockstop and fall-rails. Physiological load was assessed using a Polar S810 Heart Rate monitor (Polar Electro, Kempele, Finland) and a BodyMedia® SenseWear® Body Monitoring System (BMS® Armband (BodyMedia Inc., Pittsburgh, PA) in December 2009 (mean ambient temperature 19.3 ± 3.6°C).

**RESULTS**
Table 1 – Mean ± standard deviations of the physiological response variables for “old” and engineering intervention (EI) standpipe cleaning methods

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**Figure 1: H-shaped Frame**
DISCUSSION AND CONCLUSIONS
While these results suggest a modest reduction in physiological load attributable to the engineering intervention, the reduction in both energy expenditure rate as well as METs for the EI trials indicate that the workload requirements were probably reduced particularly when the cumulative physiological effects of cleaning subsequent standpipe coupled with the learning of new methods are considered. However, to determine whether the reduction is due to taking more time to clean, or if it results from a reduced physiological load which is directly attributable to the EI, requires further habitation to the EI coupled with physiological monitoring.

REFERENCES

P2-65
PHYSIOLOGICAL RESPONSES TO OVERHEAD CRANE OPERATION
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INTRODUCTION
Crane operators work long hours in constrained workspaces often requiring deviated postures. Neck extension, trunk flexion and repetitive arm movement are associated with an increased risk of neck pain and shoulder. Previous work conducted by our lab revealed surprisingly high upper limb and trunk muscle loading with an increased risk of developing neck and shoulder pain. Previous work conducted by our lab revealed surprisingly high upper limb and trunk muscle loading with an increased risk of developing neck and shoulder pain. Methods

METHODS
Eight male crane operators aged 25-54 years (42.7±8.8 yrs; 172.5±4.5 cm; 89.4±16.0 kg; 6/8 smokers, all right handed) were monitored in an elevated crane cab during ten cycles of loading and unloading sheet steel. A cycle consisted of travelling and manoeuvring the cab into position over the work area, positioning the electromagnets onto the plate steel, lifting and travelling to the unload area, and positioning and releasing the plate steel. Physiological load was assessed using a Polar S810i Heart Rate monitor (Polar Electro, Kempele, Finland) and a BodyMedia® SenseWear® Body Monitoring System BMS® Armband (BodyMedia Inc., Pittsburgh, PA) in September 2008 (ambient temperature in the mill was approximately 24°C).

RESULTS
Table 1 – Mean ± standard deviations of the physiological response variables (n=8 subjects)

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Heart Rate (bpm)</th>
<th>Heat Flux (W/m2)</th>
<th>Near Body Temperature °C</th>
<th>Skin Temperature °C</th>
<th>Galvanic Skin Response (μS)</th>
<th>Energy Expenditure (kcal/min)</th>
<th>METs</th>
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<tr>
<td>Rest</td>
<td>76.6±6.1</td>
<td>54.0±1.6</td>
<td>32.1±2.0</td>
<td>31.6±1.7</td>
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such as camera systems to reduce postural deviations as well as the use of lighter controllers.

REFERENCES

P2-66
CONCEPT AND PROTOTYPICAL REALISATION OF AN ACCELEROMETRY-BASED INTEGRATED FALL DETECTION AND PREVENTION SYSTEM FOR THE ELDERLY
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INTRODUCTION
About 35-40% of the elderly >65 years and 50% of >80 years fall at least once a year [1]. A major problem is that half of the elderly who fall at home become helpless and require assistance to get up. That could be avoided by automatically calling for help when a person is unable to summon help. Current commercially available alarm systems suffer from problems with usability and high false alarm rates.

METHODS
The actibelt™, an ICT-platform including a tri-axial accelerometer integrated in a belt buckle, was developed [2]. Threshold-based algorithms for fall detection and gait speed were developed and validated. In parallel a biomedical data warehouse for physical activity data is built.

RESULTS
An independent evaluation of the usability of actibelt showed its high user acceptance. This was confirmed in a recent study with 357 healthy people (mean age: 48.1, sd 12.3); 78% of the participants wore the actibelt® over the whole study time (7 days), 88% for at least 85% of the study time. Fall detection algorithms were tested using data from “artificial” falls. Sensitivity and specificity were 95% and 91%, resp. False alarm rate was estimated from long-term measurements (>1 week, n=37) with 2.5/1 month. Gait speed assessment based on support vector regression has a mean error rate of 8% and a concordance correlation coefficient of 95%.

DISCUSSION AND CONCLUSION
First steps to integrate mobile accelerometry into a fall detection system are taken. Further refinement and validation of the fall detection algorithms is necessary to reduce false alarm rates. Prospective trials in seniors will be conducted to explore early warnings for falls that can then be integrated in a system for fall prevention.

REFERENCES

DISCUSSION AND CONCLUSIONS
While ANOVA procedures (p<0.01) revealed that most variables expressed by loading and unloading cycles were elevated over rest values, variable values were for the most part quite low (Table 1), suggesting that the overall physiological load was relatively low. When these results are interpreted in light of our previous work [1], this confirms that the primary issue with overhead crane cab operation is upper limb and trunk muscle loading. Results from the two studies confirm the need to investigate the muscle load reduction efficacy of a variety of potential engineering interventions.
P2-67 DATA COLLECTION OF REAL-LIFE FALLS USING ACCELEROMETER-BASED SYSTEM

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INTRODUCTION
Automatic fall detectors have been seen as one way to improve the safety of elderly people. The main limitation in testing of fall detectors has been the usage of young subjects performing intentional falls in laboratory to mimic real falls among elderly people.

We have developed a fall detection concept consisting of waist-attached accelerometer and a threshold-based fall detection algorithm [1,2]. This concept has been implemented into a wireless sensor system capable of collecting acceleration data during fall events in real life. Here we present the system setup and the first results from a field test.

METHODS
The system (Caretex AB, Kalix, Sweden) includes a tri-axial accelerometer, microcontroller, battery and a wireless transmitter. Embedded fall detection algorithm detects falls based on thresholds for prefall, impact and end posture [1,2]. In a case of a detected fall, acceleration data are sent wirelessly to base station and further to server using IP-based technology. A SMS message is generated for care personnel.

The collection of data begins four seconds before the fall-related impact and lasts for 16 seconds. The sensor is worn on a waist with an elastic belt.

The functionality of the system was tested in a pilot laboratory test with intentional falls from middle-aged persons. For real life test, 7 volunteer elderly people (81-101 years) living in a residential home were recruited to wear the sensor system.

RESULTS
All intentional falls (n=30) performed in the laboratory were detected by the system and the acceleration data was transmitted to the server. In real life environment so far, we have obtained acceleration data from two fall events. In both cases the person had got up from the bed and entangled to the blanket when started walking. In both cases, the fallen person was found due to the generated alarm.

DISCUSSION AND CONCLUSION
A wireless system for acceleration data collection during real life fall was developed and tested with elderly people. So far, acceleration data from two falls have been obtained. In the future, the collected data is used to develop fall detection methods further.

REFERENCES

P2-68 GENDER DIFFERENCES IN PHYSICAL ACTIVITY OF OLDER MEN AND WOMEN VERSUS DIFFERENCES BETWEEN OUTSIDERS AND INSIDERS

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INTRODUCTION
Current knowledge on physical activity levels in older persons is limited to walking time. Men are usually described as more active than women. The aim of the present study was to establish differences in the level of physical activity between men and women including standing time. Furthermore we wanted to test the hypothesis that persons engaging in outdoor activities demonstrate higher levels of physical activity.

METHODS
100 community-dwelling older persons living in a German urban area were wearing a body-fixed activity monitor based on accelerometers and gyrosopes over 24 hours. This sensor allows to distinguish between walking, standing and inactivity. Participants were asked retrospectively if they had engaged in any outdoor activities during the course of monitoring (outiders/insiders). Gait speed was measured over 4 m.

RESULTS
The mean age (± SD) of the sample was 79.32 (± 4.9) years with 45 women and 55 men. Of these, 15 (12 women, 3 men) reported not having engaged in outdoor activities during recording. In both groups the cumulative walking time was 106.5 minutes (± 46.2 men / 53.0 (women)) during 24 hours. Yet, women were standing significantly longer then men with a cumulative standing time of 254.6 (± 65.3) minutes vs. 223.4 (± 77.0) minutes. Gait speed was not significantly different between men and women. In contrast, we found significant differences in cumulative walking time between outsiders and insiders. Outsiders walked a mean of 41.2 minutes more than insiders. At the same time there was no significant difference in cumulative standing time between outsiders and insiders.

DISCUSSION AND CONCLUSION
While there are reports on older men being more physically active than women we could not confirm this finding. Even more so, women were more active when adding accumulated standing time to accumulated walking time.

While walking time was the same in men and women outsiders walked significantly longer than insider but were standing about as long as insiders. Hence, we propose to report on the number of insider and outsider when evaluating physical activity data. The development of algorithms to identify outdoor and indoor activities from sensor data could overcome some recall problems.

REFERENCES
**P2-70** LOWER PHYSICAL FUNCTION IS RELATED TO SEDENTARY BEHAVIOR IN OLDER ADULTS

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**INTRODUCTION**
Physical function (PF) impairment is an influencing factor on the health of older adults. It has been noted that approximately 66% of older adults report difficulties in carrying out tasks integral to activities of daily living (ADL) (1). Conceivably, with the increasing proportion of older adults, large numbers of the population will be at risk for functional limitations, thus increasing health care demands. The purpose of this study was to examine whether PF was related to time spent in sedentary behavior (SB) and different physical activity intensities, with a future aim of disrupting SB to improve PF.

**METHODS**
Thirty-one community dwelling older adults underwent measures of height and weight and completed the short physical performance battery (SPPB), an objective evaluation of functionality comprised of standing balance, chair-stand, and gait speed sub-scores (2). SPPB was used to group individuals into a low/moderate ((n=11) or high functional classification (n=20). Participants also wore an Actigraph GT1M accelerometer (ACC) for 7 consecutive days. ACC output was classified into time spent in SB, light activity (LA), and moderate general activity (MGA), moderate walking activity (MWA), and vigorous activity (VA) categories using standard procedures (3). Independent samples t-tests were used to examine SB and activity differences across functional classification (p<0.05).

**RESULTS**
The mean age and body mass index (BMI) for participants was 66.7±8.9 years and 30.9±6.6 kg/m², respectively, with no differences noted across functional classification. On average, all participants wore the ACC for 941.0±64.8 mins/d, of which 625.8±65.5 mins/d were spent in SB, 232.0±56.9 mins/d in LA, 61.0±20.2 mins/d in MGA, moderate walking activity (MWA), and vigorous activity (VA) difference (t=5.663, p<0.001) in time spent in SB between those with a low/moderate functional status (mean = 688±48.1 mins/d) and those with a high functional status (mean = 591±44.8 mins/d). No significant differences (p>0.05) across functional classification were noted for time spent in other demarcations of physical activity intensity.

**DISCUSSION AND CONCLUSION**
These preliminary results reveal that older adults who spent more time in SB had lower scores of measured functionality, with no such differences observed in time spent in different physical activity intensities. Plausibly, interventional attempts directed towards decreasing the time older adults spend in sedentary pursuits may serve to prevent functional decline, while maintaining independence and ability to perform ADL.

**REFERENCES**

**P2-71** PHYSICAL ACTIVITY VARIABLES AND THEIR RELATIONSHIP TO MEASURES OF FUNCTION IN OLDER PERSONS 4 MONTHS AFTER HIP FRACTURE

Taraldsen K1, Vereijken B1, Sletvold O1,2, Thingstad P1, Helbostad JL1,3
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**INTRODUCTION**
Objective methods are essential when assessing physical activity and activity monitoring is an increasingly used method for this purpose, also in older adults. Activity monitoring in older adults following a hip fracture provides information about daily activity that is important for rehabilitation, as low levels of activity could be one of the explanations for the lack of return in function following a hip fracture. However, it is not known which variables are optimal when monitoring activity in frail, relatively inactive persons. The aim of this study was to quantify amount of daily activity with several variables and evaluate the relationship between physical activity variables and physical function in older adults following a hip fracture.

**METHODS**
This study is part of an ongoing RCT on hip fracture patients where activity monitoring by use of small body-worn accelerometer-based sensors is part of the data collection. Study inclusion will be finished by the end of December 2010, aiming at a total of 400 participants. The present study is designed as a longitudinal cohort study with activity monitoring one day during the hospital stay and 4 days 4 months after the fracture. Home-dwelling older adults above the age of 70 yrs, admitted to St.Olav University Hospital with a hip fracture were included if they were able to walk with or without assistance prior to the fracture. Pre-fracture ADL was measured retrospectively by Barthel index and Netherlands Extended ADL index. Physical function was measured by use of the Short Physical Performance Battery during hospital stay and at the 4 months examination.

**PRELIMINARY RESULTS**
Of the first 200 included participants, 135 (27 males, 108 females) with a mean age of 62.9 (SD 5.8) years were able to self-report measures 4 months after the fracture. The mean gait speed was 0.56 m/sec (SD 0.21, range 0.08-1.24) for those performing the physical function test 4 months after the fracture (121 out of the 135). Outcome measures derived from the activity monitors are total amount of time in upright position (standing and stepping), number of active periods (upright position), and duration of active periods. The data on duration and number of active periods 4 months after the fracture for one randomly selected participant is shown below. Across 4 registered days, this participant shows many instances of extremely short active periods and only 2 longer active periods. Subsequent analyses will address the relationship between measures of physical activity and physical function.

**P2-72** PHYSICAL ACTIVITY INTERVENTION FOR RESIDENTIAL OLDER ADULTS EVALUATED WITH AN INSTRUMENTED PERFORMANCE TEST

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**INTRODUCTION**
The health of seniors is one of the greatest medical problems facing developed nations and is one of the largest single economic burdens. [1] Physical exercise and an active lifestyle can reduce disability. The objectives of the present study were: i) to implement a physical activity intervention in a residential care home; ii) to quantify the physical performance using body fixed sensors; and iii) to evaluate the relationship between participation and improvement.

**METHODS**
Thirty older adults in a residential care home (Dunhage) were divided in an experimental group (mean age 85.5, SD 5.4) and a control group (mean age 86.8, SD 6.3). The experimental group followed a 7-week program: group training on Monday and Friday, treadmill training on Wednesday, and three more days of exercise at home. The control group participated in one existing weekly training session. At baseline and after the training the Short Physical Performance Battery (SPPB) and the SF-36 were assessed. The SPPB score was performed and calculated as recommended [2]. During the SPPB, a sensor system (Dynaport, McRoberts, The Hague) was fixed around the waist, including 3 accelerometers, three gyroscopes and a wireless connection with a computer. A summary score of 0 to 12 (higher score indicating better function) is based on performance on three tasks: gait speed, chair rise, and three standing positions. Participation of all training elements was scored. After the baseline measurement an educational meeting was organized explaining the aim of the program, the pre-measurements and the importance of physical activity for health. Promotion of the program called “Dunhage Moves!” was realized with T-shirts, posters, banners and a website. Statistical analysis was done with the T-test and the Pearson correlation coefficient.
RESULTS

Table 1 Scores on the SPBB in the Pre and Post Measurement for the Experimental and Control groups

<table>
<thead>
<tr>
<th></th>
<th>pre</th>
<th>post</th>
<th>post-pre</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP</td>
<td>6.3(3.6)</td>
<td>7.4(2.1)</td>
<td>1.1(1.1)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>CON</td>
<td>5.7(2.9)</td>
<td>5.6(2.6)</td>
<td>0.1(1.4)</td>
<td>0.837</td>
</tr>
</tbody>
</table>

The mean duration of assessing the SPBB was largely 5 minutes. At baseline the SPBB and SF-36 scores of two groups were the same. The control group did not improve and the experimental group improved significantly on the SPBB (Table 1) and the functional and vitality dimension of the SF-36. The mean improvement of the SPBB was 1.1 which is clinically relevant [3]. Overall participation (%) of the physical activity correlates significant (0.73) with the improvement of the SPBB score.

DISCUSSION AND CONCLUSION

Our 7 week physical activity program for older adults improves their physical capacity measured with the SPBB and self-report of function and vitality measured with SF-36. Improvement seems to be attributable to participation. The SPBB could be used to select older adults for physical activity interventions and to attenuate these interventions to individual patients and patient groups.

REFERENCES


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P2-73

ACCELEROMETER-BASED MEASUREMENT OF EXERCISE TARGETED FOR BONE AND ARTICULAR CARTILAGE

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INTRODUCTION

The response of bone to exercise depends on loading magnitude rather than number of loadings, high impacts being most effective [1,2]. It is unclear how impact exercise affects articular cartilage in joints. Pedometers and accelerometers do not provide information to the mechanical loading level. The aim of this study was to test an accelerometer-based method to measure the intensity of exercise which might be beneficial for both bone and articular cartilage.

METHODS

A waist-worn body movement monitor [1,2] (Newtest, Finland) was used to measure mechanical loading level during supervised group exercise in 35 women (51-66 years) participating in progressive high-impact training for 12 months. The women were screened to have an early osteoarthritis at their knee joint at baseline. Exercise program consisted of modified aerobics and step-aerobics with multiple high-impact jumps, and it was remodeled every three months. The magnitude of the ground reaction forces was gradually increased. The peak forces in different types of jumping exercise were previously measured to vary between 2.5–5.6 times body weight [3]. The actual mechanical loading level was measured during the exercise program every three months. The device recorded and classified acceleration peaks to 32 levels from 0.3 to 9.8g, with 0g corresponding to standing.

RESULTS

The body movement monitor enabled individual measurement of the loading intensity during the supervised exercise. The average number of high impacts (>3.9g) in the aerobics and step-aerobics programs were 115 and 68, respectively, whereas the total number of impacts were similar.

DISCUSSION AND CONCLUSION

This acceleration-based measurement method enabled identifying the loading magnitude of physical exercise. The acceleration results confirmed that exercise targeted for women with early osteoarthritis can reach the osteogenic intensity levels [1,2]. Next we will analyze the relationship between accelerometer data and the cartilage changes assessed using MRI. This will confirm the applicability of the method in identifying optimal loading levels to prevent osteoarthrits.

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P2-74

THE IMPACT OF SCOLIOSIS SURGERY ON PHYSICAL ACTIVITY

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INTRODUCTION

Severe idiopathic scoliosis ( Cobb >40°) is a common reason for spinal surgery. While the disease itself is not known to have an impact on patients’ physical activity little is known about the influence of surgery. Aim of the study was to assess the level of activity before and in the follow-up of surgery to determine if and when patients regain their pre surgery level of activity.

METHODS

The study included twenty patients (Table 1) with idiopathic scoliosis scheduled for surgery. Both the volume (steps/ day) and time spent on a moderate intensity level (>100 steps/ minute) were measured using an ankle-worn uniaxial accelerometer. All patients were investigated before and shortly after as well as 3, 6 and 12 months after surgery.

Table 1: Patients’ anthropometric data

<table>
<thead>
<tr>
<th>patients</th>
<th>Age (years)</th>
<th>Height (m)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m2)</th>
<th>Female/male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17.4 ± 3.3</td>
<td>1.48 ± 0.1</td>
<td>59 ± 10.5</td>
<td>20.8 ± 3.3</td>
<td>18/2</td>
</tr>
</tbody>
</table>

RESULTS

Both the volume and the intensity of physical activity were considerable reduced right after surgery (56.5%, Table 2). Six months after surgery patients achieved their pre- surgery level of activity. No significant differences between measurements could be revealed.

Table 2: Results of activity assessment

<table>
<thead>
<tr>
<th></th>
<th>pre</th>
<th>post 1</th>
<th>post 2</th>
<th>post 3</th>
<th>post 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>20</td>
<td>19</td>
<td>20</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Gait cycles/ day</td>
<td>5094 ± 1564</td>
<td>2829 ± 1263</td>
<td>4049 ± 1714</td>
<td>5063 ± 1391</td>
<td>4884 ± 1305</td>
</tr>
<tr>
<td>min &gt; 50 gait cycles</td>
<td>21.7 ± 12.3</td>
<td>9.3 ± 3.3</td>
<td>21.2 ± 13.4</td>
<td>18.0 ± 9.4</td>
<td>16.2 ± 5.2</td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSION

Our data confirmed that patients with idiopathic scoliosis did not experience any activity reductions by the disease itself as they nearly reached general activity recommendations [1]. Surgery limited patients’ physical activity; however, no lasting negative effect on patients’ mobility could be assessed. Neither the pre-surgery extent of the main curve nor the extent of correction had any effect on patients’ level of activity.

The device used was well accepted by the patient and is a feasible tool for assessing and evaluating patients with spinal surgeries. Data must be considered as preliminary as not all patients were measured one year post surgery yet.

In conclusion, surgery for correcting idiopathic scoliosis did not sustainably reduce patients’ level of physical activity. Therefore no surgery- induced immobility or detrimental effect of surgery on being active had to be feared.

REFERENCES

P2-75

**MOBILE ACCELEROMETRY DATA AND ITS ASSOCIATION WITH DISABILITY LEVELS IN MULTIPLE SCLEROSIS**

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**INTRODUCTION**
Using physical activity (PA) as diagnostic and therapeutic option for MS patients is a relatively new and promising approach. Reliable devices and measurements are needed to assess the PA of MS patients in daily life and to assess the performance of standard clinical tests in detail. Aim of this study was to assess the association between patients’ performance during a set of standard rapid tests and disease status.

**METHODS**
25 MS patients performed a predefined set of balance and walking tests including Romberg stance test, Timed Up and Go (TUG), timed tandem walk (TTW) and 6 Minute Walking Test (6MWT) while wearing a tri-axial accelerometer, the acti6 [1], around their waist. Data of 3 patients were excluded from analysis, since patients required holding assistance during balance tests as a possible bias source. Collected accelerometry data were pre-processed by noise and gravity filtering and compared with MS relevant patient data: Expanded Disability Status Scale (EDSS, with 0-2.5, 3.0-4.5, 5.0-6.5, > 6.5 referring to mild, moderate, advanced, and severe disability), MS Severity Scale, disease duration and course. Parameters extracted from the accelerometry data were: Balancecount, an unbalancing measurement during static tests, and time, speed and distance for the dynamic tests. Kruskal-Wallis and Wilcoxon non-parametric tests were used to assess the association between patient data and accelerometry parameter.

**RESULTS**
Data on 22 patients (16 female, 6 male; mean age 41.5±10.2 years) were available for analysis. Clinical patients characteristics were as follows: EDSS 3.2±2.0, disease duration 8.5±6.9 years, MSSS 4.7±3.0, disease course: 10 RRMS, 5 SPMS, 5 PPMS, walking aid was used by 5 patients. Time of unbalancing during a 30sec. Romberg stance test was significantly associated to EDSS levels 0-2.5, 3.0-4.5, 5.0-6.5 (p=0.042). Respective median times were 0.01s, 0.08s, 0.54s. Patients with SPMS or PPMS had more balance problems compared to RRMS (p=0.041). Results of TTW are biased by use of walking aids. Therefore, analysis was restricted to patients walking without aids. Patients with EDSS 0–2.5 had less unbalancing than patients with EDSS 3.0–4.5 (median proportion: 0.97 vs. 11.72, p=0.083). This difference between the two groups was not detectable when performing TUGa and 6MWT. There was a trend association between speed reduction during the 6MWT and MSSS in the subgroup of patients walking without aid (p=0.07).

**DISCUSSION AND CONCLUSION**
Accelerometry parameters assessed during a set of rapid tests seem to be usable as an objective tool to differentiate between disability levels in MS patients.

**REFERENCES**

P2-76

**DEVELOPMENT OF A TEREHABILITATION INTERVENTION TO INCREASE ACTIVITY LEVELS, WALKING ABILITY AND LOWER EXTREMITY FUNCTION IN PEOPLE WITH STROKE**

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**INTRODUCTION**
Many people who experience a stroke are disabled, require assistance during ambulation, and are extremely inactive. Our long-term goal is the development and testing of a comprehensive telerehabilitation intervention strategy that incorporates intensive, task-oriented practice with behavioral enhancing feedback provided by a novel shoe based sensor (SmartShoe) that can accurately identify functional postures and activities in people with stroke.

**METHODS**
The proposed methodology utilizes inexpensive, user-friendly technology based on consumer off the shelf products (a cellular phone and a Nintendo Wii gaming system) and the SmartShoe. Figure. The SmartShoe consists of a flexible insole, which incorporates five force-sensitive resistors and a 3-dimensional accelerometer positioned on the back of the shoe.

**RESULTS**
Acceleration and pressure data are sampled at 25Hz by a 12-bit analog-to-digital converter and are sent from the SmartShoe via BlueTooth to the phone. Using specific algorithms that we have developed and validated [1, 2], the amount of time spent in different functional postures and walking activity are displayed on the phone providing automated, on-going behavioral feedback to the patient. Daily activity levels and behavioral goals can be viewed and set on a TV using a Wii, web-based interface. The rehabilitation professional can review progress and communicate with the patient through this same Wii interface.

**DISCUSSION AND CONCLUSION**
The SmartShoe telerehabilitation system may have several key advantages over other wearable sensor systems: information presented to the patient is easy to understand, user receives immediate feedback, automated messages recommend specific actions to increase activity and praise for reaching set goals, only requires an inse to be placed in the user’s shoes and a sensor clipped to the side of the shoes, and it does not take a great deal of technological expertise to use the system. We are in the process of pilot testing the SmartShoe telerehabilitation intervention in people with stroke.

**REFERENCES**

P2-77

**DAILY ARM-HAND ACTIVITY IN CHRONIC STROKE PATIENTS IMPROVES AFTER ROBOT-ASSISTED TASK-ORIENTED ARM TRAINING**

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**INTRODUCTION**
In chronic stroke patients arm-hand skill performance (AHP) is often impaired. It is unknown to what extent robot-assisted training may improve AHP, and to what extent outcome may be predicted. To assess these issues, monitoring daily arm-hand use is essential. Several tests are available; some of which measure a person’s capacity (e.g. Action-Research-Arm-Test (ARAT)), perceived performance (Motor-Activity-Log (MAL)) and actual performance (accelerometry). Aim of the study is to objectively quantify changes in AHP after robot-assisted training in chronic stroke patients living at home, at the aforementioned levels.

**METHODS**
Twenty-two chronic stroke patients are randomly assigned to an 8-weeks task-oriented, robot-assisted training (HM) or a task-oriented control training (control). Subjects train for 4 days/week, 2x 30min/day. For training, the Technology-supported-Task-Oriented-Arm-training method (T-TOAT) is used [1]. Haptic Master (MOOG, Netherlands) is the robotic device used. Measurements, taken at baseline(T0), directly after training(T1), and at 6 months follow-up(T2), include ARAT, MAL, and bilateral arm-accelerometry (Actiwatch, Cambridge Neurotechnology Ltd, UK). The latter is used during 3 consecutive days at home.

**RESULTS**
Preimmary data, i.e. mean (sd) values and relative improvement over time (%) of ARAT, MAL and accelerometry, recorded from the first patients in both training conditions (n=3 for both groups) at T0 and T1 are presented in table 1.
In both training conditions patients improved more than 10% on the ARAT, MAL and activity level as measured by accelerometer. Furthermore, patients receiving Haptic Master training seem to improve more on actual performance compared to the control group members. In contrast, the controls seem to improve more on the MAL and ARAT, indicating that the three measures used may represent different underlying constructs, at least to a certain extent. As to the predictive value of ARAT and MAL, data currently available are still inconclusive. However, one should keep in mind the limited number of participants enrolled until now. After completion of the data acquisition the predictive value of ARAT and MAL for AHS treatment outcome, i.e. actual performance as measure by arm-accelerometer will be analysed.

REFERENCES

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Table 1: Preliminary data concerning ARAT, MAL and accelerometery

<table>
<thead>
<tr>
<th></th>
<th>ARAT</th>
<th>MAL</th>
<th>Accelerometry (activity counts)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>T0</td>
<td>T1</td>
<td>%</td>
</tr>
<tr>
<td>HM</td>
<td>30</td>
<td>34</td>
<td>13.3</td>
</tr>
<tr>
<td></td>
<td>206</td>
<td>217</td>
<td>(13.9)</td>
</tr>
<tr>
<td>Control</td>
<td>27</td>
<td>40</td>
<td>48.1</td>
</tr>
<tr>
<td></td>
<td>(10)</td>
<td>(10)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>37</td>
<td>35.3</td>
</tr>
<tr>
<td></td>
<td>(17)</td>
<td>(15)</td>
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</tbody>
</table>

DISCUSSION AND CONCLUSION

The ambulatory activity of stroke people is usually very reduced but sometimes close to normal sedentary subjects. There is a good correlation between the step counting per day and the distance performed during the 6MWT and with the speed during 10MWT. Those two clinical tests may be good predictors for daily-life walking performance. In contrast, self-reported measures of physical activity have been found to be inflated or incoherent as compared with mean steps per day. Thus, activity monitoring captures aspects of walking performance not captured by other clinical tests and should be considered as an additional outcome measure in stroke rehabilitation.

P2-78

DAILY-LIFE ASSESSMENT OF THE WALKING ACTIVITY IN CHRONIC STROKE PATIENTS

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INTRODUCTION

Although commonly used, survey-based and timed-walks measures of mobility recovery after stroke do not capture all the elements of ambulatory behaviour. Little information exists regarding the quantity of walking in daily-life conditions (e.g. 1, 2). We propose a new magnetometer-based system (MAG system) to: (1) count steps during a complete ambulatory day, (2) investigate the correlations between actual performance in daily life, and function, capacity and self-perceived performance.

METHODS

Twenty-five individuals with chronic stroke (6 - 24 months) participated in the study and wore a MAG system (CEA-LETI) during 3 days in their home environment. The MAG system is made of one 3-axis magnetometer sensor, connected to a recording device, and placed on the outer face of the hemiparetic leg, on the shank. Data processing was performed with dedicated software (CEA-LETI). Correlation coefficients were computed between actual performance (number of steps measured with the MAG system), and various clinical tests and scales: six-minute walk test (6MWT), ten-meter walk test (10MWT), the Activity Specific Balance Confidence Scale (ABC Scale), the Fugl-Meyer Assessment, and the Rivermead Mobility Index (RMI).

RESULTS

The mean number of steps per day was very inconsistent between patients (from 361 to up to 6700 steps/day). High correlations were found between actual performance (number of steps) and the distance at the 6MWT (r = 0.91, 95%-CI [0.82–0.95]), the speed at the 10MWT (r = 0.76, 95%-CI [0.48–0.91]), whereas a moderate correlation was found between actual performance and self-perceived performance (e.g. with the ABC scale: r = 0.63, 95%-CI [0.26–0.60]). For the relationship between actual performance and both the ABC Scale and the Rivermead Mobility Index, logarithmic regression explained more variance than did linear regression.

DISCUSSION AND CONCLUSION

The ambulatory activity of stroke people is usually very reduced but sometimes close to normal sedentary subjects. There is a good correlation between the step counting per day and the distance performed during the 6MWT and with the speed during 10MWT. Those two clinical tests may be good predictors for daily-life walking performance. In contrast, self-reported measures of physical activity have been shown to be inflated or incoherent as compared with mean steps per day. Thus, activity monitoring captures aspects of walking performance not captured by other clinical tests and should be considered as an additional outcome measure in stroke rehabilitation.

REFERENCES

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P2-79

METHODS FOR MEASURING PHYSICAL ACTIVITY IN CHALLENGING POPULATIONS

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INTRODUCTION

The purpose of this pilot study was to find out how long term physical activity can be measured in adolescents in danger of marginalization and how the physical activity information can be processed. A connection has been found between physical activity and psychological health in young people [1]. Therefore an intervention was conducted aiming to decrease the likelihood of marginalization by increasing adolescents’ physical activity.

Long term physical activity measurement with objective methods is important in order to study the efficacy of physical activity interventions. The objective of the study was to find out how to perform physical activity measurement with wrist-worn accelerometers in larger populations of challenging subjects.

METHODS

Dropping out of educational system is one of the main mechanisms causing adolescents’ marginalization [2]. Therefore the selection of subjects was based on their education, and two post-comprehensive school orientation classes were chosen. The intervention group (N=10) had twice as much physical education as the control group (N=10), and they were also guided to leisure-time activities. The physical activity levels were measured with a wrist-worn uni-axial accelerometer developed for research (Polar Electro Oy, Kempele, Finland). The accelerometer data was reduced and studied with custom-developed software. Physical activity was measured in five one week periods during five months. Students’ health and fitness parameters and body composition were measured in the beginning and in the end of the intervention.

RESULTS

Compliance ranged from 35.3% to 64.7% meeting the analysis criteria. Only four students provided data on all measurements. Time spent in physical activities was higher than in previous studies [3]. Throughout the intervention period majority of the students met the daily recommendation of 60 minutes of physical activity. The trend seemed to be that the males in the intervention group had increased physical activity at all intensity levels during the intervention. Health and fitness parameters did not show improvement.

DISCUSSION AND CONCLUSION

Even in this challenging population good compliance was received on a few weeks. Thus accelerometers worn on the wrist seems to be a good method of measurement also in challenging populations.

As a result of the pilot study, proposals for a full scale research protocol were devised. Accelerometer data analysis methods should be studied in the context of long term physical activity measurement. Also the long measurement period requires more research especially with regard to compliance strategy.

REFERENCES
LIFESTYLE FACTORS THAT INFLUENCE AMBULATORY ACTIVITY IN THE ELDERLY

Coleman KL1, Laing LS1, Rosenbaum-Chou TG1
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INTRODUCTION

More research is demonstrating the benefits of exercise, especially in the elderly population. However, some people have difficulty maintaining an exercise routine. Therefore, this study investigated various lifestyle factors to determine if other activities, than activities classified as exercise, were also associated with higher levels of ambulatory activity.

METHODS

The protocol was approved by Western IRB, funded by NIH SSBIR grant R44 HD 39036-02, and conducted by Cyma Corporation. Subjects were required to be ≥ 65 years old (typical retirement age in USA), ambulatory, no present injury or illness, no history of chronic disease, and a BMI < 39. Following enrollment, subjects were asked 39 questions about lifestyle topics on demographics, occupation, and home life. Subjects then wore a StepWatch activity monitor [1] (Orthocare Innovations, Seattle, WA) for 7 ± 1.2 days.

The following activity measures were calculated for each full 24-hour day and then averaged across the included days: 1) Daily steps – daily strides per day; 2) Peak performance – strides/min of the most intensive 30 individual minutes in the day; 3-7) Max 60, Max 30, Max 20, Max 5, Max 1 – strides/min of the most intensive continuous 60, 30, 20, 5, or 1 minute in the day, respectively; 8) High activity – percent time at > 40 strides/min; 9) Med. activity – percent time at 15-40 strides/min; 10) Low activity – percent time at ≤15 strides/min; 11) Inactive – percent time inactive. An unpaired t test or linear regression was used to determine associations between activity measures and lifestyle factors.

Table 1 – Lifestyle factors that were statistically associated with greater or reduced activity levels in the elderly (p<0.05). Each arrow represents one of the 11 activity measures.

RESULTS

The ages of the subjects were 75 ± 6 years. Self-reported exercise had the strongest correlation to the activity measures. However, the correlation was stronger for males (r=0.41-0.68) than females (r=0.37). Males also demonstrated an increase in activity levels with increased days cleaning house (r=0.44-0.50), working in the yard (r=0.51-0.68), and using a computer (r=0.27-0.68). None of these lifestyle factors correlated to activity levels for females.

DISCUSSION AND CONCLUSION

This study suggests that increased cleaning of the home and working in the yard may increase the activity of elderly males that have not had success in exercise routines.

REFERENCES


ENERGY COST OF STEP FREQUENCIES ACROSS AGE

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INTRODUCTION

Limited research has explored the relationship between step rates and energy cost of activity [1,2]. Further, research exploring this relationship across ages and using measured relative energy cost is lacking. The purpose of this study was to determine moderate intensity step frequencies based on energy cost relative to body weight across age groups.

METHODS

Participants (N=118) were categorized by age into one of three groups: Group1, 18-39y (n=48); Group2, 40-59y (n=39); Group3, 60-79y (n=31). Resting metabolic rate (RMR) and maximal graded exercise testing were completed. Participants completed 4 minutes of treadmill (TM) walking at each of the following speeds: 53.6, 67, 80.4, 93.8, 107.2 m/min while wearing an accelerometer (ACC, Actigraph GT3X) on the left hip and a portable oxygen uptake system (Cosmed K4b2, Rome, Italy). Each ACC was initialized to record steps, with mean steps derived from averaging the last 2-min of each TM speed. Regression analysis was used to predict step frequency of moderate intensity (40-59%) based on percent V02max for each age category [3].

RESULTS

Group1 (28.0 ± 6.2 y; 25.6 ± 4.5 kg/m2) had an average RMR of 3.03 ± 0.39 ml/kg/min and V02 max of 42.6 ± 7.8 ml/kg/min. Group2 (49.9 ± 5.8 y; 26.1 ± 5.2 kg/m2) had an average RMR of 2.83 ± 0.37 ml/kg/min and V02 max of 33.1 ± 8.7 ml/kg/min. Group 3 (66.1 ± 5.1 y; 29.9 ± 5.3 kg/m2) had an average RMR of 2.66 ± 0.30 ml/kg/min and V02 max of 26.1 ± 6.0 ml/kg/min. Individual regression analyses showed percent V02 max was a significant predictor of steps taken for group 1 (R2 = 0.40, F (1, 47) = 131.3, p < 0.001), group 2 (R2 = 0.196, F (1, 39) = 55.3, p < 0.001), and group 3 (R2 = 0.271, F (1, 30) = 44.9, p < 0.001). Moderate intensity step frequencies ranged from 108-123 (Group1), 103-114 (Group 2), and 93-106 (Group 3).

DISCUSSION AND CONCLUSION

Data from this study shows that 30 minutes of moderate intensity exercise is the equivalent of 3240-3690 steps/30min for 18-39y, 3080-3420 steps/30min for 40-59y, and 2790-3180 steps/30min for 60-79y. These ranges are slightly higher than previously reported moderate intensity step frequencies (2700-3390 steps/30 min) for younger (mean age 39y) individuals based on absolute METs and body height. These data demonstrate that moderate intensity step frequencies change with age and should be based on individual fitness level.

REFERENCES

and reliable for young adults [2]. After filtering for non-physiological movement and non-wear, accelerometer data, in the form of counts, were differentiated into physical activity intensities using designated cut-points [3]. A paired t-test was performed to test differences between objectively-measured PA and self-reported PA. Linear stepwise regression was conducted to examine the impact of misperception of PA, the difference between objectively-measured and self-reported PA, on body fat percentage (%BF) controlling for year in school.

RESULTS
Accelerometer results show participants spent an average of 39 ± 15 minutes in moderate-intensity physical activity (MPA) and 4 ± 7 min/d in vigorous-intensity physical activity (VPA). Participants over-estimated time spent in MPA by 76 ± 98 min/d (p < 0.001) and VPA by 19 ± 36 min/d (p < 0.001). Results from the linear regression showed that, when accounting for year in school, misperception of MPA, and VPA, misperception of time spent in MPA was a significant predictor of %BF (β = 0.393, F [1, 29] = 5.534, p = 0.002), predicting 16.3% of the variance in %BF. Higher overestimation was associated with higher levels of %BF. Misperception of time spent in VPA was not a significant predictor of %BF.

DISCUSSION AND CONCLUSION
Results from this study provide evidence that this sample of college women over-estimated the amount of PA in which they participate, and these misperceptions were associated with higher body fat levels. For instance, an over-estimation of 30 min of MPA was associated with an approximately 6.2% increase in body fat values. Further investigation of undergraduate women in health-related majors is advised to examine if lack of knowledge surrounding PA among non-health-related majors may be a contributing factor to misperceptions of PA participation and in turn, obesity in this population.

REFERENCES

P2-83
DETECTION OF HEAD AND NECK TRAUMA WITH A DISCRETE SENSOR
Baker S1, Hwang F1, Minchinton P1, Godfrey A2
1Interactive Systems Research Group, School of Systems Engineering, University of Reading, Reading, UK; 2Clinical Ageing Research Unit, Newcastle University, Newcastle upon Tyne, UK

INTRODUCTION
Rugby is a well know collision sport where players repeatedly come into contact with other players or the ground. A previous study [1] suggested that concussion accounted for 5.5% of the total injuries in rugby. It is known that having consistently large forces acting upon the head and neck region is likely to cause more damage than that of a sudden impulse which on many occasions can be tolerable. This study examined the use of developing a discrete unit for long term monitoring of head collisions.

METHODS
A head mounted sensor consisted of a tri-axial accelerometer and a Bluetooth transmitter. Power to the system is provided via a 6V power pack held within a belt pack. A MATLAB® GUI was developed to present medical advice/information that is dependent on the processed information from the unit. The GUI also displayed the processed data visually via plots, traffic lights, head quadrant indication and a medical advice section. The GUI’s traffic light system (red, amber, green) and head quadrant processed data visually via plots, traffic lights, head quadrant indication and a medical advice section. The GUI’s traffic light system (red, amber, green) and head quadrant indication and a medical advice section.
P2-85 ASSOCIATIONS BETWEEN VO₂ AND THE GT3X ACCELEROMETER DURING FREE LIVING ACTIVITIES
Reid-Larsen N¹, Hermann A¹, Holsgaard-Larsen E¹, Froberg K¹, Andersen LB¹
¹ University of Southern Denmark, Institute of Sports Science and Clinical Biomechanics, RICH
² University of Southern Denmark, Orthopaedic Research Unit, Department of Orthopaedic Surgery and Traumatology, Odense University Hospital, Institute of Clinical Research

INTRODUCTION
Studies have produced mixed results when validating the triaxial accelerometer. Previous studies have found both an underestimation (1) and an overestimation of TEE during simulated free living conditions. (2, 3) The observations could have been confounded by placement of monitors and difference in prediction equations. Furthermore differences in filtering software between brands make direct comparisons hard. Inter model differences could therefore be expected. Thus, the influence of inclusion of the different axes should thus be investigated within the same model and brand.

The aim of the study is to test the hypothesis that the association between VO₂ during simulated free-living physical activities and acceleration is dependent on the number and the direction of axis of the acceleration using the Actigraph model GT3X.

METHODS
7 persons completed a two hour protocol consisting of eight different activities of different intensities. VO₂ was measured using a portable system (Cosmed model K4b²) and expiration was analyzed breath-by-breath. Acceleration was measured by the Actigraph model GT3X. 3 linear regression random-incept models with covariates were fitted with VO₂*kg⁻¹ as dependent variable and acceleration (vector magnitude - VM) as independent variable. All analyses were adjusted for gender.

RESULTS
All models provided a significant association between VO₂*kg⁻¹ and VM. VM including all three axis provided the strongest association to VO₂ (R² = 0.58), whereas an omission of all three axis reduced the association slightly (R²=0.56), whereas an omission of both the 2nd and 3rd axis reduced the r² to 0.52. R² of the models, overall and by type of activity, were significantly improved with an increasing number of axes included in the model. This did not affect the predicted VO₂ values. An increasing disagreement in the 2nd and 3rd axis reduced the r² to 0.52. Fits of the models, overall and by type of activity, were significantly improved with an increasing number of axes included in the model. This did not affect the predicted VO₂ values. An increasing disagreement in the 2nd and 3rd axis reduced the r² to 0.52.

DISCUSSION AND CONCLUSION
Models including all 3 axes of acceleration displayed a significantly better fit to the data compared to both 1 and 2 axes but it did not affect the predicted mean VO₂ in this sedentary protocol. However, within common activities of daily living characterized by upper body movements.

REFERENCES

P2-86 A MULTICOMPONENT INTERVENTION STUDY FOR IMPROVING PHYSICAL ACTIVITY IN ADOLESCENTS: A CLUSTER RANDOMISED CONTROLLED STUDY DESIGN
Authors Toftnappe ML, Christiansen LB, Troelsen J²
¹ Institute of Sport Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark ²National Institute of Public Health, University of Southern Denmark, Copenhagen, Denmark

INTRODUCTION
SPACE for physical activity is a multicomponent intervention study investigating the impact of structural and organizational interventions to promote everyday moderate physical activity among adolescents (11-15 year old). The comprehensive intervention consists of four domains: active transport, play sport (adolescent playground), school yard and teen fitness.

METHODS
A cluster randomised controlled study design is used to evaluate the effectiveness of the intervention. Because prior studies have shown tendencies of clustering in schools regarding physical activity, we chose a matched pair design. 21 eligible schools were matched and randomised in seven pairs according to best match regarding eight matching variables. The four objective matching variables were 1) crow-fly distance of residence to school for 5th-6th grade, 2) area household income, 3) area education and 4) area ethnicity. The subjective data consisted of ratings based on visits at the 21 school sites and interview with municipality consultants and managing school personnel. The four subjective parameters were 1) area urbanity, 2) school outdoor areas, 3) school health policy and 4) active transport in the local area.

In spring 2010 baseline measurements were conducted using accelerometers, questionnaires, diaries, and physical fitness test on 1348 students (5th-6th grade) in 7 intervention schools and 7 control schools. Follow-up measurements will take place in spring 2012 (7th-8th grade). Furthermore anthropological observations and process and health economic analyses will take place Primary outcomes are average daily physical activity measured with accelerometer (Actigraph GT3X Activity Monitor) (counts/min/child/day).

RESULTS
There were no significant differences between intervention (n=623) and control (n=725) groups at baseline according to selected background variables and outcome measures: Age (p = 0.09), Gender (p = 0.54), BMI (p = 0.61) Physical activity (accelerometer) (p = 0.09), Waist circumference (p = 0.17), Physical fitness (p = 0.93), Active transport to/from school (p = 0.06), and Physical activity in recess periods/self-reported (p = 0.13).

DISCUSSION AND CONCLUSION
The randomisation and matched pair design produced equivalent groups according to central outcome measures and background variables. The Space for physical activity study will provide new insights on the effectiveness of multicomponent interventions to improve adolescents’ physical activity level.

P2-87 INTEGRATION OF A PORTABLE KIT IN A CASCADE OF WALKWAYS IN TELE-REHABILITATION
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¹ Dipartimento di Tecnologie e Salute, IJS, via Regina Elena 299, Roma, Italia

INTRODUCTION
The present work is focused on the Daily-rehabilitation for gait and outside the Hospital. The global aim of this study is to allow to perform the rehabilitation exercise by using measurements obtained thanks to the sensorization of both the patient and the rehabilitation tools and or walkways (WWs) currently available. The rationale of the idea has arisen from the consideration that a patient, a physician, a therapist could benefit from a sensorization of the used rehabilitation tools WWs for furnishing easy-to-process performance parameters in order to carry out quantitative information useful for gait assessment and to be added to a qualitative interpretation of clinical exercise.
METHODS
The functionalities of the proposed portable kit were:
(1) Monitoring the steps performed during a rehabilitation task on the basis of a predefined protocol and on an assigned cascade of WWs of a defined length and thus the determination of all the relevant parameters of velocity and time. (2) Formatting this information according to a text file easy to send to a communication centre for post-processing purposes and archiving according to a specified format of database.

The minimum hardware solution is based on the following components: (A) Step counters (1-2) properly designed for disable people; (B) Detectors positioned, to detect the timing of the gait exercise; (C) One central unit for the collection of the row data; (C) Software interface developed by Labview 8.2 for the data-processing and hand-shaking with WAN.

RESULTS
As an example of application of the methodology to one subject at the 2nd level of the Tinetti test of motor imbalance disability (male; height 1.78 cm; weight 76 Kg; age 64 years) wearing a Gastrocnemius Expansion measurement Unit (GEMU) we report an output (Table) of a single clinical application and the values relevant to 10 repetitions at two different speeds in a configuration with two 10 m long walkways (WW) in cascade (with a handrail and two different ground/rugosity: linoleum and moquette).

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DISCUSSION AND CONCLUSION
The kit has been successfully tested in an application comprehending a cascade of two walkways with different rugosity in a case study on a subject at the Level 2 of the Tinetti test.

To date three directions seems to be mostly possible for the kit: (A) The integration of the equipment versus the Hospital LAN. (B) The integration with homecare units assessing the most relevant medical parameters (C) The integration of walkways at home in domotics.

REFERENCES

P2-88 COMPARISON OF THE GT3X ACTIGRAPH WITH THE GT1M ACTIGRAPH FOR ASSESSMENT OF ACTIVITY IN CHILDREN AND VALIDATION OF THE GT3X INCLINOMETER FUNCTION

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2 School of Sport and Health Sciences, University of Exeter, UK

PURPOSE
The GT1M ActiGraph is one of the most widely used physical activity monitors, but is no longer available for purchase since it was replaced in January 2009 by the GT3X ActiGraph. The GT3X contains a triaxial accelerometer and an inclinometer to detect three different postures (sit, lie, stand) and whether the monitor is worn. The primary purpose of this study was to investigate the comparability of the vector magnitude of the vertical activity counts from the GT3X and the GT1M. Additionally, the validity of the GT3X inclinometer for posture detection was tested and the benefit of three axes compared to a single axis for the prediction VO2, was investigated.

METHODS
Seventeen children (10 to 14 y) wore an ActiGraph GT3X and GT1M, during structured activities (lying down, sitting, standing, active computer games, walking and running) in a laboratory setting. Oxygen consumption was measured throughout by indirect calorimetry using the Cosmed K4b2 gas analyser.

RESULTS
The GT3X recorded significantly higher (p< 0.05) vertical mean counts per second than the GT1M for standing (0.4±0.7 (GT1M); 0.7±0.5 (GT3X)), active computer games (4.8±11.8 (GT1M); 5.8±12.7 (GT3X)), brisk walking (5.6±13.7 (GT1M); 6.1±13.4 (GT3X)), slow running (105.0±26.6 (GT1M); 116.9±28.2 (GT3X)) and medium running (114.2±22.8 (GT1M); 127.6±25.0 (GT3X)). The inclinometer correctly detected standing 29% of the time, lying 9%, sitting 89% and the off position 81% of the time. The use of the vector magnitude of three axes from the GT3X did not significantly improve the prediction of oxygen consumption compared to the vertical axis of the GT3X alone, except for active computer games.

DISCUSSION AND CONCLUSION
Vertical activity counts were not comparable during activities of at least moderate intensity. The inclinometer had limited validity and was location dependent, supporting the findings of McMahon et al. [1]. In the present study the vector magnitude only improved the estimation of energy expenditure over a single axis for prediction of VO2, during active computer games, the solely less structured activity. This supports earlier studies suggesting that a triaxial accelerometer is superior to a uniaxial accelerometer for prediction of energy expenditure of free-living activities in children [2,3]. Thus, the triaxial GT3X may provide potential for the enhanced estimation of energy expenditure in children, particularly during less structured activities.

REFERENCES
PAL Technologies Ltd – Stand 1

The activPAL™ is an accelerometer-based posture and activities logger validated to quantify postural allocation. In addition to recording the time spent in sedentary activities, the activPAL™ also quantifies upright time and activities including stepping bouts and activity intensity with a sub-second resolution over a seven day recording period.

The activPAL™ is the solution for objectively quantifying time spent in sedentary activities chosen by more than 200 research centres across the world.

GENEActiv – Stand 4

Launching GENEActiv, The original wrist-worn, wave-form, accelerometer for behavioral mapping.

GENEActiv is a reliable, body worn accelerometer that measures and tracks everyday living in all environments. This leading technical design offers 0.5Gb of raw data in an open format and comes as a uniquely fully waterproof, value for money instrument with 2 months of battery life. Come and visit us on stand 4 at this year’s icampam event.

GENEActiv for every body.

McRoberts – Stand 6

McRoberts is a dynamic and experienced company and one of the leaders in ambulatory monitoring of physical activity. With light-weight and ambulatory systems based on accelerometry, activity classification (MoveMonitor) and physical assessment (MoveTest) is relatively simple to realize. Our goal: improving physical functioning and hence quality of life.

APDM – Stand 10

APDM produces wearable inertial sensors and a system for assessing gait and balance. The sensors are small, unobtrusive, wirelessly synchronized, and operate throughout the day. They never drop data and can log data for rapid download or stream wirelessly. APDM has just announced an applications store and program for developers.

Hidalgo – Stand 12

The Equivital™ TnR product range is designed with precision to deliver accurate, mobile human condition and performance data. The Equivital LifeMonitor is a miniaturised sensor which facilitates comprehensive ambulatory multi-parameter data collection and the eqView software suite is developed to acquire, analyse and display data. Current uses include training and research applications, Safety critical monitoring, Patient monitoring for mobile health applications and Pharmaceutical clinical trials. The Equivital platform also enables partner communities to create bespoke solutions for custom applications.

ActiGraph – Stand 15

ActiGraph is the leading provider of ambulatory monitoring systems for the global research community. Known for accuracy, reliability and innovation, ActiGraph’s extensively validated suite of hardware and software products are used by prominent academic and scientific organizations in 60 countries and have earned the reputation as the gold standard in ambulatory monitoring.

Delsys – Stand 16 & 17

Primarily focusing on surface and decomposition electromyography (sEMG and dEMG™), Delsys has established itself as an inventive leader in EMG and other biosensor solutions. Today, Delsys continues to lead the innovation path by developing tools for neuromuscular research, rehabilitation and injury clinics, human performance enhancement, and biofeedback applications.

The current product line includes: Desktop EMG solutions, Wireless EMG solutions for lab and field research, biosensor solutions, and dEMG™ technology for motor control studies.

CamNtech - Stand 19

CamNtech manufactures and distributes the Actiheart combined activity, heart rate & energy expenditure monitor. With users worldwide and extensive scientific validation, the Actiheart is the proven ‘gold standard’ for ambulatory energy expenditure monitoring. CamNtech is a distributor of Cosmed’s Fitmate system for REE measurement in the UK. Combining the two systems provides the ideal solution for measuring total energy expenditure (TEE).
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(Teeside University, Middlesbrough, UK)
## Tuesday 24 May 2011

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<td>19:30-21:00</td>
<td>CIVIC RECEPTION – Glasgow City Chambers</td>
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## Wednesday 25 May 2011

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<td>Welcome: Malcolm Granat, Glasgow Caledonian University – Strathclyde Suite</td>
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<td>K1: David Bassett – Strathclyde Suite Chairs: Malcolm Granat, Hans Bussmann</td>
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<td>09:30-10:00</td>
<td>I1: Jo Salmon – Strathclyde Suite Chair: Hans Bussmann</td>
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<td>POPULATION &amp; INTERVENTION ASSESSMENT – Strathclyde Suite</td>
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<td>Chair: Hans Bussmann, Stephen Redmond</td>
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<td>DEVICE DEVELOPMENT – Buchan Suite</td>
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<td>Novel Devices and Sensors 1</td>
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<td>Chair: Weijsen Zijlstra</td>
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<td>11:45-12:15</td>
<td>I3: Jorunn Helbostad – Strathclyde Suite Chair: Charles Matthews</td>
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<td>12:15-13:15</td>
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<td>15:15-18:30</td>
<td>METHOD DEVELOPMENT – Strathclyde Suite Posture and Activity Classification</td>
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<td>Poster Session 1 – Lomond and Clyde Foyers</td>
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<td>09:30-10:00</td>
<td>I5: Charles Matthews – Strathclyde Suite Chair: Yukitoshi Aoyagi</td>
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<td>10:00-11:00</td>
<td>POPULATION &amp; INTERVENTION ASSESSMENT – Strathclyde Suite</td>
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<td>Chair: Charles Matthews, Yukitoshi Aoyagi</td>
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<td>METHOD DEVELOPMENT – Buchan Suite</td>
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<td>Kinetics and Kinematics</td>
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<td>Chair: Kamiar Aminian, Malcolm Granat</td>
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<td>MORNING BREAK</td>
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<td>11:45-12:15</td>
<td>I7: Nick Wareham – Strathclyde Suite Chair: Soren Brage</td>
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<tr>
<td>12:15-13:15</td>
<td>POPULATION &amp; INTERVENTION ASSESSMENT – Strathclyde Suite</td>
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<td>Device Validation &amp; Reliability</td>
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<td>Chair: Weijsen Zijlstra</td>
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<td>15:15-16:30</td>
<td>METHOD DEVELOPMENT – Strathclyde Suite Sedentary Behaviour</td>
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<td>Chair: Neville Owen, Ulrich Ebner-Priemer</td>
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<td>Physical Activity Patterns</td>
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<td>Chair: Kamiar Aminian, Catrine Tudor-Locke</td>
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<td>AFTERNOON BREAK</td>
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<td>16:30-17:45</td>
<td>Poster Session 2 – Lomond and Clyde Foyers</td>
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<td>17:45-18:30</td>
<td>GALA DINNER</td>
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## Friday 27 May 2011

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<th>Time</th>
<th>Activity</th>
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<tr>
<td>08:45-09:30</td>
<td>K5: Catrine Tudor-Locke – Strathclyde Suite Chairs: Neville Owen, Jorunn Helbostad</td>
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<td>09:30-10:00</td>
<td>I9: Malcolm Granat – Strathclyde Suite Chair: Neville Owen</td>
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<td>10:00-11:00</td>
<td>METHOD DEVELOPMENT – Strathclyde Suite Walking Patterns</td>
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<td>Chair: Ulrich Ebner-Priemer, Jorunn Helbostad</td>
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<td>MORNING BREAK</td>
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<td>11:45-12:15</td>
<td>I11: Hans Bussman – Strathclyde Suite Chair: Jo Salmon</td>
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<td>12:15-13:15</td>
<td>METHOD DEVELOPMENT – Strathclyde Suite Clinical Outcome Measures</td>
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<td>Novel Devices and Sensors 2</td>
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<td>13:15-13:45 Closing – Strathclyde Suite</td>
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