Effects of Locomotor Skill Program on Minority Preschoolers’ Physical Activity Levels

Sofiya Alhassan, Ogechi Nwaokelemeh, Manneh Ghazarian, Jasmin Roberts, Albert Mendoza, and Sanyog Shitole
University of Massachusetts Amherst

This pilot study examined the effects of a teacher-taught, locomotor skill (LMS)-based physical activity (PA) program on the LMS and PA levels of minority preschool-aged children. Eight low-socioeconomic status preschool classrooms were randomized into LMS-PA (LMS-oriented lesson plans) or control group (supervised free playtime). Interventions were delivered for 30 min/day, five days/week for six months. Changes in PA (accelerometer) and LMS variables were assessed with MANCOVA. LMS-PA group exhibited a significant reduction in during-preschool ($F(1,16) = 6.34, p = .02, d = 0.02$) and total daily ($F(1,16) = 9.78, p = .01, d = 0.30$) percent time spent in sedentary activity. LMS-PA group also exhibited significant improvement in leaping skills, $F(1, 51) = 7.18, p = .01, d = 0.80$). No other, significant changes were observed. The implementation of a teacher-taught, LMS-based PA program could potentially improve LMS and reduce sedentary time of minority preschoolers.

Approximately, 58% of 2.9- to 5-year olds in the US spend the majority of their day in an early childcare program (9). Therefore, early childcare programs present a unique opportunity to increase physical activity (PA) levels in this population. A strong correlate of PA levels is the amount of time in which children are allowed to engage in outdoor playtime (26). However, Alhassan et al. recently documented that the addition of a substantial amount of outdoor free playtime (60 min per day) was not sufficient to impact preschoolers’ PA levels (1). One possible reason for this outcome is that the majority of the children frequently chose to participate in sedentary activities (e.g., sandbox) during outdoor playtime. Researchers have reported that to effectively engage in PA, preschoolers need specific and systematic opportunities to learn fundamental movement skills (12,33). Fundamental movement skills (locomotor and object control skills) are movements that are integrated into complex patterns upon which activities/games of increasing complexity are built (4,14,30). Locomotor skills (LMS) involve actions that move the body through
space (i.e., running, hopping, galloping) and objective control skills involve object manipulation with either the hands or feet (i.e., throwing, catching, kicking; 15, 30).

Current cross-sectional data support associations between LMS and PA level in older children (3,23,32). However, the data on the association between LMS in preschoolers have been less consistent (6,10,40,43). It has been suggested that LMS development in young children may be an important predictor of their PA level later in life because LMS proficiency tracks into adolescence (3,24,28,38). Nevertheless, researchers have observed that low-income Latino and African-American children from urban disadvantaged areas have developmental delays in their locomotor proficiency (13,16,18). A recent review, provided evidence that with the appropriate learning environment children can obtain LMS proficiency as early as 6 years of age (32). Therefore, interventions targeting the development of young children’s LMS are essential. The importance of LMS development is highlighted in the current national PA guidelines, which states that preschoolers are encouraged to develop competency in LMS (25).

In early childcare centers, particularly does in low socioeconomic status (SES) environment, classroom teachers are often responsible for teaching LMS and ensuring that children participate in the recommended amount of PA. Due to their low competency in LMS concepts, teachers frequently allow children to participate in free play during outdoor or gross motor playtime, which seems to have little impact on preschoolers’ PA levels (1,31). Currently, it is unknown if LMS instruction from classroom teachers would improve preschooler’s LMS and compel them to engage in PA. Therefore, the purpose of this pilot study was to examine the effect of a classroom teacher-taught, LMS-based PA program on the LMS and PA levels of minority preschoolers.

Methods

Participants

Participants consisted of low SES Latino/Hispanic and African-American preschool-aged (2.9–5 years) children participating in the Square One early education program (Springfield, MA, North Eastern part of USA). Two preschool centers (classrooms, n = 8) participated in this pilot study. The outdoor and indoor play areas at the two preschool sites were comparable in size with similar equipment and facilitates. Within a given center, classrooms participated in gross motor playtime at different times; therefore, blocked randomization was used to randomize classrooms (group) into a treatment (LMS-based structured PA program, or LMS-PA) or control (unstructured free playtime, or UF-PA) condition after the completion of preliminary measurements. All children within a given classroom participated in the assigned intervention. However, children within each classroom were individually recruited for assessment of the outcome variables, due to the PA and LMS assessment protocol.

A total of 114 preschoolers participated in the interventions and were eligible to participate in the assessment portion of the study (LMS-PA, n = 69; UF-PA, n = 45). Of that, 78 families responded to the study advertisement and were eligible for assessment of the outcome variables (LMS-PA, n = 46; UF-PA, n = 32). In the LMS-PA group, one participant was terminated from the preschool, and two participants had malfunctioned accelerometers, for a final sample size of 43. In
the UF-PA group, one participant dropped out because the child did not want to wear the accelerometer, and three participants had malfunctioned accelerometers, for a final sample size of 28. The study was approved by a university institutional human research review board. A parent/guardian provided written informed consent to have their child assessed for the study.

**Procedure**

This pilot study was conducted from November 2010—April 2011. In Massachusetts, a regulatory policy adopted in January 2010 by the State Department of Early Education mandates that preschools provide a minimum of 60 min of daily playtime (gross motor time) for preschool-age children. Therefore as part of the usual preschool day, all classrooms that participated in this study received 60 min of playtime (30 min in the morning and afternoon). Both the LMS-PA and the UF-PA interventions were delivered for 30 min/day, five days/week for six months during morning gross motor playtime. Teachers were encouraged to participate in morning playtime at approximately the same time for the 6-month study period. All classroom teachers participated in training sessions based on their group assignment. The training of the LMS-PA teachers (8 hr) was led by a trained PE specialist and consisted of learning the proper execution of LMS and LMS-PA curriculum. The training for the UF-PA teachers (2 hr) focused on the importance of allowing students to play freely during the allocated intervention time and was led by the study PI. Teachers’ knowledge of LMS and preschool PA guidelines was assessed via a questionnaire before and after the training session, and six-month after the initiations of the intervention.

The LMS-PA curriculum was designed to meet the Early Childhood Program Standards and Guidelines for Preschool Learning Experiences, based on the Massachusetts Comprehensive Health Curriculum Framework. Specifically, the curriculum focused on the Health Education Standards, including Physical Development, which involves movement and dance. Instructions and activities were designed to teach LMS and movement concepts. The curriculum was designed to be taught by classroom teachers within their classroom environment or outdoor play space. Teachers were encouraged to implement the intervention in the outside playground area. However, on days when the weather did not permit outdoor play, the intervention lesson plans were delivered in the classroom environment.

The LMS-PA curriculum consists of 30 individual lesson plans. The number of days needed to instruct each lesson ranged from 2 to 5 days. LMS-PA teachers were given lesson plans at two-week intervals and were asked to follow the curriculum and use the full 30-min sessions. For each lesson plan, only one LMS was implemented. Within each two-week cycle, teachers were provided a free day, when they did not have to implement the LMS lesson plan. A typical lesson plan consisted of a 3–5 min low-intensity musical activity, 20 min of activities designed to teach LMS, and 5 min of extension activities designed to reinforce LMS (i.e., Cowboy Rodeo, where students were pretending to ride horses on a farm to reinforce galloping). Teachers were encouraged to review each lesson before the first day of implementation. Each lesson plan provided teachers the following information: 1) equipment needed, 2) instructions and initial activities designed to teach LMS, and 3) additional activities to reinforce the LMS. Lesson plans were accompanied by preparation sheets, which were intended to aid teachers in preparing for lessons.
in advance. Preparation sheets provided information on: 1) teaching style to be used—team teaching (two or more teachers are needed to ensure consistent instruction) or any style teaching (teacher can employ either single or team teaching); 2) if advanced preparation of equipment(s) was required, and 3) duration (days) of each lesson plan. All equipment needed to teach and implement the LMS curriculum activities were provided to the preschool centers. LMS-PA classroom teachers were provided a calendar to indicate the dates each lesson plan was implemented.

The control (UF-PA) intervention consists of unstructured free playtime, either outdoors or within preschool classroom environment. The UF-PA intervention consists of supervised free time for the preschoolers to play on their own or with other children. Their playtime activities were not altered. Children were not given any instructions about how to play. During playtime, children had access to their usual during school equipment (i.e., climbing structures, sandbox, see-saw, slides, swinging equipment, tricycle, parachute, tunnels, and twirling equipment) that were available at their preschool. Researchers were able to observe the implementation of one LMS lesson per week. In addition, the PE specialist observed multiple lessons per week to ensure that the lesson plans were being delivered as intended.

**Instruments/Measures**

Teachers provided start and end dates for each lesson plan, daily start and stop times of each lesson plan, and attendance. Anthropometric, PA, and LMS variables were assessed at baseline and six months after the initiation of the intervention. Standing height to the nearest millimeter (direct reading stadiometer) and weight to the nearest 0.1 kg (digital scale) were assessed with children wearing light clothing, shoes removed. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters.

Children's PA levels were assessed using the Actigraph GT1M accelerometer (Actigraph, LLC, Pensacola, FL). This accelerometer has been previously validated and used in preschool-age children (1,29). The accelerometer was attached to an adjustable elastic belt and worn around participants’ waists at the center of their lower back to be unobtrusive (22). Participants were asked to wear the monitor during all waking hours for seven consecutive days (including two weekend days) and to remove it only when the monitor would get completely wet. Parents/guardians and teachers were instructed on monitor placement and asked to ensure accurate repositioning of the monitor whenever removed. The monitor was programmed to store data at 15-s epochs daily. A custom software program was used to process all data using the Sirard et al. 15-s epochs count cut off (11). The age-specific 15 s counts cut-offs for 3, 4, and 5 year olds for the different activity intensities were sedentary £301, £363, £398; light 302–614, 364–811, 399–890; moderate 615–1230, 812–1234, 891–1254; and vigorous ³1231, ³1235, ³1255, respectively (36). To assess PA patterns, the preschool day was divided into during preschool (8:30am-4:30pm), and after school/evening hours (4:31pm-10:00pm). For inclusion in the analysis at each time point, participants were required to have a minimum of nine hours/day and four weekdays of accelerometer data. Data from the 15-s counts cut-off were converted to average counts/min and the percent of time spent in the different activity intensity thresholds and used for analysis. Parents/guardians reported the amount of time their child engaged in sedentary activity (e.g., watching television, playing video games) using a self-reported survey (1,34,35).
Locomotor skills were assessed using the Test of Gross Movement Development, 2nd edition (TGMD-2; 41). TGMD-2 has been shown to provide valid and reliable assessment of LMS typically taught to children (3–10 years old; 41). TGMD-2 assesses six LMS (running, galloping, hopping, leaping, horizontal jumping, and sliding), with three-to-five observable performance criteria for each skill (Table 1). Emphasis is placed on the ability to perform the skills performance criterion in sequence, rather than the product of the performance. TGMD-2 has been used previously in preschool-aged children (6,13,21).

<table>
<thead>
<tr>
<th>Locomotor skills</th>
<th>Performance Criteria</th>
</tr>
</thead>
</table>
| Run              | 1. Arms move in opposition to legs, elbows bent  
                   2. Brief period where both feet are off the ground  
                   3. Narrow foot placement landing on heel or toe (i.e., not flat footed)  
                   4. Nonsupport leg bent approximately 90 degrees (i.e., close to buttocks) |
| Gallop           | 1. Arms bent and lifted to waist level at takeoff  
                   2. A step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot  
                   3. Brief period when both feet are off the floor  
                   4. Maintain a rhythmic pattern for four consecutive gallops |
| Hop              | 1. Nonsupport leg swings forward in pendulum fashion to produce force  
                   2. Foot of nonsupport leg remains behind body  
                   3. Arms flexed and swing forward to produce force  
                   4. Takes off and lands three consecutive times on preferred foot  
                   5. Takes off and lands three consecutive times on nonpreferred foot |
| Leap             | 1. Take off on one foot and land on the opposite foot  
                   2. A period where both feet are off the ground longer than running  
                   3. Forward reach with the arm opposite the lead foot |
| Horizontal Jump  | 1. Preparatory movement includes flexion of both knees with arms extended behind body  
                   2. Arms extend forcefully forward and upward reaching full extension above the head.  
                   3. Take off and land on both feet simultaneously  
                   4. Arms are thrust downward during landing |
| Slide            | 1. Body turned sideways so shoulders are aligned with the line on the floor  
                   2. A step sideways with lead foot followed by a slide of the trailing foot to a point next to the lead foot  
                   3. A minimum of four continuous step-slide cycles to the right  
                   4. A minimum of four continuous step-slide cycles to the left |
The LMS assessments were conducted indoors under similar conditions at both preschools. Participants were removed from class and asked to perform the LMS individually. Participants were first asked to observe a PE specialist demonstrate the skill, and then asked to perform the skill, which was video recorded. In groups of two, trained evaluators were randomly assigned participants’ videos to assess. Evaluators within each group individually assessed participants’ performance and gave a score of 1 if they performed the criteria correctly and 0 if performed incorrectly. The score for each criterion was the average given by the two evaluators. All criteria were summed to give the raw score, which was used to determine their percentile score based on age (41). All evaluators underwent training on LMS performance criteria by a PE specialist based on the TGMD-2 trainer manual. The interevaluator reliability, determined by intraclass correlation coefficient, was 0.86 for the locomotor skill test.

Statistical Analysis

Statistical comparisons of between groups’ baseline characteristics were assessed with Wilcoxon Rank Sum tests for scaled variables and Chi-Square tests for categorical variables. The effect of the intervention on PA and LMS was assessed using multivariate analysis of covariance (MANCOVA). The dependent variables for PA were percent of time spent in sedentary, light, and MVPA, while the dependent variables for LMS were the average scores for each locomotor skill (running, galloping, hopping, leaping, horizontal jumping, and sliding). MANCOVA model for PA was covariate for BMI z-score, and the LMS model was covariate for BMI z-score and age. A random effect was included to account for variations among classrooms within a given preschool and group. Statistical significance was set at alpha < .05. A series of analysis of covariance (ANCOVA) were used to further explore significant group-by-time interaction for each model. ANCOVA models for PA variables were covariate for BMI z-score, while the models for LMS were covariate for both BMI z-score and age. Bonferroni adjustment of alpha was calculated as 0.02 and 0.01 for PA and LMS, respectively. The magnitude of the intervention effect was determined using Cohen’s $d$ effect size estimates. All analyses were computed using SAS (version 9.2).

Results

Baseline variables (Table 2) did not significantly differ between preschools. Therefore, data for both preschools were combined for all analyses. The study populations consisted of African-American (39%) and Latino/Hispanic (61%) preschoolers. Sixty-five percent of the study samples were from single-family homes with an annual household income less than $39,000. There was no significant difference in any baseline characteristics between the two groups. Average baseline BMI for LMS-PA and UF-PA were 66th and 69th percentile, respectively. The baseline prevalence of overweight and obesity in the LMS-PA group was 9% and 23%, and in the UF-PA group, it was 8% and 23%, respectively. At follow-up, there was a significant increase in participants’ age ($p = .01$) in both groups (not significantly different between groups). No other significant changes were observed at six-months.
## Table 2  Baseline Demographic Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>LMS-PA (n = 43)</th>
<th>UF-PA (n = 28)</th>
<th>P</th>
<th>All (n = 71)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>4.5 ± 0.6</td>
<td>4.1 ± 0.6</td>
<td>0.19</td>
<td>4.3 ± 0.6</td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>22 (51%)</td>
<td>13 (46%)</td>
<td>0.22</td>
<td>35 (49%)</td>
</tr>
<tr>
<td>Girls</td>
<td>21 (49%)</td>
<td>15 (54%)</td>
<td></td>
<td>36 (51%)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>18.1 ± 2.9</td>
<td>21.1 ± 6.4</td>
<td>0.13</td>
<td>18.9 ± 4.1</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>107.4 ± 9.6</td>
<td>106.4 ± 2.5</td>
<td>0.81</td>
<td>107.1 ± 8.3</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>16.6 ± 2.3</td>
<td>16.9 ± 2.6</td>
<td>0.08</td>
<td>16.7 ± 2.4</td>
</tr>
<tr>
<td>Body mass index percentile</td>
<td>66.3 ± 24.1</td>
<td>69.3 ± 23.1</td>
<td>0.81</td>
<td>68.6 ± 23.4</td>
</tr>
<tr>
<td>Screen media use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly hours of television viewing</td>
<td>4.4 ± 2.4</td>
<td>4.2 ± 2.6</td>
<td>0.72</td>
<td>4.3 ± 2.5</td>
</tr>
<tr>
<td>Weekly hours of VCR/DVD Viewing</td>
<td>2.3 ± 1.8</td>
<td>1.4 ± 2.6</td>
<td>0.10</td>
<td>2.0 ± 2.2</td>
</tr>
<tr>
<td>Weekly hours of video game playing</td>
<td>0.5 ± 0.9</td>
<td>0.3 ± 0.7</td>
<td>0.31</td>
<td>0.4 ± 0.8</td>
</tr>
<tr>
<td>Race/Ethnicity, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>15 (35%)</td>
<td>13 (46%)</td>
<td>0.27</td>
<td>28 (39%)</td>
</tr>
<tr>
<td>Latino/Hispanic</td>
<td>28 (65%)</td>
<td>15 (54%)</td>
<td></td>
<td>43 (61%)</td>
</tr>
<tr>
<td>Parent/guardian marital status, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-never married</td>
<td>28 (60%)</td>
<td>14 (56%)</td>
<td>0.94</td>
<td>42 (58%)</td>
</tr>
<tr>
<td>Married</td>
<td>16 (34%)</td>
<td>9 (36%)</td>
<td></td>
<td>25 (35%)</td>
</tr>
<tr>
<td>Divorced/Separated or Widowed</td>
<td>3 (6%)</td>
<td>2 (8%)</td>
<td></td>
<td>5 (7%)</td>
</tr>
<tr>
<td>Maximum household education level, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school graduate or less</td>
<td>11 (26%)</td>
<td>9 (32%)</td>
<td>0.24</td>
<td>20 (28%)</td>
</tr>
<tr>
<td>Some college/technical school</td>
<td>22 (51%)</td>
<td>12 (43%)</td>
<td></td>
<td>34 (48%)</td>
</tr>
<tr>
<td>College graduate</td>
<td>10 (23%)</td>
<td>7 (25%)</td>
<td></td>
<td>17 (24%)</td>
</tr>
<tr>
<td>Annual total household income, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $20,000</td>
<td>21 (49%)</td>
<td>16 (57%)</td>
<td>0.89</td>
<td>37 (52%)</td>
</tr>
<tr>
<td>$20,000—$39,000</td>
<td>15 (35%)</td>
<td>9 (32%)</td>
<td></td>
<td>24 (34%)</td>
</tr>
<tr>
<td>$40,000—$59,000</td>
<td>7 (16%)</td>
<td>3 (11%)</td>
<td></td>
<td>10 (14%)</td>
</tr>
</tbody>
</table>

Unless otherwise noted, variables are presented as mean±SD. LMS-PA = locomotor skills PA group; UF-PA = unstructured free PA group.

During the 6-month intervention, all LMS-PA classrooms implemented all the lessons within the set two-week timeframe. The lessons that were observed by researchers and the PE specialist were implemented as designed. To examine changes in PA during the intervention times, we compared the same 30-min
Overall, the MANCOVA revealed no significant group-by-visit interactions for any of the PA variables during the 30-min intervention, $F(3, 14) = 2.61, p = .09$. The calculated Cohen’s $d$ for percent time spent in sedentary, light, and MVPA were 0.62, 0.28, and 0.30, respectively. Compared with the same 30 min at baseline, sedentary PA decreased in the LMS-PA group (baseline, $77.1 \pm 17.5$; post, $54.4 \pm 20.8$) but increased in the UF-PA group (baseline, $64.9 \pm 12.4$; post, $67.9 \pm 15.5$) with an adjusted mean difference of $-33.2$ (95% confidence interval (CI), $-60.91$ to $-5.47$). In addition, the LMS-PA group exhibited an increase in percent of time spent in MVPA (baseline, $9.0 \pm 9.7$; post, $10.4 \pm 9.1$); while the UF-PA group decreased their percent time spent in MVPA (baseline, $12.8 \pm 5.3$; post, $9.1 \pm 6.1$), with an adjusted mean difference of $1.12$ (95% CI, $-3.12$–$5.36$).

During-preschool and total daily PA variables are presented in Table 3. For during-preschool PA, the MANCOVA revealed a significant group-by-visit interaction for the PA variables, $F(3, 14) = 3.48, p = .04$. Post hoc analysis revealed significant group-by-visit interaction for percent time spent in sedentary activity, $F(1, 16) = 6.34, p = .02, d = 0.02$, with an adjusted mean difference of $-9.63$ (95% CI, $-17.46$ to $-1.81$). The nonsignificant changes observed for percent time spent in light activity ($d = 0.67$) and MVPA ($d = 0.15$) was in the expected directions. For total daily PA, the MANCOVA revealed a significant group-by-visit interaction for the PA variables, $F(3, 14) = 4.08, p = .03$. Post hoc analysis revealed significant group-by-visit interaction for percent time spent in sedentary activity, $F(1, 16) = 9.78, p = .01, d = 0.30$, with an adjusted mean difference of $-9.32$ (95% CI, $-15.07$ to $-3.57$). No significant group-by-visit interactions were observed for percent time spent in light activity ($d = 0.80$) or MVPA ($d = 0.50$).

Locomotor variables did not differ significantly between groups at baseline (Table 4). After adjusting for age and BMI z-score, significant group-by-visit interaction was observed for the MANCOVA model, $F(6, 46) = 2.45, p = .04$. Post hoc analysis revealed significant group-by-visit interaction for leaping, $F(1, 51) = 7.18, p = .01, d = 0.80$ with an adjusted mean difference of $1.50$ (0.41–2.58). No other significant changes were observed for the remaining LMS variables; however, the estimated effect size ranged from small (running, $d = 0.05$) to medium (hopping, $d = 0.41$).

**Discussion**

This pilot study examined the effects of a classroom teacher-taught, LMS-based PA program to improve locomotor skills and PA levels of minority preschoolers. The implementation of the program into the preschool day/curriculum proved feasible. Compared with the control group (UF-PA), LMS-PA group reduced their percent of time spent in sedentary activity and noticed improvements in LMS, particularly in leaping.

After adjusting the PA variables for BMI z-score, the only significant findings were changes in percent time spent in during school and total daily sedentary activity. The LMS-PA group significantly decreased their time spent in during school sedentary activity by approximately 20 min, while the UF-PA group increased their time by approximately 19 min. A similar significant trend was observed for time spent in total daily sedentary activity. The LMS-based program did not have a
Table 3 Physical Activity Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>LMS-PA (n = 43)</th>
<th>UF-PA (n = 28)</th>
<th>Adjusted mean difference (95% CI)</th>
<th>P value</th>
<th>Cohen's d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Post</td>
<td>Baseline</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td><strong>During Preschool PA (% Time)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sedentary PA</td>
<td>78.3 ± 4.5</td>
<td>74.6 ± 8.4</td>
<td>74.2 ± 7.1</td>
<td>77.9 ± 4.2</td>
<td>-9.6 (-17.5 to -1.8)</td>
</tr>
<tr>
<td>Light PA</td>
<td>16.0 ± 2.5</td>
<td>16.3 ± 3.0</td>
<td>17.0 ± 3.7</td>
<td>14.9 ± 3.1</td>
<td>2.9 (-1.3–7.2)</td>
</tr>
<tr>
<td>MVPA</td>
<td>5.7 ± 2.6</td>
<td>6.5 ± 4.3</td>
<td>8.7 ± 4.4</td>
<td>7.2 ± 1.9</td>
<td>3.4 (-0.7–7.6)</td>
</tr>
<tr>
<td><strong>Total Daily PA (% Time)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary PA</td>
<td>76.2 ± 5.5</td>
<td>73.7 ± 8.0</td>
<td>70.6 ± 7.0</td>
<td>74.7 ± 6.0</td>
<td>-9.3 (-15.1 to -3.6)</td>
</tr>
<tr>
<td>Light PA</td>
<td>16.7 ± 2.5</td>
<td>17.1 ± 3.1</td>
<td>17.5 ± 3.0</td>
<td>17.2 ± 3.3</td>
<td>1.4 (-1.7–4.4)</td>
</tr>
<tr>
<td>MVPA</td>
<td>7.1 ± 3.9</td>
<td>7.9 ± 3.9</td>
<td>10.7 ± 4.8</td>
<td>8.9 ± 3.0</td>
<td>2.9 (-1.1–7.0)</td>
</tr>
</tbody>
</table>

All values are Mean±SD. Values are adjusted for BMI z-score. PA = physical activity; LMS-PA = locomotor skills PA group; UF-PA = unstructured free PA group; MVPA = moderate to vigorous PA. Average accelerometer wear time for baseline and experimental week for the LMS-PA and UF-PA groups were 558.5 ± 37.2, 545.1 ± 35.7 and 542.9 ± 31.3, 545.3 ± 60.9 min/day, respectively. Adjusted mean difference = change (post—baseline) in PA variable for LMS-PA—change in PA variable for UF-PA group, adjusted for the treatment effect.

* Significant with Bonferroni adjustment (p = .02).
<table>
<thead>
<tr>
<th>Variable</th>
<th>LMS-PA (n = 43)</th>
<th>UF-PA (n = 28)</th>
<th>Adjusted mean difference (95% CI)</th>
<th>P value</th>
<th>Cohen's d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Post</td>
<td>Baseline</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>Running</td>
<td>6.5 ± 1.4</td>
<td>7.5 ± 0.8</td>
<td>6.0 ± 1.3</td>
<td>7.1 ± 1.0</td>
<td>-0.06 (-0.81–0.68)</td>
</tr>
<tr>
<td>Galloping</td>
<td>4.4 ± 1.9</td>
<td>6.3 ± 1.6</td>
<td>3.7 ± 2.2</td>
<td>5.0 ± 1.8</td>
<td>0.25 (-1.13–1.63)</td>
</tr>
<tr>
<td>Hopping</td>
<td>3.7 ± 2.5</td>
<td>6.2 ± 2.6</td>
<td>2.6 ± 2.4</td>
<td>5.9 ± 2.3</td>
<td>-0.90 (-2.05–0.25)</td>
</tr>
<tr>
<td>Leaping</td>
<td>1.7 ± 1.9</td>
<td>3.7 ± 2.0</td>
<td>1.0 ± 1.3</td>
<td>1.7 ± 2.0</td>
<td>1.50 (0.41–2.58)</td>
</tr>
<tr>
<td>Jumping</td>
<td>3.6 ± 1.6</td>
<td>5.4 ± 2.0</td>
<td>2.8 ± 2.0</td>
<td>4.4 ± 2.4</td>
<td>0.59 (-0.57–1.74)</td>
</tr>
<tr>
<td>Sliding</td>
<td>2.6 ± 2.2</td>
<td>6.4 ± 2.2</td>
<td>1.6 ± 2.1</td>
<td>4.8 ± 2.4</td>
<td>0.371 (-1.36–2.10)</td>
</tr>
<tr>
<td>Percentile</td>
<td>29.7 ± 20.6</td>
<td>52.5 ± 17.9</td>
<td>28.1 ± 20.0</td>
<td>41.7 ± 22.1</td>
<td>8.70 (-4.66–22.07)</td>
</tr>
</tbody>
</table>

All values are Mean ± SD. Values adjusted for age and BMI z-score and age. LMS-PA = locomotor skills physical activity group; UF-PA = unstructured free physical activity group. Adjusted mean difference = change (post—baseline) in PA variable for LMS-PA – change in PA variable for UF-PA group, adjusted for the treatment effect.

* Significant with Bonferroni adjustment (p = .01).
significant impact on time spent in light or MVPA either during the preschool or total day. Nonetheless, the estimated effect size indicated that LMS-based PA intervention had small (MVPA; LMS-PA, 6 min; UF-A, -4 min; $d = 0.15$) to medium (light activity; LMS-PA, 2 minutes; UF-PA, -4 min; $d = 0.67$) effect on during-preschool PA variables. Similar trends were observed for the effect of the intervention on total daily PA variables. For example, although time spent in during-preschool MVPA increased by only 5 min, the estimated effect size indicates that the LMS intervention had a medium effect ($d = 0.50$) on time spent in MVPA.

Compared with baseline, LMS-PA significantly decreased percent time spent in sedentary activity. This reduction could be attributed to the reduction in sedentary activity during the intervention ($d = 0.62$). Researchers report an independent association between sedentary activity and disease risk (e.g., obesity), psychological distress, and reduced cognitive performance (8,20). A small increase in time spent in MVPA during the preschool day was also observed in the LMS-PA group. Greater opportunities to participate in the PA program could have resulted in the observed improvement in locomotor proficiency. Researchers have hypothesized that in young children, increased PA could provide opportunities to promote neuromotor development, which in turn promotes locomotor proficiency (10,37).

At baseline, the study participants were only at the 29th percentile for locomotor skills. Low-income Latino and African-American children from urban areas have been reported to have developmental delays in locomotor skills, which may account for some disparities in PA between minority and Caucasian children (13,16,18,37). It is a commonly held belief that young children acquire locomotor proficiency naturally. However, growing evidence indicates that children do not achieve proficiency without instruction and/or practice (13,16,17). Without instruction, it is possible they may not attain locomotor competence through adolescence. Overall, the classroom teacher-taught, LMS-based PA program led to significant improvements in leaping skills. While no other significant changes were observed, it is key to point out that we observed small to medium effects size for the LMS variables of interest. In addition, we observed a medium effect size for the effect of the intervention on LMS percentile.

Cross-sectional evidence correlates LMS proficiency during preschool with PA participation (6,10,21,43). For example, Fisher et al. found a significant association between habitual PA and LMS in 394 preschoolers (10). Similarly, William et al. report that preschoolers with better-developed LMS spent significantly more time in both MVPA and VPA, and less time in sedentary activity compared with preschoolers with less-developed locomotor skills (43). Other researchers have hypothesized that LMS competency in childhood predicts self-reported PA in adolescence (3,24). Improvements in LMS proficiency in preschool could lead to improvements in skills through adolescence. In addition, improvements in LMS could lead to improvements in PA self-esteem, making participation in PA more likely during childhood and adolescence (23). Strong evidence shows that PA gradually decreases during adolescence, especially in minority children (19).

Only a few randomized control studies have examined interventions designed to improve children’s LMS (5,32). For example, Cliff et al. reported that a 6-month PA intervention could lead to significant improvements in movement skill proficiency of obese elementary school-age children (5). However, the majority of remaining studies have examined either the influence of special physical education programs...
in elementary school-age children (2,42) or the ability of interventions to improve movement skills in children with disabilities or movement impairment conditions (7,39,42). Currently, only two studies address preschool-aged children. In one study in preschool-aged children with developmental coordination disorders, Sugden et al. report that a 40-week LMS program resulted in significant improvements in motor skills (39). Only one study to date has explored interventions to improve the LMS of preschool-aged children without coordination disorders. Reilly et al. examined the impact of an enhanced PA program in 36 nursery schools (Glasgow, Scotland) plus a home-based health education program on preschoolers’ LMS and PA levels (31). The nursery intervention, designed to increase children’s PA and improve LMS, was delivered by nursery staff for three 30-min sessions per week for 24 weeks. Similar to the current study, Reilly et al. observed improvements in the total LMS score in children in the intervention school. However, unlike the current study where we observed significant improvements in PA levels, Reilly et al. did not observe any significant changes in PA levels (31). The observed difference in PA levels can be attributed to differences in PA assessment (i.e., accelerometer epoch) and data reduction procedure (intensity cut-point) between the two studies. For example, Reilly et al. used one-minute epochs for accelerometer data storage, whereas the present investigation used 15-s epochs. Previous studies have reported that due to the intermittent nature of preschoolers’ PA, the utilization of one-minute epochs could potentially reduce the observable bouts of MVPA (27,29). In addition, although total LMS score increased in the study by Reilly et al. due to the assessment protocol (which provided a composite score in performance for jumping, balance, skipping, and ball exercise), we are unable to determine which locomotor skills were impacted by the intervention. In the current study, LMS was assessed using TGDM-2, which provides an assessment of each locomotor skill. Therefore, we can determine which observable performance criterion for each locomotor skill was or was not impacted by the LMS-PA intervention.

Project PLAY has several strengths. The curriculum was taught by teachers, thereby significantly reducing the cost associated with implementing the intervention. Ease-of-implementation in small spaces greatly enhances its use in preschools with limited space. Children’s PA levels were measured objectively using accelerometers. A process-oriented test assessed locomotor skills, which allowed for the assessment of individual observable components that make up each skill. Finally, the study participants were low-income minority preschoolers. Research suggests that low-income Latino and African-American preschoolers from urban environments tend to have developmental delays in locomotor skills (37).

Project PLAY also has limitations. While accelerometers provide an objective measure of PA, accelerometers also have some limitations. For example, uniaxial accelerometers positioned at the waist cannot capture upper body activities or activities that occur predominantly in the horizontal plane with minimal vertical acceleration such as throwing. It is therefore; possible that time spent in MVPA could have been underestimated. Although 114 preschoolers participated in this pilot study, not all families consented to participate in assessment. Families had to be individually recruited to give consent, due to the accelerometer assessment protocol (days and time of wear time). While most parents/guardians were willing to have their children participate in the in-class PA interventions, many were not interested in having their child assessed/observed. In addition, it is possible that
even though the classroom teachers were trained in the LMS curriculum, not all the teachers were able to implement the curriculum to the same fidelity. Although researchers and the PE specialist were able to observe some of the lesson each week, not all lesson plans were observed due to the duration of each lesson plan. It is therefore, possible that the lessons that were not observed were not delivered to the set requirements of the study. Regardless of this limitation the utilization of classroom teachers, to implement the intervention is a strength because it minimizes the cost of implementing such an intervention in preschool centers with few resources.

Conclusion

Despite efforts to prevent the alarming decline of PA in children, few studies have demonstrated an intervention that successfully increases PA in preschoolers. Project PLAY is an innovative pilot study to increase PA in minority preschoolers through the improvement of LMS. Locomotor skills have been hypothesized to be important in the development of PA, and the attainment of these skills allows preschoolers to develop and sustain healthy levels of PA throughout adolescence. Preschool teachers are responsible for teaching these skills and ensuring that preschoolers participate in the recommended daily PA. Due to their low competency in LMS concepts, teachers frequently allow free play during playtime, which has minimal impact on preschoolers’ PA levels. The study results suggest that an LMS-based PA program implemented by classroom teachers could potentially improve LMS (particularly leaping) and reduce percent time spent in sedentary activity. Future longitudinal studies will be needed to determine the impact of locomotor skill proficiency during preschool on future PA levels.

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References


