Estimating Physical Activity From Incomplete Accelerometer Data in Field Studies

Sofiya Alhassan, John R. Sirard, Tirzah R. Spencer, Ann Varady, and Thomas N. Robinson

Background: The purpose of this study was to develop a data-driven approach for analyzing incomplete accelerometer data from field-base studies. Methods: Multiple days of accelerometer data from the Stanford Girls health Enrichment Multi-site Studies (N = 294 African American girls) were summed across each minute of each day to produce a composite weekday and weekend day. Composite method estimates of physical activity were compared with those derived from methods typically described in the literature (comparison methods). Results: The composite method retained 99.7% and 100% of participants in weekday and weekend-day analysis, respectively, versus 84.7% to 94.2% and 28.6% to 99.0% for the comparison methods. Average wearing times for the composite method for weekday and weekend day were 99.6% and 98.6%, respectively, 91.7% to 93.9% and 82.3% to 95.4% for the comparison methods. Composite-method physical activity estimates were similar to comparison-methods estimates. Conclusion: The composite method used more available accelerometer data than standard approaches, reducing the need to exclude periods within a day, entire days, and participants from analysis.

Keywords: ActiGraph, data reduction, African American, girls

Data from the National Longitudinal Study of Adolescent Health indicate that approximately 49% of adolescent African American girls reported 2 or fewer instances of vigorous physical activity compared with 37% for their Caucasian counterparts. Accurate quantification of physical activity is necessary to validly document prevalence, compare groups, assess the associations of physical activity with obesity, assess changes in physical activity, and test interventions to increase

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physical activity. Physical activity is often assessed with subjective, self-report measures or more objective measures such as doubly labeled water, heart-rate monitoring, and accelerometry.\textsuperscript{2-4} Large-scale prospective studies have relied heavily on self-reports to quantify physical activity because of their low cost and ease of use. The use of self-reports, however, does not provide an objective measure of physical activity because self-reports rely on children’s and adolescents’ ability to report and recall their past physical activity.\textsuperscript{5,6} Because of the inherent problems of self-reported physical activity in children and adolescents, more researchers are using accelerometers to provide an objective means for quantifying physical activity.\textsuperscript{5,6}

One of the most common accelerometers used for research is the ActiGraph accelerometer (Manufacturing Technologies Inc Health Services, Ft Walton Beach, FL, previously known as the Computer Science Application accelerometer). Because of the need for valid assessment of physical activity, accelerometers are now being employed in large-scale field studies.\textsuperscript{7,8} Researchers using accelerometers in field-based studies are, however, still faced with significant methodological challenges in processing and analyzing accelerometer data. In these large-scale field studies, investigators generally have less control over whether participants fully follow protocols for wearing the accelerometer. In particular, participants might not complete the required number of hours or days for wearing the accelerometer. Excluding study participants with incomplete data or using partial data can potentially produce biased estimates of physical activity and reduce statistical power, altering results and conclusions. To try to address these issues, we developed a data-driven approach for reducing and analyzing accelerometer data that uses all available data and used this procedure to characterize the physical activity patterns of a sample of African American preadolescent girls.

\section*{Methods}

\subsection*{Participants}

This study used baseline data from the Stanford Girls health Enrichment Multi-site Studies (GEMS) trial, a randomized, controlled, weight-gain-prevention trial among lower-socioeconomic-status, African American, preadolescent girls. Girls were recruited from low-income areas of Oakland, CA. Participants were required to be 8 to 10 years of age and have a body mass index (BMI) \(\geq\) 50th percentile for their age\textsuperscript{9} and/or at least 1 parent or guardian with a BMI \(\geq\) 25 kg/m\textsuperscript{2}. Girls were excluded from the study if they were taking medications or had a medical condition affecting their growth, if they had a condition limiting their participation in the interventions, if they were unable to understand or complete informed consent, or if they planned to move from the San Francisco Bay area within the next 24 months. A parent or guardian provided written informed consent, and girls gave assent to participate in the study. The study was approved by the Stanford University Panel on the Protection of Human Subjects in Medical Research and received oversight from an independent Data and Safety Monitoring Board formed by the National Heart, Lung, and Blood Institute.
Measures

BMI. Body weight was measured using a calibrated electronic scale (Scaletronix Model 5602, White Plains, NY), and height was measured using a portable stadiometer (Shorr Height Measuring Board, Olney, MD) with participants in light clothing without shoes. BMI was calculated as the weight in kilograms divided by the square of the height in meters.

Physical Activity Monitoring. Participants’ physical activity levels were monitored using an ActiGraph. A number of laboratory and field studies have been conducted in the calibration and validation of the ActiGraph.\textsuperscript{10-13} In general, these studies report that the ActiGraph can provide an objective measure for quantifying physical activity in children and adolescents. The ActiGraph accelerometer is a single-axis accelerometer designed to measure and record vertical accelerations ranging in magnitude from 0.05 to 2.00 $g$ with a frequency response from 0.25 to 2.5 Hz.\textsuperscript{14,15} Within these set parameters, the ActiGraph is capable of detecting normal human motion and rejecting motions associated with high-frequency vibrations. Accelerations were measured in 1-minute epochs in this study.

The ActiGraph was attached to a belt and worn around the participant’s waist over the right hip. The protocol called for monitoring of 4 days including 1 weekend day. To account for starting on different days of the week, participants were asked to wear the accelerometer for a total of 4 to 8 days. Participants were instructed to wear the accelerometer at all times, including during sleep, and to remove them only when showering, bathing, swimming, or when monitors would get completely wet. Participants were given an activity log to record times and reasons when monitors were removed. After the scheduled number of monitoring days, participants were asked to return the accelerometer to the study facility by prescheduled overnight delivery.

Accelerometer-Data Cleanup

Minute-by-minute accelerometer data were first reviewed visually to determine whether (1) the number of days with accelerometer data appeared sufficient and matched study protocol; (2) sleep and awake times were logical (ie, periods of high and low counts matched normal sleep and awake times; if not, the participant’s parent or guardian was contacted for verification); (3) if there were error codes indicating a monitor malfunction (ie, counts/min values of 32,767, which has been reported to represent a voltage signal saturation within the ActiGraph\textsuperscript{16}); and (4) if there were any counts/min values $\geq 15,000$, which were flagged and the participant’s parent or guardian was contacted to verify if the participant was involved in any activity that might have resulted in such a high counts/min value. Counts/min $\geq 15,000$ were included in the analysis if it was verified with parents or guardians that the participant was involved in an activity that would potentially result in such high counts/min values, otherwise counts/min values $\geq 15,000$ were changed to missing data.

Other researchers have also flagged counts/min values $\geq 15,000$ as being biologically implausible.\textsuperscript{16} Data points with error codes and 1 minute on either side of those values were changed to missing data. Any data recorded by the monitor before the first time the monitor was put on the participant by a staff data collector
(recorded by data collector) and after the final time the monitor was taken off the participant and returned (recorded by parent or guardian) were excluded. It has been our experience that children’s self-report logs frequently contradict their recorded accelerometer data. To overcome potential errors with children self-reporting dates and times when the monitor was worn and removed in their activity log, we developed an algorithm to systematically determine when the monitors were being worn. Data were scanned to find periods of at least 20 consecutive minutes during which the ActiGraph measured only zeros, and these were considered periods when the monitor was not being worn and were changed to missing data. If there was a minute of nonzero data flanked by 2 periods of ≥20 consecutive zeros, the nonzero data point was also considered part of the nonworn period and set to missing. This latter step was intended to exclude occasional periods in which the recorded movement was likely caused by vibrations or incidental jostling. The 20-minute interval was determined based on our own pilot studies of the maximum number of consecutive zeros associated with inactivity (unpublished data). Other researchers have also reported that 20 minutes or more of consecutive zeros is biologically implausible and should be eliminated from further analysis. After the above procedures were completed, all remaining data were classified as acceptable data.

**Accelerometer-Data Reduction**

A schematic of the accelerometer data–reduction steps (composite method) is presented in Figure 1. Our goal was to produce the most valid estimates of overall physical activity over the monitored period by using all available data. Some current data reduction strategies eliminate participants or days with incomplete data. Excluding participants, large periods of time within a day, or an entire day might threaten the validity of the measure, potentially introducing bias or introducing random error and thereby reducing power to detect group differences or changes and estimate accurate effect sizes. Our main intention for the composite method, therefore, was to keep as many data and as many participants as possible to produce the most valid estimates of physical activity during the study period. Second, because we were interested in overall physical activity level, using a composite of weekday and weekend-day data would provide a better picture of participants overall physical activity than looking at each day individually. We examined the correlation (Spearman) for average counts between minutes within days and between days. For minutes within a day, the average correlation of average counts was .14. When the minutes were matched between days, however, the correlation for average counts for a given minute was .00005.

For the composite method, data were first separated into weekdays and weekend days. For all accelerometer-data-reduction procedures, weekdays and weekend days were treated separately because they are qualitatively and quantitatively different. Next, within the weekday/weekend-day data, participants’ accelerometer data were averaged across days. To average the data, the total counts for each minute of the day were calculated by averaging the counts/min for each day with data for that minute. For each participant, this procedure created a composite estimate for each minute of the day for which, at least 1 day of data was available. Participants’ (n = 294) composite day had on average 23.01 hours and 20.55 hours of data for
weekday and weekend day, respectively. The study protocol asked participants to wear the accelerometer during all times, including during sleep, and this resulted in data being available for a very high proportion of the composite day.

**Defining a Day.** Instead of choosing an *a priori* definition of a day, we used the composite data to define what constituted a full weekday and weekend day in this sample. A frequency distribution was performed on each minute between midnight (12:00 AM) and 11:59 PM to determine the percentage of participants with ActiGraph data for each minute of the day. From the frequency distribution, the start and end times for a day were defined by the approximate times when no more than 5% of participants were missing data. Based on the frequency distribution, ≥95% of the participants had data from 6:00 AM until 10:00 PM.
for a weekday (n = 293) and from 10:00 AM until 10:00 PM for a weekend day (n = 294).

**Determining the Minimum Number of Minutes Needed to Represent a Day.**

Because some participants have no data for part of the day, it is necessary to determine the minimum number of minutes of data that can be used to estimate an entire day of physical activity. To do this, the average counts/min of randomly selected 30, 60, 90, 120, up to 960 minutes for weekday, and 720 minutes for weekend day were correlated with the average counts/min for the entire day (previously defined as 6:00 AM to 10:00 PM for weekday and 10:00 AM to 10:00 PM for weekend). Blocks of 30-minute time intervals were used because for all participants with complete data (100% of minutes present), a minimum threshold of 30 minutes of data (average counts/min) was needed to estimate each hour of both weekday and weekend day at a correlation of .8 or greater for all hours. A Spearman correlation of .8 was obtained at approximately 570 minutes (9.75 hours) for weekday (Figure 2) and 330 minutes (5.5 hours) for weekend days (Figure 3). The resulting criteria of at least 9.75 hours of weekday data and 5.5 hours of weekend-day data from a participant’s composite data were used to include participants in calculating

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**Figure 2** — Weekday number of minutes needed to correlate to a complete day (average counts/d).
our specific sample-driven estimates of physical activity to compare with results of other more typical methods.

Currently, in field-based accelerometer studies there are no uniform criteria to decide which participants to include or not to include in analyses; we, therefore, applied 6 different sets of inclusion criteria representing greater and lesser thresholds for minutes per day and days of data available to define samples for use in analyses. The different inclusion criteria chosen were based on what are frequently used in the literature, when participants were instructed to wear the ActiGraph accelerometer for approximately 3 to 4 days. The 6 different inclusion criteria (comparison methods) are listed in the first 2 rows of Tables 1 and 2.

**Defining Average Number of Minutes Spent at Intensity Activities Levels.** In addition to estimating average daily physical activity levels such as average counts/min, it is often desirable to estimate the average number of minutes during a day or segment of a day that are spent at different activity intensity levels (eg, to compare with recommendations for daily moderate-to-vigorous physical activity). We started with the same sample of participants with sufficient weekday (n = 293) and
weekend-day (n = 294) data to estimate average daily physical activity, as determined previously. Before summing the data across days as described previously, we classified each minute according to the counts/min intensity thresholds for adolescent girls determined by Trueth et al\(^1\): very light (<100), light (101–2999), moderate (3000–5200), vigorous (>5200). Each minute of each day was first classified as either meeting (coded as 1) or not meeting (coded as 0) the threshold. Each participant’s data were then summed, minute by minute through the day, across all weekdays, and across all weekend days, by averaging the 1s and 0s for each minute with data. For example, if a participant had data for the minute from 1:00:00 PM to 1:00:59 PM that exceeded a threshold on 2 of 3 days of monitoring, that minute would be counted as 0.667 or 66.7% above that threshold. This procedure results in an average number of min/d above or below a defined intensity threshold, without having to ignore data from partial days of monitoring. Average minutes in each intensity interval were calculated separately. The average minutes spent at the different activity intensity levels were also compared to those calculated using the 6 comparison methods representing standard methods found in the existing literature. In these more standard methods, the number of minutes at the counts/min intensity thresholds were summed across days then divided by the number of acceptable days of monitoring.

**Statistical Analyses**

We calculated sample means and standard deviations for the following variables for our procedure (composite method) and 6 different inclusion criteria derived from the existing literature (the comparison methods): number of participants with valid data (N), average accelerometer wearing time, average counts/min, and the average min/d spent at the different activity intensity levels (very light, light, moderate, and vigorous). Statistical testing of differences between composite and each comparison method was completed with paired \(t\) tests using those participants included in both samples. Correlational validity was then assessed by Spearman correlation between derived physical activity estimates and BMI. Statistical analyses were performed using SAS version 9.1 (SAS Institutes Inc, Cary, NC). Bonferroni adjustment \(\alpha\) level of .002 (.05/30) for weekday and .003 (.05/18) for weekend day were used to correct for the multiple testing.

**Results**

Mean age of the participants used in this analysis was 9.4 ± 0.9 (years). Participants’ mean weight (kg), height (cm), and BMI (kg/m\(^2\)) were 42.1 ± 14.9, 139.8 ± 9.1, and 21.2 ± 5.7, respectively. Of the 294 possible participants, our composite method retained 293 (99.7%) participants for weekday analysis and all 294 (100%) participants for weekend-day analysis. Comparison methods 1, 2, 3, and 4 retained 249 (84.7%), 255 (86.7%), 274 (93.2%), and 277 (94.2%), respectively (Table 1). Comparison methods 5 and 6 for weekend days retained 84 (28.6%) and 291 (99.0%) participants in the analyses (Table 2).

Average weekday and weekend-day wearing time for the present cohort was 956 and 710 minutes, respectively. The average wearing time for the composite method was 955.9 ± 14.5 min/d (99.5%) for weekday (Table 1) and 709.7 ± 31.6 min/d
<table>
<thead>
<tr>
<th>Variable</th>
<th>Composite method</th>
<th>Comparison method 1</th>
<th>Comparison method 2</th>
<th>Comparison method 3</th>
<th>Comparison method 4</th>
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<td>Inclusion criteria</td>
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<td>minimum number of days of monitoring required</td>
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<td>600 (10 h)</td>
<td>300 (5 h)</td>
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<td>293</td>
<td>249</td>
<td>274</td>
<td>255</td>
<td>277</td>
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<tr>
<td>average wearing time (min/d)</td>
<td>955.9 ± 14.5</td>
<td>901.9 ± 44.7(^a)</td>
<td>886.0 ± 67.8(^a)</td>
<td>898.6 ± 54.9(^a)</td>
<td>880.3 ± 83.8(^a)</td>
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<td>average counts/min</td>
<td>611 ± 175</td>
<td>623 ± 174</td>
<td>624 ± 182</td>
<td>615 ± 173</td>
<td>616 ± 181</td>
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<td>very light intensity (min/d)</td>
<td>403.7 ± 74.7</td>
<td>366.0 ± 71.8(^a)</td>
<td>361.2 ± 73.8(^a)</td>
<td>369.2 ± 76.8(^a)</td>
<td>362.1 ± 77.5(^a)</td>
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<tr>
<td>light intensity (min/d)</td>
<td>516.8 ± 67.8</td>
<td>501.5 ± 65.2(^a)</td>
<td>491.2 ± 67.2(^a)</td>
<td>499.6 ± 65.0(^a)</td>
<td>485.7 ± 71.0(^a)</td>
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<td>moderate intensity (min/d)</td>
<td>26.9 ± 14.4</td>
<td>26.2 ± 13.9</td>
<td>25.7 ± 14.2</td>
<td>25.9 ± 14.2</td>
<td>25.4 ± 14.3</td>
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<tr>
<td>vigorous intensity (min/d)</td>
<td>8.6 ± 8.6</td>
<td>7.8 ± 7.2</td>
<td>7.8 ± 7.5</td>
<td>7.3 ± 6.5</td>
<td>7.3 ± 7.0</td>
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</tbody>
</table>

\(^a\) Statistically significantly different (P < .002) compared with composite method by paired t test using those participants represented in both samples.
Physical Activity Accelerometer Data

Table 2  Weekend-Day Physical Activity Variables, Mean ± SD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Composite method</th>
<th>Comparison method 5</th>
<th>Comparison method 6</th>
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<tr>
<td>Inclusion criteria</td>
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<tr>
<td>minimum number of days of</td>
<td>—</td>
<td>1</td>
<td>1</td>
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<tr>
<td>monitoring required</td>
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</tr>
<tr>
<td>minimum number of min (h)/d</td>
<td>300 (5 h)</td>
<td>600 (10 h)</td>
<td>300 (5 h)</td>
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<tr>
<td>of monitoring required</td>
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<td>Results</td>
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<tr>
<td>N</td>
<td>294</td>
<td>84</td>
<td>291</td>
</tr>
<tr>
<td>average wearing time (min/d)</td>
<td>709.7 ± 31.6</td>
<td>687.0 ± 35.1*</td>
<td>592.4 ± 75.3*</td>
</tr>
<tr>
<td>average counts/min</td>
<td>692 ± 281</td>
<td>745 ± 300</td>
<td>745 ± 416</td>
</tr>
<tr>
<td>very light intensity (min/d)</td>
<td>251.9 ± 70.7</td>
<td>225.0 ± 83.9</td>
<td>205.2 ± 73.7</td>
</tr>
<tr>
<td>light intensity (min/d)</td>
<td>430.9 ± 62.8</td>
<td>431.9 ± 72.6</td>
<td>361.4 ± 64.7</td>
</tr>
<tr>
<td>moderate intensity (min/d)</td>
<td>20.4 ± 14.4</td>
<td>24.0 ± 20.2</td>
<td>18.8 ± 15.7</td>
</tr>
<tr>
<td>vigorous intensity (min/d)</td>
<td>6.4 ± 11.3</td>
<td>6.1 ± 7.8</td>
<td>7.0 ± 16.2</td>
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</table>

* Statistically significantly different (P < .003) compared with composite method by paired t test using those participants represented in both samples.

(98.6%) for weekend day (Table 2). For the different weekday comparison methods, average wearing time ranged from 880.3 ± 83.8 min/d (91.7%) for comparison method 4 to 901.9 ± 44.7 min/d (93.9%) for comparison method 1. Average wearing time was significantly higher in the composite method than in all weekday and weekend-day comparison methods (P < .001). Average counts/min and average minutes spent in the different intensity thresholds are reported for all methods for weekday and weekend days in Table 1 and 2, respectively. Average wearing time, time spent in very-light- and light-intensity activities were the only statistically significant differences between the composite and comparison methods.

To provide an assessment of the correlational validity of our composite method, we assessed the associations between individual average counts/min estimates produced by the composite method and comparison methods and BMI in this sample. The Spearman correlation between average weekday and weekend counts/min and BMI was −.23 and −.19, respectively, for our composite method versus −.14, −.16, −.13, −.13 for weekday comparison methods 1 through 4, respectively, and −.01 and −.15 for weekend-day comparison methods 5 and 6, respectively. These differences were statistically significant (P < .001).

Discussion

The primary objective for this study was to develop and test a data-driven, sample-specific approach for analyzing accelerometer data in field studies that uses all available accelerometer data to provide estimates of physical activity. It is common to have incomplete accelerometer data in field studies to estimate individual or group physical activity. Incomplete data might be missing at random or systematically. Randomly missing data might increase variability of estimates and reduce statistical power, and systemically missing data might produce biased estimates.20
Our review of patterns of daily accelerometer counts in our sample showed wide variations in counts/min over the course of the day within individuals and between individuals. If ignored, missing accelerometer data either during the day or across days is, therefore, likely to produce biased physical activity estimates. We conceptualized a data-driven approach (composite method) that would allow us to use all available data from a participant to result in the least amount of missing data and, therefore, more accurately estimate participants’ typical physical activity levels and patterns. We demonstrated our new method using data from 1 study, but the proposed method can be applied to any other accelerometer data set.

By summing each participant’s data into a composite weekday and weekend day, we were able to retain 99.7% to 100% of the total sample of participants in our study for analysis, whereas the more standard inclusion criteria derived from those typically used in the published literature resulted in excluding more participants from analysis. Average wearing time for each participant was also greater with the composite method. As would be expected, the comparison methods that required more days and/or more hours per day of monitoring retain the least amount of participants for analysis. These different standard methods had a trade-off between including more participants with more missing data versus including fewer participants with more complete data. In contrast, the composite method uses all available data, thus not requiring a trade-off between participants included and missing data. Differences in the number of participants included and the amount of individual missing data also resulted in different estimates of time spent in very-light- and light-intensity activity. For intensities above light activity, physical activity estimates calculated using the composite method were similar to those calculated using the comparison methods. Regardless of the method used to estimate physical activity, participants in this study spent a great portion of their average day in very-light- to light-intensity activities.

Producing valid sample estimates of physical activity is important for assessing sample changes over time and the effects of an intervention. Random error in individual estimates might, however, still result in valid sample estimates but invalid estimates at the individual level. This can result in attenuated or spurious relationships or nonrelationships between individual physical activity behavior and other factors, such as health-related physiological measures, misleading clinical and policy decision making. Our composite method estimates of individual physical activity demonstrated evidence for greater correlational validity with BMI than the traditional comparison methods. Though many factors other than concurrently measured physical activity contribute to BMI, a demonstrated relationship between individual-level physical activity estimates and BMI provide additional evidence for the validity of the composite method.

Currently, not all studies provide an in-depth description of their decision-making steps regarding accelerometer-data reduction. For example, in a recent review by Masse et al., it was reported that although a relatively high percent (96.6%) of researchers reported the number of days participants were asked to wear the accelerometer, only 45.3% reported the minimum number of days needed for analyses, and only 32.8% reported their criteria for determining the minimum number of h/d needed for analyses. In the studies that do report these decision-making processes, minimum h/d (1 to 15.6 hours) and minimum days (1 to 7 days) required for analysis ranged considerably. Most accelerometer data are used to
provide summary estimates such as average counts/min of physical activity and average amount of time spent at different physical activity–intensity thresholds. Our results demonstrate that decision-making rules such as minimum h/d or minimum number of days required for inclusion in analyses can influence physical activity estimates such as average wearing time and time spent in very-light- and light-intensity activities.

One of the biggest issues facing the area of accelerometer field research is how to deal with missing data caused by variable participant compliance. Currently, to deal with missing data, some researchers rely on complicated imputation techniques that assume that the missing data are missing at random. The mechanism behind these missing data and the proportion of missing data are major limitations when dealing with reducing accelerometer data because they could affect average counts/min and average time spent at different intensity levels. Other researchers have dealt with missing data by ad hoc decision making such as eliminating large periods of time within a day, entire days, or eliminating participants. The ad hoc method of dealing with missing data leads to potential bias in the days or participants eliminated or kept and potentially threaten the reliability and validity of the results. By using our method to sum each participant’s data into a composite day, it was assumed that the best estimate of a participant’s missing activity measure for any given minute of the day is that same participant’s activity measured during that same minute on other days. Because we are using a participant’s own existing data to essentially impute their own missing data, we believe this assumption is the simplest and most defensible possible, more so than the assumptions behind excluding data or modeling using other participants’ data. Our composite method also defines a data-driven, sample-specific length of day, which is a better strategy for maximizing internal validity.

Our composite method has a number of strengths, but some of our results might have been influenced by our specific study sample and protocols. Participants were asked to wear the monitor for only 4 days, which included 1 weekend day. Participants who did not have any data for at least 1 weekday and 1 weekend day were asked to wear the accelerometer again, and therefore nearly all of the study participants had at least some data for at least 1 weekday and 1 weekend day. This might not be standard practice for all field studies. Participants’ accelerometer counts were measured in 1-minute epochs; this could have potentially masked some short bursts of activities and reduced the estimated minutes spent in moderate and vigorous activity. The most appropriate epoch length for different populations and different contexts is in need of additional study. The participants involved in this study were a sample of low-income, preadolescent, African American girls in a single city, and it is unknown whether these results would be similar for other groups. In addition, participants’ physical activity was assessed with ActiGraph accelerometers; it is unknown whether similar results would be achieved with other types of accelerometers. The general data-reduction approach could, however, be similarly used and tested across all accelerometers that provide a count value for a given unit of time.

In conclusion, because of the popularity and easy of use of accelerometers, more studies are using them to measure physical activity in field studies. Some researchers have advocated for standardized methods; however, not all standardized methods can be applied to every population. We propose a novel, simplified, composite method for maximizing the number of participants and amount of collected
data that are included in analysis. The composite method uses more available data than standard approaches and thereby reduces the need to eliminate large periods within a day, entire days, or participants from the analysis. The results also demonstrate correlational validity with BMI.

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