Pedometer-Determined Step-Count Guidelines for Afterschool Programs

Michael W. Beets, Aaron Beighle, Matteo Bottai, Laura Rooney, and Fallon Tilley

Background: Policies to require afterschool programs (ASPs, 3 PM to 6 PM) to provide children a minimum of 30 minutes of moderate-to-vigorous physical activity (MVPA) exist. With few low-cost, easy-to-use measures of MVPA available to the general public, ASP providers are limited in their ability to track progress toward achieving this policy-goal. Pedometers may fill this gap, yet there are no step-count guidelines for ASPs linked to 30 minutes of MVPA. Methods: Steps and accelerometer estimates of MVPA were collected concurrently over multiple days on 245 children (8.2 years, 48% boys, BMI-percentile 68.2) attending 3 community-based ASPs. Random intercept logit models and receiver operating characteristic (ROC) analyses were used to identify a threshold of steps that corresponded with attaining 30 minutes of MVPA. Results: Children accumulated an average of 2876 steps (standard error [SE] 79) and 16.1 minutes (SE0.5) of MVPA over 111 minutes (SE1.3) during the ASP. A threshold of 4600 steps provided high specificity (0.967) and adequate sensitivity (0.646) for discriminating children who achieved the 30 minutes of MVPA; 93% of the children were correctly classified. The total area under the curve was 0.919. Children accumulating 4600 steps were 25times more likely to accumulate 30 minutes of MVPA. Conclusions: This step threshold will provide ASP leaders with an objective, low-cost, easy-to-use tool to monitor progress toward policy-related goals.

Keywords: moderate-to-vigorous, children, adolescents, benchmark

Afterschool programs (3 PM to 6 PM) are an important behavioral setting where children (5–14 years) can accumulate a sizable portion of their total daily recommended level of moderate-to-vigorous physical activity (MVPA). To ensure physical activity-related opportunities are infused within the ASP schedule, state and national level organizations in the United States have developed guidelines for the amount of physical activity children attending ASPs should accumulate while in attendance. Currently only 14 states and 1 national organization (National Afterschool Association) have developed guidelines. Yet for the majority of the states and organizations, these guidelines are voluntary. Only 1 state (California) has recently introduced legislation to require ASP to ensure children accumulate 30 minutes of MVPA daily within their ASP by the year 2013 (see http://gov.ca.gov/press-release/14519#mb).

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**Methods**

**Participants and Setting**

Participants for this study were recruited from a single community-based organization that conducted 3 large-scale (attendance across locations ranged from 80 to 150 children daily) afterschool programs serving the greater Columbia, South Carolina area that served 27 schools. Each site was staffed with a program leader and multiple part-time afterschool counselors who were responsible for supervising, planning, and implementing daily ASP activities. Counselors received 30 hours of training as part of their preemployment requirements. All counselors were required to have basic safety training (eg, CPR/First Aid). The staff to student ratio across the sites ranged from 1:10 to 1:15 depending on the number of children attending on any given day. All sites had a similar schedule of offerings that consisted of homework/academic time with counselor support/tutoring, snack and beverage, and structured (eg, staff led sports and/or games) and unstructured (ie, free-play) activities. On all days, an outdoor and/or indoor physical activity option was provided. Each site had access to both indoor and outdoor facilities that included gymnasiums, soccer fields, walking trails, and open green spaces. The programs were scheduled from 3 PM (immediately after school finishes) until 6 PM. Data were collected during the fall of 2009 and spring of 2010. All children arrived directly from school at each site via a bus at the same time. Conversely, children could leave at any time from the program as long as they were accompanied by an adult (parent and/or guardian). Approximately three-fourths of the scheduled time was dedicated to opportunities for children to be physically active.

All children attending the ASP were invited to participate in the study. The only exclusion criterion for participation was the inability to be physically active without an assistive device (eg, wheelchair, crutches). Children self-reported their race/ethnic background and provided their date of birth to determine their age in decimal (date of assessment minus date of birth). All procedures were approved by the Institutional Review Board at the University of South Carolina. Written informed consent and verbal assent were collected from the participants’ parent/guardian and each participant, respectively, before data collection.

**Pedometer and Accelerometer Data Protocol**

Physical activity was collected objectively using the ActiGraph GT1M accelerometer (Shalimar, FL) and the spring-levered Walk4Life MVPA pedometer (Walk4Life, Plainfield, IL). The accelerometer epoch was set at a 5-second interval to account for the intermittent and sporadic nature of children’s physical activity and to improve the ability to capture the transitory physical activity patterns of children. The pedometer used is similar to previous models validated for step-count accuracy with children. Upon arrival to the ASP, children were fitted with a numbered accelerometer and pedometer and the arrival time recorded (start time). After affixing the devices to the participants’ waist on the right side with an elastic belt, the children were allowed to participate in their normal ASP activities. Research staff continuously monitored the entire ASP for compliance in wearing the devices. Research staff removed the child’s elastic belt and recorded the time of departure (stop time) and the pedometer step counts before the child departed from the ASP. This procedure was performed throughout the duration of the study. Physical activity data were collected on Mondays through Thursday, with each child having the opportunity to wear the devices for a total of 4 days.

For the accelerometer, 60-second epoch cutpoint thresholds associated with sedentary, light, moderate, and vigorous were reintegrated for a 5-second epoch from a calibration study on a sample of youth of similar age to the current study. Reintegration of cutpoints has been used extensively to accommodate differing cutpoint epoch length vs. the epoch of measurement. These cutpoints have been found to provide an accurate estimate of total minutes spent in moderate-to-vigorous physical activity in relation to a criterion measure (ie, expired gases). Accelerometer data with 10 minutes of continuous zeros was used as the criteria for nonwear. Children were considered to have a valid day of accelerometer and pedometer data if their total wear time (stop time minus start time minus nonwear time) was equal to or greater than 60 minutes and pedometer step counts were at or above 500 steps.

**Anthropometric Measures**

Height (measured to the nearest 0.1 cm) and weight (measured to the nearest 0.1 lb) without shoes and heavy clothing were collected using standardized protocols. Height was measured using a portable stadiometer (Seca 214 Portable Height Rod, Hamburg Germany) and weight measured using a digital scale (Model HD314; Tanita Corporation, Tokyo, Japan). Units were converted accordingly and age-sex specific BMI percentiles computed. Children were classified according the CDC guidelines for healthy (<85th percentile), overweight (≥85th and <95th percentile), and obese (≥95th percentile).

**Statistical Analysis**

Initially, a covariate adjusted random intercept logit model was estimated with meet/exceed 30 minutes of MVPA as a binary outcome, with the inclusion of total steps and time in attendance centered at the sample average time in attendance and the covariates of boy and African American as binary predictors and the interaction between these binary covariates and steps were included. A significant interaction term (eg, boys-by-steps) in
the model would provide evidence that different step thresholds would need to be developed for the different groups. The probability of meeting the 30-minute MVPA threshold was then computed from the random effects logit model and plotted against steps. The predicted probability, in increments of .05 (range 0 to 1), were used to calculate sensitivity, specificity, the cumulative area under the curve, and the percentage of correctly classified. Sensitivity was defined as the ability of the step thresholds to correctly identify children that met the 30 minutes of MVPA. Specificity was defined as the ability of the step thresholds to correctly identify children that failed the 30 minutes of MVPA. Classification precision provided a sample estimate of those correctly classified children based on 30 minutes of MVPA and a given step threshold. Since pedometer steps provide an assessment of total physical activity and does not distinguish between light, moderate, or vigorous physical activity, the optimal threshold was determined by placing greater emphasis on specificity (step threshold that correctly corresponded with a child failing to accumulate 30 minutes of MVPA) and classification precision of a given step threshold. The area under the curve and sensitivity were also taken into consideration when arriving at the optimal threshold. After identification of an optimal steps threshold, a random effects logit model was computed to determine the odds of meeting the steps threshold with meeting the 30-minute MVPA. In addition, based on the optimal step threshold, the predictive values of both positive and negative results were calculated. Because children attended the ASP for varying lengths of time and time in attendance may influence the number of steps and minutes in MVPA accrued, we graphically depicted the relationship between time in attendance with steps and MVPA. This was performed to determine if any systematic bias was present favoring children that attended for longer durations at the ASP. All analyses were performed using STATA (v. 10, College Station, TX).

**Results**

Of the 344 children enrolled in the ASPs, 274 (80%) provided written informed consent and verbal assent to participate and wore the devices. No children were excluded based on the criteria stated previously. The descriptive characteristics of the participants are presented in Table 1. Of those measured with both devices, 245 (71.2% of total sample, 89.4% of measured sample) had at least 1 day of 60 or more minutes of valid accelerometer wear time with 1 day of at least 500 steps. The numbers of valid days the children were monitored were 1 day (14%), 2 days (21%), 3 days (35%), and 4 complete days (30%). This resulted in an average of 2.7 days for each child (range 1 to 4 days) and a total of 652 observations on 245 children. The average time girls and boys attended the ASPs was 113.0 and 108.9 minutes, respectively. Children who met the 30 minutes of MVPA guideline accumulated significantly more steps (5289 ± 2124 vs. 2609 ± 1396) and time in attendance at the ASP (127 ± 22 vs. 109 ± 29 minutes) in comparison with children who failed to achieve the 30 minutes of MVPA guideline.

The results of the covariate adjusted random intercept logit model predicting 30 minutes of MVPA from steps is presented in Figure 1. From this figure, the relationship between increased step counts to the probability of meeting or exceeding the 30 minutes of MVPA.

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**Table 1  Demographic Characteristics of Children Attending the Afterschool Programs (ASP, 3 PM to 6 PM)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Boys (n = 120)</th>
<th>Girls (n = 125)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td>Age (years)</td>
<td>8.4 ± 1.9</td>
<td>8.1 ± 1.9</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>128.8 ± 11.4</td>
<td>128.5 ± 12.4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>30.8 ± 10.2</td>
<td>32.0 ± 14.5</td>
</tr>
<tr>
<td>BMI percentile</td>
<td>67.2 ± 26.7</td>
<td>69.2 ± 26.2</td>
</tr>
<tr>
<td>African American</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>White</td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>Time in attendance at ASP (minutes)*</td>
<td>108.9 ± 28.2</td>
<td>113.0 ± 29.3</td>
</tr>
<tr>
<td>Accelerometer time (minutes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary</td>
<td>63.7 ± 25.1</td>
<td>74.7 ± 24.6</td>
</tr>
<tr>
<td>Light</td>
<td>26.8 ± 11.2</td>
<td>24.9 ± 10.4</td>
</tr>
<tr>
<td>MVPA</td>
<td>18.4 ± 11.1</td>
<td>13.3 ± 8.8</td>
</tr>
<tr>
<td>Percentage of children meeting 30 minutes MVPA (%)</td>
<td>16.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Pedometer steps</td>
<td>3252.1 ± 1921.4</td>
<td>2625.6 ± 1476.5</td>
</tr>
</tbody>
</table>

* Range of time spent at the ASP was 60 to 171 minutes for both boys and girls.
threshold is demonstrated, with clear indication that at or around 4000 steps an exponential increase in the probability occurs. No interaction terms were significant in the model and therefore excluded from all subsequent analyses. The results of the ROC analysis are illustrated in Figure 2. Based on this, the maximal correct classification (93%) was obtained at a probability threshold of 0.35, which corresponded with a step-count threshold of 4592 (95% CI 4456–4728). In addition, the specificity at this threshold was 0.976 with a sensitivity of 0.646 and the total area under the curve was .919. The positive and negative predictive values were 0.49 and 0.95, respectively. Children accumulating 4,600 steps were 26 times more likely (95% CI 10.3–65.4) to meet the 30 minutes of MVPA. Thus, based on these analyses, the accumulation of 4600 steps during an ASP (60–171 minutes) corresponded with accumulating 30 minutes or more of MVPA. Figure 3 depicts the relationship between steps and minutes of MVPA, separately, to total time in attendance. It is clear from this graph that time in attendance was unrelated to the amount of steps accrued or minutes spent in MVPA.

Conclusions

This study provides an initial attempt at developing pedometer-determine guidelines for ASPs. These guidelines can assist practitioners in evaluating the physical activity levels of children attending their ASPs. Importantly, for frontline practitioners, where accountability for policies is high, such guidelines developed using an easy-to-use, relatively inexpensive, low-tech device can provide real-time feedback on advancement toward policy-relevant goals. Programs wishing to evaluate their progress toward the 30 minute guideline by using this step recommendation should do so by using data only from children who attend the program for greater than 60 minutes each day. Conversely, children attending the
Figure 2 — Probability of meeting or exceeding 30 minutes of MVPA and its relation to sensitivity, specificity, and percent of children correctly classified during an afterschool program (3 PM to 6 PM).

Figure 3 — Relationship between steps and minutes of MVPA (y-axis) during the afterschool program (3 PM to 6 PM) and time in attendance (x-axis).
program for less than 60 minutes should not be expected to accumulate 4600 steps. Thus, frontline practitioners can use the overall guideline of 4600 steps as an indicator of meeting the 30 minutes of MVPA when children attend ASPs for approximately 60 to 180 minutes per day.

It is important to note that although the ASPs in this study allocated nearly 75% of the time for physical activity and that simply lengthening the amount of time students attend the program on a daily basis does not guarantee they will achieve the step guideline. That is, the amount of time a child attended the ASP was not directly associated with achieving the step threshold or MVPA guideline (see Figure 3). Thus, strategies to maximize physical activity during already scheduled afterschool time may be an effective approach for increasing physical activity in ASPs. These would include the modification of games to make them more active, training staff to encourage inactive or unwilling children to be active, and offering a variety of games that appeal to all skill levels and gender.

The pedometer guideline developed in this study does not explicitly relate to a given level of physical activity intensity. Rather, the guideline of 4600 steps should be interpreted as a proxy for 30 minutes of MVPA, with the understanding it is likely a child could accrue 4600 steps during an ASP by performing light activities only (eg, slow walking). However, our analyses and the resulting 4600 steps guideline emphasizes the ability to accurately categorize children that failed to meet the 30-minute MVPA guideline, thereby minimizing the possibility of a false positive (child classified as meeting the 30-minute guideline when in fact they did not). It is recognized that intensity level of physical activity is an important public health outcome.17 For weight management or reduction high intensity activity, particularly MVPA, is essential.18 Thus, as technology improves19,20 the ability of frontline practitioners to affordably and easily measure children’s physical activity intensity will become more readily available. Currently, the guideline developed herein represents the most valid and setting-specific cutpoint that frontline practitioners can use to determine if children attending their ASP accumulate sufficient levels of MVPA.

The sole focus on accumulating 30 minutes of MVPA within an ASP should not overshadow the importance of engaging in any amount of physical activity both light and MVPA. Any additional activity that can occur within the ASP, regardless of intensity level, should therefore be encouraged. In this study, there were children that met the 30 minutes of MVPA via accelerometry but failed to achieve the 4600 steps. Conversely, there were children that accumulated 4600 steps but failed to achieve the 30 minutes of MVPA. Both of these scenarios represent the lack of precision inherent in these measures and the fallacy of the literal interpretation of the guideline that only includes kids with “meaningful” amounts of physical activity. It is important that practitioners understand these issues and that the 4600 step guideline represents an approximation and children may be incorrectly classified. Hence, not only do estimates of children meeting the step guideline need to be reported, but also the total amount of steps accrued. Both serve as valuable markers of an ASPs ability to improve the physical activity levels of the children attending.

A prior study attempted to link steps with MVPA in a sample of Boy Scouts.21 In this, they found that 4000 steps within 30 minutes translated into 30 minutes of MVPA. However, this was based on walking and jogging at 3 different speeds around an athletic track. The analyses and corresponding thresholds developed in this study were obtained from children attending ASPs engaged in routine physical activities. Thus, the context for which the 4600 steps step guideline was developed is an authentic representation of the types of activities, participants (boys, girls, ethnic/racial composition), and activity patterns and levels expected of children within ASPs. These differences likely explain the discrepancy between the 2 thresholds. Additional research is required that examines the validity of this guideline in samples of other ASPs, since ASPs vary widely in their access to indoor/outdoor spaces, qualifications of staff, and the demographics of children attending. Moreover, additional factors may influence step counts, such as differences in waist circumference (pedometer tilt),22 speed of movement (slow speeds),11 and types of activities performed (eg, climbing).23

Future directions include examining the extent to which ASPs are meeting this step guideline and to identify the context or environment that most effectively provides students with sufficient physical activity. Furthermore, the most effective approach to creating that environment, either through in person training, online training, observation, or a combination of these approaches has yet to be determined.

References


