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BRIEF REPORT

Are We Overestimating Physical Activity Prevalence in Children?

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Background: Physical activity guidelines state that children should achieve at least 60 minutes of moderate to vigorous physical activity (MVPA) on each day of the week. Accurate assessment of adherence to these guidelines should, ideally, include measurement over 7 days. When less than 7 days of data are available, researchers often report the average minutes of MVPA per day as a proxy for 7-day measurement. The aim of this study was to compare prevalence estimates generated by average MVPA per day versus MVPA assessed over 7 days. **Methods**: Data were collected as part of the Healthy Lifestyles Programme. One class from each school was randomized to wear a GENEActiv accelerometer for 8 days. The percentages of children achieving an average of ≥60 minutes of MVPA per day and those achieving ≥60 minutes of MVPA on each of 7 days were calculated. **Results**: A total of 807 children provided 7 days of data. When the average MVPA per day was calculated, 30.6% (n = 247) of children accumulated ≥60 minutes of MVPA per day. Only 3.2% (n = 26) accumulated ≥60 minutes of MVPA on every day of the week. **Conclusion**: Previous studies utilizing average MVPA per day are likely to have overestimated the percentage of children meeting recommendations.

Keywords: accelerometry, measurement, pediatrics, public health

Understanding the prevalence of physical activity (PA) in children is important to the design of population-level health promotion initiatives.[1] It is recommended that children achieve a minimum of 60 minutes of moderate to vigorous physical activity (MVPA) on each day of the week[2,3] to obtain the associated physical and psychological health benefits.[4]

Physical activity is commonly measured using accelerometry in childhood populations,[5] yet incomplete wear time can often hinder estimates of PA prevalence. To compensate and minimize missing data, researchers frequently use a minimum wear time criteria of 10 hours per day (a valid day) for 4 days (including 1 weekend day),[6] although some large cohort studies have used as little as 6 hours for 2 days to estimate PA prevalence.[7] In such cases, where less than 7 days of data are available, researchers estimate the prevalence of ≥60 minutes of MVPA on "every" day of the week using the average time per day of MVPA on valid days (average method). Alternatively, a limited number of valid days (daily method) may be used to indicate whether children are active on "every" day. For example, if a child has 3 valid days of data and MVPA ≥ 60 minutes on each of those days, then the child may be classed as "active at recommended levels," despite time in MVPA on nonvalid days being unknown or not considered.

Cooper et al[8] adopted this approach using the International Children's Accelerometry Database, which pools data from 20 studies. They estimated that 9.0% of boys and 1.9% of girls aged 5–17 years met the current recommendation of being active on every day, with the data used ranging from 3 to 7 days. Mooses et al[9] reported that 52% of children were active at recommended levels when using the "average" method and 24% when using the "daily" method, but only school day data were used in their analysis. In addition, Moose classed children as "active" if they achieved ≥60 minutes of MVPA on 4 of 5 measured days, rather than on every day. Estimating the proportion of children meeting government PA guidelines with less than 7 days of valid data assumes that the daily level of PA is consistent on every day of the week. However, there is evidence that children's PA varies across the week[10] with less time in MVPA on weekend days[11] than weekdays. Using a limited number of valid days for either the "average" or the "daily" method is unlikely to provide an accurate estimate of the proportion of children meeting government PA guidelines.[2,3]

To obtain more precise prevalence estimates, a minimum of 7 days of valid accelerometer data should be used, but only retaining participants who meet these criteria can result in small and potentially biased samples, especially if compliance is low. This in turn may result in biased estimates of prevalence and thereby limit generalization. For example, in a subsample of children in the 2008 Health Survey for England who had full 7 days of accelerometer data, Esliger and Hall[12] reported that 33% of boys and 21% of girls were achieving ≥60 minutes of MVPA on every day of the week, yet only 16% of boys and 17% of girls provided 7 days of valid accelerometry data. Therefore, it is possible that those included in the analysis were more active than those excluded, leading to an overestimate of the true prevalence.[13]

This study aims to expand the current understanding of PA prevalence by comparing 2 different methods for determining prevalence estimates in a large cohort of 9- to 10-year-old children and to report these estimates for the whole cohort and by gender. The prevalence estimates were calculated using 2 definitions of "active at recommended levels" for a large representative sample (n = 886) of children with full 7 days of objectively measured PA data.

Methods

Participants

Data were collected as part of the Healthy Lifestyles Programme trial, a definitive cluster randomized controlled trial of a novel

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school-based obesity prevention program.[14] Data were collected from children in 32 schools across Devon, United Kingdom, and included 53 classes of Year 5 children (aged 9–10 y at baseline). One class from each school was randomly selected and all children in these classes were asked to wear an accelerometer (n = 886). This study utilizes accelerometer data collected during baseline measurements only, which were collected in October 2012 (cohort 1) and October 2013 (cohort 2) for 2 phases of the program. Full details of the Healthy Lifestyles Programme trial are available elsewhere.[14,15] Prior to data collection, parents received an information sheet and an opt-out form. The Peninsula College of Medicine and Dentistry Ethics committee approved the trial in March 2012 (reference number 12/03/140).

Physical Activity Measurement

Physical activity was assessed using a GENEActiv (Activinsights Ltd, Kimbolton, United Kingdom) wrist-worn triaxial accelerometer, attached to a polyurethane strap. The GENEActiv can measure acceleration between ± 8 g at a rate of up to 100 Hz. During the study, data were collected at a rate of 85.7 Hz. Participants were asked to wear the monitor continuously for a period of 8 days, including 1 familiarization day.

Data Analysis

Data were downloaded using the GENEActiv PC software (version 1.4; Activinsights Ltd) and analyzed using the GGIR software[16] package for R (cran.r-project.org). Data were analyzed in 1-second epochs, with the first and final 6 minutes removed from analysis. Nonwear time was recorded if the SD of 2 axes was less than 13 mg and the value range was less than 50 mg and was assessed over 60-minute windows, using moving increments of 15 minutes.[17] Time spent in MVPA was estimated using published accelerometer cut points.[18] To be classed as a "valid day," a minimum of 10 hours of wear time was required.

Children who achieved 7 valid days were then categorized as being active at or above recommended levels based on the following 2 methods:

(1) The "average" method, when the average minutes of MVPA accumulated over the week is ≥60

(2) The "daily" method, when ≥60 minutes of MVPA is accumulated on each of the 7 days of the week

McNemar's test was used to assess whether the proportion of children categorized as being active was the same for both methods. Pearson's chi-squared test was used to assess whether there was an association between prevalence and gender for each of the 2 methods, with 95% confidence intervals (CIs) presented for the difference in proportions.

Results

Of the 886 children in the classes randomly selected to participate in the accelerometry substudy, 851 (96.1%) had usable data and 807/851 (94.8%) achieved ≥10 hours wear time for each of the 7 days. These 807 children were included in the following analyses. Participant characteristics are presented in Table 1.

Prevalence of Moderate to Vigorous Physical Activity

Of the 807 children, 30.6% (n = 247) were active at recommended levels when calculated using the "average" method, whereas only 3.2% (n = 26) were active when the "daily" method was applied (McNemar's $\chi^2 = 221.00$; $P < .01$; diff = 27.4%; 95% CIs, 24.2–30.6). All 26 children categorized as active using the "daily" method were also categorized as active using the "average" method.

Figure 1 shows the percentage of participants active at recommended levels as determined using each method, for all children and split by gender. There was a significant association

Table 1 Characteristics of Children With 7 Days of Valid PA Data at Baseline, Collected Between 2012 and 2013 as Part of the HeLP Trial

	Total		Males		Females	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
n	807	n/a	384	n/a	423	n/a
Age, y	9.8 (0.3)	9.2–10.8	9.8 (0.3)	9.2–10.8	9.7 (0.3)	9.2–10.3
Height, cm	138.3 (6.8)	118.0–165.0	138.6 (7.0)	118–160.6	137.9 (6.5)	118.9–165.0
Weight, kg	33.5 (7.5)	18.7–67.5	33.2 (7.6)	20.4–67.5	33.9 (7.4)	18.7–61.5
BMI SDS[a]	0.17 (1.2)	−2.9–3.4	0.16 (1.2)	−2.9–3.4	0.19 (1.2)	−2.9–3.0
Waist circumference, cm	61.0 (7.4)	47.8–96.8	61.3 (7.5)	50.2–96.8	60.8 (7.4)	47.8–91.6
PA characteristics						
ENMO[b], mg	49.3 (11.1)	18.3–105.4	53.8 (11.7)	24.8–105.4	45.3 (8.8)	18.3–76.7
Total PA, min	184.1 (35.6)	69.9–292.5	189.6 (36.8)	96.3–292.5	179.1 (33.7)	69.9–269.9
Light PA, min	130.4 (24.3)	58.0–211.4	129.7 (24.9)	69.5–199.8	131.0 (23.8)	58.0–211.4
Moderate PA, min	40.3 (11.7)	9.9–85.9	43.5 (12.3)	15.0–85.9	37.4 (10.4)	9.9–72.2
Vigorous PA, min	13.4 (6.2)	2.0–51.1	16.4 (6.5)	2.7–51.1	10.7 (4.4)	2.0–34.1
MVPA, min	53.7 (16.5)	11.9–124.8	59.9 (17.2)	20.0–124.8	48.1 (13.7)	11.9–92.1

Abbreviations: BMI, body mass index; HeLP, Healthy Lifestyles Programme; MVPA, moderate to vigorous physical activity; PA, physical activity; SDS, standard deviation score.

[a]BMI SDS calculated using SD scores were derived for BMI, based on the UK 1990 BMI reference curves for children.[19] [b]ENMO refers to the Euclidean norm minus one ($\sqrt{x^2 + y^2 + x^2} - 1g$).

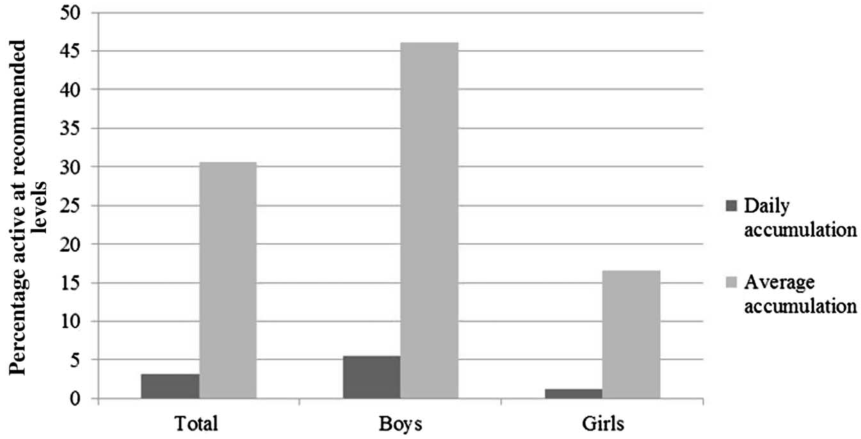

Figure 1 — Percentage of children active at recommended levels is calculated using the "average" and the "daily" methods. Data collected in Devon, United Kingdom between 2012 and 2013.

between gender and PA prevalence ($\chi^2 = 82.7$; $P < .001$; diff = 29.5%; 95% CI, 23.3%–35.5%) when using the "average" method (boys: n = 177/384, 46.1% and girls: n = 70/423, 16.6%). A significant association between gender and PA prevalence ($\chi^2 = 11.9$; $P < .001$; diff = 4.3%; 95% CI, 1.9%–7.1%) was also apparent using the "daily" method (boys: n = 21/384, 5.5% and girls: n = 5/423, 1.2%). A significantly greater proportion of boys than girls achieved the recommended level regardless of the method used.

Discussion

The aim of this study was to estimate PA prevalence at recommended levels in children using 2 established methods. The results show a large disparity between the percentages of children classed as meeting the recommended level of ≥60 minutes of MVPA per day when PA is averaged across the number of included days compared with a cumulative score across each of the 7 days. A substantially larger percentage of children (almost 10 times greater) were classified as sufficiently active when the "average" method was used. Irrespective of method use, a significantly higher proportion of boys than girls met the PA recommendations.

The findings highlight a number of important points. First, the difference in prevalence estimates between the 2 methods used highlights the need to obtain valid wear time over 7 days. The results support findings from previous studies demonstrating that the objective monitoring of PA over 7 days is possible with the appropriate device, wear time protocols, and data collection procedures.[20,21] Without the availability of such extended wear time, researchers are limited to reporting the "average" method, which, based on the results from this study, is likely to considerably overestimate the percentage of children meeting recommended PA levels. A total of 7 days of monitoring is required to capture the daily variation in PA across the week.[10,11] It should be noted, however, that PA is likely to show seasonal variation[22] and therefore prevalence may differ depending on the time of year it is measured.

Previous estimates of PA prevalence in children in the United Kingdom are likely to have been overestimated, either as a result of only small sample sizes being available with 7 days of data[12] or through the use of the "average" method.[23] The "average" method creates uncertainty when tracking population trends, as average MVPA may be calculated over dissimilar days between children. For example, 1 child may have valid data on 2 weekend days and 2 weekdays, in comparison with a child whose data were only valid on weekdays. The "average" method also hinders the identification of individual children in need of support to increase their PA and may undermine the evaluation of interventions to increase PA by failing to compare similar days across assessment points (ie, creating an average from weekend and weekdays at 1 time point and omitting weekend days at subsequent time points).

The results of the "daily" method for assessing prevalence indicate that only a very small percentage of the population are currently meeting PA guidelines (5.5% of boys and 1.2% of girls in this representative sample), substantially lower than previously reported in the 2008 Health Survey for England[12] objective data (33% of boys and 21% of girls). Prevalence estimates reported in this study are closer to those reported by Cooper et al,[8] who employed a "daily" estimate, albeit based on a limited number of valid days.

Inaccurate estimates of the prevalence of PA in the United Kingdom and elsewhere may lead to false conclusions about the scale of the burden of physical inactivity and the associated health risks. Consequently, efforts to promote PA may be under resourced and not at a scale that is likely to lead to improved prevalence levels.

It should also be noted that the low estimates observed here could themselves be overestimates in relation to estimates based on longer wear times (eg, 14–21 d). Moreover, there is considerable uncertainty about how such low levels of PA relate to health benefit; PA guidelines, in the United Kingdom and elsewhere, were established based on self-reports of PA that are likely to have been overestimated. If true, it is possible that the actual minimum level of PA required to derive health benefits may be lower than that in current guidelines. The increased accuracy available with objectively collected data[24] and the wider use of objective measurement in population samples[25] may require a revision of PA guidelines. However, prior to this, methods used to derive estimates of PA levels from accelerometers, in both etiological and surveillance studies, will need to be improved to avoid overestimating or underestimating true levels.

A number of limitations with this study should be noted. Primarily, there are known limitations with accelerometry that hinder the detection of MVPA, including the inability to detect activities with increased work load, such as carrying a bag or walking uphill.[26] As a result, some activities that have a metabolic cost equivalent to MVPA may have been misclassified, resulting in an underestimation of MVPA in the accelerometer data. In addition, there has been considerable debate within the PA literature about the impact of different MVPA thresholds[27,28] on time estimates. It is possible, therefore, that the use of a lower threshold[29] would result in increased estimates of time spent in MVPA and hence slightly higher prevalence estimates. Similarly, the use of different epochs would alter the PA estimates. Longer epochs will underestimate the time spent in higher activity intensities,[5] which occurs in short bouts in children.[30] Underestimation of MVPA would in turn impact the prevalence estimates calculated when using either the "average" or the "daily" method. However, the application of an alternative threshold and/or epochs is unlikely to alter the disparity observed between the 2 methods employed in this study to estimate prevalence. Future studies may wish to undertake sensitivity analysis to examine the prevalence estimates resulting from both methods when multiple thresholds and epochs are applied. Finally, it is likely that prevalence estimates would be lower when using longer periods of monitoring to assess habitual activity due to variation in PA between weeks[31] and seasons.[22]

Conclusion

Previous estimates of the percentage of children achieving PA guidelines are likely to have been substantially overestimated due to insufficient data being used to make reliable estimates of a child's PA on every day of the week. Fortunately, children are willing to wear wrist-worn accelerometers for up to 10 hours a day across 7 days, allowing for a more precise estimation of PA prevalence. These data indicate that only a very small percentage (3.2%) of children sampled during the Healthy Lifestyles Programme trial were "active" at levels recommended by the UK Department of Health.[2] Use of more reliable measurement techniques may indicate that considerably greater support for PA among school children is needed. Such data may also result in reconsideration of the levels of PA needed to derive health benefits.

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