Abstract

Background: Physical activity guidelines state that children should achieve at least 60 minutes of moderate-to-vigorous intensity 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 (HeLP). One class from each school was randomised 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: 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. Conclusions: Previous studies utilising average MVPA per day are likely to have overestimated the percentage of children meeting recommendations.
Introduction

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

PA is commonly measured via accelerometry in childhood populations, yet incomplete wear time can often hinder estimates of PA prevalence. To compensate and to minimise missing data, researchers frequently use a minimum wear time criteria of 10 hours per day (a valid day) for four days (including one weekend day) although some large cohort studies have used as little as six hours for two days to estimate PA prevalence. In such cases, where less than seven days of data is 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 three 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 non-valid days being unknown or not-considered.

Cooper and colleagues adopted this approach using the international children’s accelerometry database (ICAD) 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 3-7 days. Mooses and colleagues 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 the analysis. In addition, Moose classed children as ‘active’ if they achieved ≥ 60 minutes MVPA on four out of five measured days, rather than on every day. Estimating the proportion of children meeting government PA guidelines with less than seven days of valid data assumes that the daily level of PA is consistent on every day of the week. There is evidence however, that children’s PA varies across the week with less time in MVPA on weekend days.
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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.\textsuperscript{2, 3}

In order to obtain more precise prevalence estimates, a minimum of seven 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 generalisation. For example, in a subsample of children in the 2008 Health Survey for England (HSE) who had a full seven days of accelerometer data, Esliger & Hall\textsuperscript{12} reported that 33% of boys and 21% of girls were achieving $\geq 60$ minutes of MVPA on every day of the week, yet only 16% of boys and 17% of girls provided seven 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.\textsuperscript{13}

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

Methods

Participants

Data were collected as part of the Healthy Lifestyles Programme (HeLP) trial, a definitive cluster randomised controlled trial of a novel school based obesity prevention programme\textsuperscript{14}. Data were collected from children in 32 schools across Devon, UK and included 53 classes of Year 5 children (aged 9-10 years at baseline). One class from each school was randomly selected and all children in these classes asked to wear an accelerometer (n=886). The present study utilises accelerometer data collected during baseline measurements only; collected in October 2012 (cohort 1) and October 2013.
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(cohort 2) for two phases of the programme. Full details of the HeLP 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

PA was assessed using a GENEActiv, (Activinsights Ltd, Kimbolton, UK) wrist worn tri-axial accelerometer, attached to a polyurethane strap. The GENEActiv can measure acceleration between +/- 8g at a rate of up to 100Hz. During the study, data were collected at a rate of 85.7Hz. Participants were asked to wear the monitor continuously for a period of eight days, including one familiarisation day.

Data analysis

Data were downloaded using GENEActiv PC software version 1.4 and analysed using the GGIR software16 package for R (cran.r-project.org). Data were analysed in 1 second epochs, with the first and final 6 minutes removed from analysis. Non-wear time was recorded if the standard deviation of two axes was less that 13mg and the value range was less than 50mg 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. In order to be classed as a ‘valid day’, a minimum of 10 hours of wear time was required.

Children who achieved seven valid days were then categorised as being active at or above recommended levels based on the following two methods:

1) The ‘average’ method, when the average minutes of MVPA accumulated over the week is ≥ 60;

2) The ‘daily’ method, when ≥ 60 minutes MVPA is accumulated on each of the seven days of the week.
McNemar’s test was used to assess whether the proportion of children categorised 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 two methods, with 95% confidence intervals presented for the difference in proportions.

Results

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

Table 1. Characteristics of children with 7 days of valid physical activity data at baseline, collected between 2012 and 2013 as part of the Healthy Lifestyles Programme (HeLP) trial.
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<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Range</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td>807</td>
<td>n/a</td>
<td>384</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td>9.8 (0.3)</td>
<td>9.2 – 10.8</td>
<td>9.8 (0.3)</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>138.3 (6.8)</td>
<td>118.0 – 165.0</td>
<td>138.6 (7.0)</td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>33.5 (7.5)</td>
<td>18.7 – 67.5</td>
<td>33.2 (7.6)</td>
</tr>
<tr>
<td><strong>BMI sds</strong></td>
<td>0.17 (1.2)</td>
<td>-2.9 – 3.4</td>
<td>0.16 (1.2)</td>
</tr>
<tr>
<td><strong>Waist circumference (cm)</strong></td>
<td>61.0 (7.4)</td>
<td>47.8 – 96.8</td>
<td>61.3 (7.5)</td>
</tr>
</tbody>
</table>

### Physical Activity characteristics

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENMO</strong></td>
<td>49.3 (11.1)</td>
<td>18.3 – 105.4</td>
<td>53.8 (11.7)</td>
</tr>
<tr>
<td><strong>Total PA (minutes)</strong></td>
<td>184.1 (35.6)</td>
<td>69.9 – 292.5</td>
<td>189.6 (36.8)</td>
</tr>
<tr>
<td><strong>Light PA (minutes)</strong></td>
<td>130.4 (24.3)</td>
<td>58.0 – 211.4</td>
<td>129.7 (24.9)</td>
</tr>
<tr>
<td><strong>Moderate PA (minutes)</strong></td>
<td>40.3 (11.7)</td>
<td>9.9 – 85.9</td>
<td>43.5 (12.3)</td>
</tr>
<tr>
<td><strong>Vigorous PA (minutes)</strong></td>
<td>13.4 (6.2)</td>
<td>2.0 – 51.1</td>
<td>16.4 (6.5)</td>
</tr>
<tr>
<td><strong>MVPA (minutes)</strong></td>
<td>53.7 (16.5)</td>
<td>11.9 – 124.8</td>
<td>59.9 (17.2)</td>
</tr>
</tbody>
</table>

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123 *BMI sds calculated using Standard Deviation Scores were derived for body mass index (BMI), based on the UK 1990 BMI reference curves for children*.

124 ENMO – refers to the Euclidean norm minus one \( \sqrt{x^2 + y^2 + z^2} - 1 \)
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, whilst only 3.2% (n=26) were active when the daily method was employed (McNemar's chi² = 221.00; p < 0.01; diff = 27.4; 95% CIs: 24.2 – 30.6). All 26 children categorised as active using the daily method were also categorised 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 between gender and PA prevalence (X² = 82.7, p <0.001; diff = 29.5%, 95% CI: 23.3 to 35.5%) when using the average method (boys n = 177/384, 46.1%; girls n = 70/423, 16.6%). A significant association between gender and PA prevalence (X² = 11.9, p <0.001; diff = 4.3%, 95% CI: 1.9 to 7.1%) was also apparent using the daily method (boys n=21/384, 5.5%; 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 two 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 to a cumulative score across each of the seven days. A substantially larger percentage of children (almost ten 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 meet the PA recommendations.

The findings highlight a number of important points. Firstly, the difference in prevalence estimates between the two methods used underlines the need to obtain valid wear time over seven days. The results support findings from previous studies demonstrating that objective monitoring of PA over seven days is possible with the appropriate device, wear time protocols and data collection procedures. 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. Seven days of monitoring is required to capture the daily variation in PA across the week. It should be noted, however, that PA is likely to show seasonal variation and therefore prevalence may differ depending on the time of year it is measured.

Previous estimates of PA prevalence in children in the UK are likely to have been overestimated, either as a result of only small sample sizes being available with seven days of data, or through the use of the average method. The average method creates uncertainty when tracking population trends, as average MVPA may be calculated over dissimilar days between children. For example, one child may have valid data on two weekend days and two weekdays, in comparison to a child whose data was 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 (i.e. creating an average from weekend and weekdays at one 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; 1.2% of girls in this representative sample), substantially lower than previously reported in the HSE objective data (33% of boys and 21% of girls). Prevalence estimates reported in the present study are closer to those reported by Cooper et al., who employed a daily estimate, albeit based on a limited number of valid days.

Inaccurate estimates of the prevalence of PA in the UK 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 e.g., 14-21 days. Moreover, there is considerable
uncertainty about how such low levels of PA relate to health benefit; PA guidelines, in the UK 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 and the wider use of objective measurement in population samples may require a revision of PA guidelines. However, prior to this, methods used to derive estimates of PA levels from accelerometers, in both aetiological and surveillance studies will need to be improved to avoid over or underestimating true levels.

A number of limitations with the present 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. 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 on time estimates. It is possible, therefore, that the use of a lower threshold (e.g. 191.6mg) 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 physical activity estimates. Longer epochs will underestimate the time spent in higher activity intensities, which occurs in short bouts in children. 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 two 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 and seasons.
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 seven 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 HeLP trial were ‘active’ at levels recommended by the UK Department of Health. 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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Conflict of interest

MH supervises a PhD studentship that is funded by ActivInsights, the manufacturer for the device used in this study. The other authors declare they have no conflict of interest. The results of the present study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

References


