Original Article

Children's Pedometer-determined Physical Activity During School-time and Leisure-time

Charlotte A. Hardman[1], Pauline J. Horne[2], Ann V. Rowlands[3]

[1]Department of Experimental Psychology, University of Bristol, Bristol, UK
[2]School of Psychology, Bangor University, Bangor, UK
[3]School of Sport and Health Sciences, University of Exeter, Exeter, UK

The pedometer is increasingly used to quantify physical activity in children. Examination of steps accumulated in different contexts and how this varies by gender and children's activity level can inform activity interventions. The current study measured the pedometer steps of 7–11-year-old British children during school- and leisure-time on weekdays and weekend days. Participants ($n = 104$, 58% girls) wore sealed pedometers on 4 weekdays and 2 weekend days; pedometer counts were recorded at the beginning and end of the school day on weekdays, and at the child's bedtime each day. Differences in step counts across context by gender and activity tertile (high-, mid- or low-active) were examined. In both boys and girls, steps accumulated in weekday leisure time were greater in the high-active groups than in the mid- and low-active groups ($p < 0.001$), with relatively smaller differences between activity tertiles for steps accumulated at school. In girls, the high- and mid-active groups, but not the low-active group, accumulated more steps during leisure-time than during school-time ($p = 0.001$) on weekdays; in boys, all groups accumulated more steps during leisure-time relative to school-time ($p < 0.001$). Girls took fewer steps on weekend days than weekdays, whereas boys' steps did not differ by type of day. As fewer steps are accumulated at the weekend, the out-of-school environment should be a focus for activity interventions. Low-active girls, in particular, would benefit from interventions targeting weekday leisure time. [*J Exerc Sci Fit* • Vol 7 • No 2 • 129–134 • 2009]

Keywords: gender, health behavior, measurement, weekday, weekend

Introduction

The beneficial effects of physical activity on children's body fat, aerobic fitness, bone health, and psychological wellbeing are well documented (Parfitt & Eston 2005; Moore et al. 2003; Rowlands et al. 2002, 1999; Calfas & Taylor 1994). However, many children are not engaging in sufficient physical activity and are thus putting their health at risk. Indeed, recent data indicate that the recommended daily 1 hour of moderate-intensity physical activity is not sufficient to prevent the appearance of cardiovascular disease risk factors in children (Andersen et al. 2006).

Valid measurement tools are essential to determine the current activity levels of children from different populations. A growing number of studies have used the pedometer for this purpose (Cox et al. 2006; JS Duncan et al. 2006; Tudor-Locke et al. 2006; Vincent et al. 2003; Vincent & Pangrazi 2002), a low-cost and unobtrusive device that is particularly well suited to child populations. Using pedometers, Vincent and Pangrazi (2002) found that, on weekdays, preadolescent boys and girls

Corresponding Author
Charlotte A. Hardman, Department of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol BS8 1TU, UK.
Tel: (44) (0)117 3317898
E-mail: charlotte.hardman@bristol.ac.uk

averaged 13,162 and 10,923 steps per day, respectively. However, there was high interindividual variability, which the authors suggested was most likely due to differences in activity outside of the school environment. This highlights the importance of differentiating between in-school and out-of-school contexts in order to identify at what point in the day high-active children are accumulating their additional activity.

A recent study found that New Zealand children (aged 5–11 years) took significantly more steps out-of-school than in school on weekdays (Cox et al. 2006). When the sample was split into activity tertiles, this increase remained for the most-active tertile, but was not shown by the least-active group. This supports the above assertion (Vincent & Pangrazi 2002) and highlights out-of-school time as a key context for interventions aimed at low-active children. However, whether this finding extends to other populations and whether the findings remain when activity tertiles are stratified by gender is not clear. The gender difference in children's physical activity is well documented (Riddoch et al. 2004; Trost et al. 2002) and, in adolescents, it is most pronounced during the late afternoon period (Jago et al. 2005). Tudor-Locke et al. (2006) conducted a detailed breakdown of activity levels and found that 6th grade boys accumulated more steps than girls during recess, lunchtime, and after school, but there were no differences before school and during physical education (PE) classes. It is therefore likely that high- and low-active boys and girls will differ in their accumulation of steps over the day and this warrants further investigation. Furthermore, the importance of including weekend days is highlighted by studies which have found that children are significantly less active on these days relative to weekdays (MJ Duncan et al. 2007; JS Duncan et al. 2006; Rowlands et al. 1999); however, this is not always found (see Trost et al. 2000). In relation to high- and low-active children, it is interesting to examine the consistency of these activity groupings across weekdays and weekend days; that is, to determine the extent to which boys and girls who are most (or least) active on weekdays are similarly so on weekend days.

The current study thus aimed to quantify the pedometer steps taken by children during school- and leisure-time on weekdays and on weekend days in a semi-rural area of the United Kingdom. An additional aim was to determine when (i.e. school- or leisure-time) high-active boys and girls accumulated their additional activity relative to their mid- and low-active counterparts, and to examine the consistency of these activity tertile groupings across weekdays and weekend days.

Methods

Participants

Participants were 104 children (61 girls, 43 boys) aged 7–11 years recruited from two primary schools in North Wales, UK. Written informed parental consent was obtained prior to participation. Ethical approval was granted by the School of Psychology Ethics Committee, Bangor University. Data were collected from late March until June 2003.

Measures

Physical activity was measured on 4 weekdays and 2 weekend days using Yamax SW-200 pedometers (Yamax Corp., Toyko, Japan). This pedometer has been validated for use with children both in the laboratory and in the field (Rowlands et al. 1999; Eston et al. 1998). Pedometers were worn on the hip and were sealed so as to blind the participants to the activity count. Prior to measurement, the accuracy of all pedometers was verified using a walking test, which involved a researcher wearing each pedometer while walking 50 steps. The count on each pedometer was recorded after each 50 steps (in accordance with the procedure reported by Vincent & Sidman 2003) and no pedometer exceeded 4% error (i.e. more than 2 steps incorrectly recorded out of 50).

Body mass (to the nearest 0.1 kg) and height (to the nearest 0.1 cm) were measured using a Hanson electronic scale (Hanson, Hemel Hempstead, Hertfordshire, UK) and a tape measure that was attached to a vertical wall, respectively, and body mass index (BMI, $kg \cdot m^{-2}$) was calculated for each participant.

Procedures

Before beginning data collection, a researcher visited the parents of each participant to explain the procedures. On the Monday of the week allocated to data collection, anthropometric measurements were taken at school and pedometers were distributed to all participants. Participants were instructed to wear the pedometers at all times with the exception of sleeping, bathing and swimming. At the child's bedtime, the parent recorded the pedometer count on a provided recording form and then reset and resealed the pedometer. The parent also recorded the time that the pedometer was taken off at bedtime, and the time it was put on the following morning. If the pedometer was temporarily removed during the day or not worn at all, the parent was asked to indicate this on the form. Pedometer data were recorded in this way until Sunday evening, giving 4 complete weekdays and 2 weekend days of data (incomplete data from the initial Monday were not included in the analysis). On each of the 4 weekdays, the researcher also recorded the pedometer counts for the participants upon their arrival at school at 0900 hours and again at the end of school at 1500 hours. Pedometer counts were not revealed to the children until after the study had finished.

Data analysis

Any days where the pedometer was removed for more than 2 consecutive hours were discarded. Participants needed to have at least 3 complete days of weekday data to be included in the analysis, in accordance with previous findings (Ozdoba et al. 2004), and nine participants (5 boys, 4 girls) were excluded on this basis. Independent samples *t* tests showed that excluded boys did not differ significantly from the included sample on age, height, mass, or BMI. Excluded girls were significantly younger and shorter than the included sample but there were no other significant differences.

Descriptive statistics were computed for age and anthropometric variables, and independent *t* tests were used to examine gender differences. Mean school-time and leisure-time step counts were computed for each participant. A 2 × 2 ANOVA was conducted where gender was the between-subjects factor and time of day (school-time, leisure-time) was the within-subjects factor. Means were also computed for steps per day on weekdays and on weekend days and a 2 × 2 ANOVA examined differences by gender (between-subjects factor) and type of day (within-subjects factor). This analysis included only those children who had data for 2 weekend days, in addition to at least 3 weekdays (boys, $n = 33$; girls, $n = 51$).

For each gender separately, participants were divided into tertiles on the basis of their mean steps per day on weekdays. Differences between school- and leisure-time step counts by tertile group (i.e. high-, medium-, or low-active) were examined using a 2 × 3 ANOVA, conducted for boys and girls separately.

Finally, tertile groups were created based on mean steps per day on weekend days. The extent to which participants who were high-, mid-, or low-active on weekdays remained in the same tertile group on weekend days was examined using 3 × 3 matrices and kappa (κ) statistics for each gender separately. As before, this analysis only included participants with sufficient data on weekend days. The κ statistic was interpreted as follows: $\kappa \leq 0.20$ = poor tracking; κ 0.21–0.40 = fair; κ 0.41–0.60 = moderate; κ 0.61–0.80 = good; κ 0.81–1.0 = very good (Altman 1991).

For all ANOVAs, significant interactions were followed-up using Bonferroni-corrected *post hoc* tests. Otherwise, the significance level was set to 0.05.

Results

Descriptive characteristics of the sample are shown in the Table. There were no significant gender differences for age, height, mass or BMI. The ANOVA comparing school- and leisure-time steps showed a significant main effect of time of day, $F(1, 93) = 69.3$, $p < 0.001$, indicating that, overall, participants accumulated significantly more steps during leisure-time than in school. Boys were significantly more active than girls overall, $F(1, 93) = 24.8$, $p < 0.001$, but there was no interaction between time of day and gender.

The comparison of weekday and weekend physical activity showed a significant interaction between day and gender, $F(1, 82) = 8.49$, $p < 0.01$, with main effects of day, $F(1, 82) = 6.91$, $p < 0.05$, and gender, $F(1, 82) = 35.84$, $p < 0.001$. *Post hoc* analysis showed that boys were more active than girls on both weekdays, $t(82) = 4.73$, $p < 0.001$, and weekend days, $t(82) = 5.61$, $p < 0.001$. Girls were less active on weekend days than on weekdays, $t(50) = 4.52$, $p < 0.001$, whereas boys' activity did not differ between weekdays and weekend days, $t(32) = -0.18$, $p = 0.860$.

For girls, the high-active tertile took > 14,056 steps/day on weekdays, the middle tertile took > 11,455 and ≤ 14,056 steps/day, and the low-active tertile took

Table. Descriptive statistics by gender*

	Boys ($n = 38$)	Girls ($n = 57$)
Age (yr)	9.8 ± 1.4	10.0 ± 1.2
Height (cm)	138.4 ± 10.0	139.0 ± 9.7
Mass (kg)	35.8 ± 8.8	37.0 ± 11.2
Body mass index ($kg \cdot m^{-2}$)	18.4 ± 2.3	18.8 ± 3.6
School-time step count (total steps)	7,312 ± 1,816†	5,782 ± 1,748
Leisure-time step count (total steps)	9,742 ± 2,995†‡	7,309 ± 2,259‡
Weekday steps/day	17,054 ± 4,165†	13,091 ± 3,535
Weekend steps/day§	17,608 ± 4,868†	10,944 ± 3,749‖

*Data presented as mean ± standard deviation; †boys greater than girls ($p < 0.001$); ‡leisure-time steps greater than school-time within-group ($p < 0.001$); §for weekend steps/day, there were $n = 33$ boys and $n = 51$ girls; ‖weekend steps lower than weekday steps within-group ($p < 0.001$).

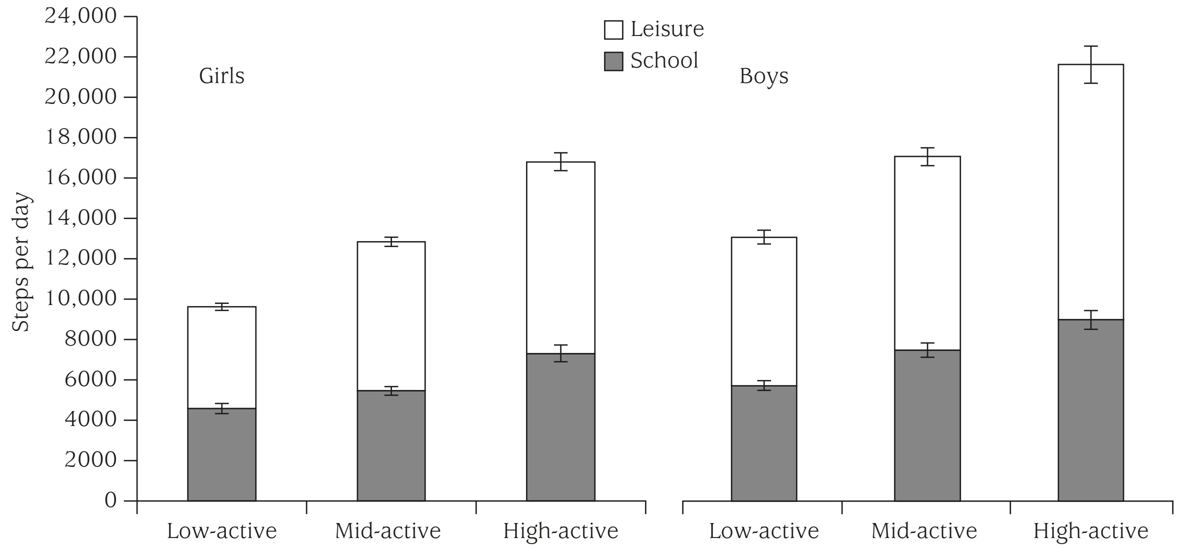

Fig. School- and leisure-time steps per day for low-, mid-, and high-active girls (left panel) and boys (right panel).

≤ 11,455 steps/day. The Figure (left panel) shows the mean step counts on weekdays of high-, mid-, and low-active girls segmented into school- and leisure-time activity. There were significant main effects of time of day, $F(1, 54) = 39.7$, $p < 0.001$, and tertile group, $F(2, 54) = 64.3$, $p < 0.001$, and a significant interaction between the two, $F(2, 54) = 4.9$, $p < 0.05$. *Post hoc* tests showed significant differences between the step counts of all three tertile groups during leisure-time ($p < 0.001$). For school activity, there were significant differences between the high- and low-active groups and between the high- and mid-active groups ($p < 0.001$) but not between the mid- and low-active groups ($p = 0.149$). Furthermore, both the high- and mid-active groups took significantly more steps during leisure-time compared to school-time, $t(18) = -3.88$, $p = 0.001$, and $t(18) = -4.88$, $p < 0.001$, respectively, whereas the low-active group showed no significant difference, $t(18) = -1.99$, $p = 0.063$.

For boys, the high-active tertile took > 18,373 steps/day on weekdays, the middle tertile took > 15,322 and ≤ 18,373 steps/day, and the low-active tertile took ≤ 15,322 steps/day. The Figure (right panel) shows the mean step counts on weekdays of the tertile groups by time of day. Step counts were significantly higher during leisure-time compared to school, $F(1, 35) = 33.8$, $p < 0.001$. There was also a significant effect of tertile group, $F(2, 35) = 41.4$, $p < 0.001$, with significant differences between the overall step counts of all groups ($p < 0.001$). The interaction between time of day and tertile group was not significant, $F(2, 35) = 2.0$, $p = 0.15$.

In girls, a κ statistic of 0.29 ($p = 0.003$) indicated fair tracking between weekday and weekend physical activity. In total, 53% of girls (27/51) fell into the same tertile group on weekdays and on weekend days. In boys, however, there was poor tracking between weekday and weekend activity ($\kappa = 0.09$, $p = 0.46$), and 39% (13/33) fell into the same tertile group on weekdays and weekend days.

Discussion

The current study measured the pedometer steps of 7–11-year-old children during school- and leisure-time on weekdays and on weekend days. Consistent with previous research (Cox et al. 2006; Tudor-Locke et al. 2006; Vincent & Pangrazi 2002), on weekdays overall step counts were significantly higher during leisure-time (i.e. before and after school) than during school. This is to be expected, as activity levels are largely restricted during the school day, apart from recess periods and PE lessons (Tudor-Locke et al. 2006). The leisure-time context provides many opportunities for children to be physically activity through sports clubs, free play and active commuting. The sample was then divided into activity tertiles (i.e. high-, mid- and low-active) and gender differences examined. In both boys and girls, the differences between the activity tertiles were greater during the weekday leisure context than during school. This was particularly true for girls; furthermore, the low-active girls differed from their more active counterparts in that they did not increase their activity during leisure-time once the constraints of school were removed. This is consistent with previous findings

(Cox et al. 2006), but the current study is the first to show this effect in girls only. Boys showed a different pattern of results with all groups accumulating significantly more steps during leisure-time relative to school.

The mean daily step counts on weekdays were 13,091 (±3,535) and 17,055 (±4,165) for girls and boys, respectively. While the average for girls is generally consistent with other studies (range, 10,923–14,124), the boys' step count is slightly higher than has been previously reported for this age group (13,162–16,421; MJ Duncan et al. 2007; Cox et al. 2006; JS Duncan et al. 2006; Tudor-Locke et al. 2006; Vincent & Pangrazi 2002; Rowlands et al. 1999). This may be due to the different populations sampled across studies and seasonal effects. In the current study, the data were collected during the spring and summer months when the weather was conducive to outdoor physical activity. Previous UK-based research indicates that objectively measured physical activity is higher in summer than winter in children (Rowlands & Hughes 2006). As boys may be more likely to engage in unsupervised outdoor play than girls, due to lessened safety concerns of parents, the favorable weather conditions may have particularly potentiated their physical activity.

The inclusion of weekend days is a strength of the study and this revealed a further gender difference—girls took fewer steps on weekend days relative to weekdays whereas boys showed no significant change. While other studies have indicated lower overall activity levels on weekend days (MJ Duncan et al. 2007; JS Duncan et al. 2006; Rowlands et al. 1999), to our knowledge, ours is the first to show a differential effect by gender. This again highlights the out-of-school environment as a time when girls are vulnerable to lower activity levels. In relation to the activity tertile groups, the kappa analysis indicated that children who are highly active on weekdays will not necessarily remain so on weekend days, and this appears particularly true for boys. This suggests that children's activity levels are somewhat contextual, at least in the short term, and dependent on the environment and the presence of cues that are conducive to physical activity.

The objective measurement of physical activity is an additional strength; however, the pedometer does not accurately measure certain activities (e.g. swimming), nor does it provide a measure of intensity of activity. Despite these limitations, the measure of total steps per day encompasses the intermittent activity patterns of children, and pedometers are ideally suited to large population studies of children due to their low cost and convenience (Rowlands & Eston 2007).

In conclusion, these findings indicate that all groups of boys and the high- and mid-active girls accumulated more steps during leisure-time relative to school-time on weekdays; the low-active girls, however, did not show this increase. Overall, girls took fewer steps on weekend days relative to weekdays whereas boys' steps did not differ by type of day. This has important implications for the development of physical activity interventions that are specifically tailored to meet the needs of boys and girls. To engage girls, particularly those who are least active, the results suggest that interventions should be aimed primarily at the out-of-school environment (i.e. before and after school, and weekend days).

The "Fit 'n' Fun Dudes" intervention has been developed on the basis of these findings to increase step counts in preadolescent girls and boys. Children are given individualized step targets, which they are challenged to achieve each day. Although the intervention is implemented within the school context, children are free to obtain their additional steps at any point during the day (i.e. in-school and/or out-of-school) through activities of their own choosing. There is thus considerable flexibility to address the needs of low-active children, and the intervention goes beyond the school setting rather than being focused on only one environment. This is particularly important given the contextual nature of children's physical activity. Initial findings indicate that this is a promising strategy to address the problem of inactivity in children (Hardman et al. 2009; Horne et al. 2009).

Acknowledgments

The authors thank the children and parents who participated in this study. Funding was provided by an Economic and Social Research Council postgraduate studentship.

References

Altman DG (1991). *Practical Studies for Medical Research*. Chapman & Hall: London.

Andersen LB, Harro M, Sardinha LB, Froberg K, Ekelund U, Brage S, Anderssen SA (2006). Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *Lancet* 368:299–304.

Calfas KJ, Taylor WC (1994). Effects of physical activity on psychological variables in adolescents. *Pediatr Exerc Sci* 6:406–23.

Cox M, Schofield G, Greasley N, Kolt GS (2006). Pedometer steps in primary school-aged children: a comparison of school-based and out-of-school activity. *J Sci Med Sport* 9:91–7.

Duncan JS, Schofield G, Duncan EK (2006). Pedometer-determined physical activity and body composition in New Zealand children. *Med Sci Sports Exerc* 38:1402–9.

Duncan MJ, Al-Nakeeb Y, Woodfield L, Lyons M (2007). Pedometer determined physical activity levels in primary school children from central England. *Prev Med* 44:416–20.

Eston RG, Rowlands AV, Ingledew DK (1998). Validity of heart rate, pedometry, and accelerometry for predicting the energy cost of children's activities. *J Appl Physiol* 84:362–71.

Hardman CA, Horne PJ, Lowe CF (2009). A home-based intervention to increase physical activity in girls: the Fit 'n' Fun Dudes program. *J Exerc Sci Fit* 7:1–8.

Horne PJ, Hardman CA, Lowe CF, Rowlands AV (2009). Increasing children's physical activity: a peer modelling, rewards and pedometer-based intervention. *Eur J Clin Nutr* 63:191–8.

Jago R, Anderson CB, Baranowski T, Watson K (2005). Adolescent patterns of physical activity—differences by gender, day, and time of day. *Am J Prev Med* 28:447–52.

Moore LL, Gao D, Bradlee ML, Cupples LA, Sundarajan-Ramamurti A, Proctor MH, Hood MY, Singer MR, Ellison RC (2003). Does early physical activity predict body fat change throughout childhood? *Prev Med* 37:10–7.

Ozdoba R, Corbin C, Le Masurier G (2004). Does reactivity exist in children when measuring activity levels with unsealed pedometers? *Pediatr Exerc Sci* 16:158–66.

Parfitt G, Eston RG (2005). The relationship between children's habitual activity level and psychological well-being. *Acta Paediatr* 94:1791–7.

Riddoch CJ, Bo Andersen L, Wedderkopp N, Harro M, Klasson-Heggebo L, Sardinha LB, Cooper AR, Ekelund U (2004). Physical activity levels and patterns of 9- and 15-yr-old European children. *Med Sci Sports Exerc* 36:86–92.

Rowlands AV, Eston RG (2007). The measurement and interpretation of children's physical activity. *J Sport Sci Med* 6:270–6.

Rowlands AV, Eston RG, Ingledew DK (1999). Relationship between activity levels, aerobic fitness, and body fat in 8- to 10-yr-old children. *J Appl Physiol* 86:1428–35.

Rowlands AV, Hughes DR (2006). Variability of physical activity patterns by type of day and season in 8–10-year-old boys. *Res Q Exerc Sport* 77:391–5.

Rowlands AV, Powell SM, Eston RG, Ingledew DK (2002). Relationship between bone mass and habitual physical activity and calcium intake in 8–11-year-old boys and girls. *Pediatr Exerc Sci* 14:358–68.

Trost SG, Pate RR, Freedson PS, Sallis JF, Taylor WC (2000). Using objective physical activity measures with youth: how many days of monitoring are needed? *Med Sci Sports Exerc* 32:426–31.

Trost SG, Pate RR, Sallis JF, Freedson PS, Taylor WC, Dowda M, Sirard J (2002). Age and gender differences in objectively measured physical activity in youth. *Med Sci Sports Exerc* 34:350–5.

Tudor-Locke C, Lee SM, Morgan CF, Beighle A, Pangrazi RP (2006). Children's pedometer-determined physical activity during the segmented school day. *Med Sci Sports Exerc* 38:1732–8.

Vincent SD, Pangrazi RP (2002). An examination of the activity patterns of elementary school children. *Pediatr Exerc Sci* 14:432–41.

Vincent SD, Pangrazi RP, Raustorp A, Tomson LM, Cuddihy TF (2003). Activity levels and body mass index of children in the United States, Sweden, and Australia. *Med Sci Sports Exerc* 35:1367–73.

Vincent SD, Sidman CL (2003). Determining measurement error in digital pedometers. *Meas Phys Educ Exerc Sci* 7:19–24.