Preventive Medicine 56 (2013) 273–277

Contents lists available at SciVerse ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Is wearing a pedometer associated with higher physical activity among adolescents?

Vanda Ho [a], Rebecca K. Simmons [b], Charlotte L. Ridgway [b], Esther M.F. van Sluijs [b,c], Diane J. Bamber [d], Ian M. Goodyer [d], Valerie J. Dunn [d], Ulf Ekelund [b,e], Kirsten Corder [b,c,*]

[a] Murray Edwards College, Huntingdon Road, Cambridge, CB3 0DF, United Kingdom
[b] MRC Epidemiology Unit, Institute of Metabolic Science, Box 285, Addenbrooke's Hospital, Hills Road, Cambridge, CB2 0QQ, UK
[c] UKCRC Centre for Diet and Activity Research (CEDAR), Box 296, Institute of Public Health, Forvie Site, Robinson Way, Cambridge, CB2 0SR, UK
[d] Developmental Psychiatry Section, Department of Psychiatry, University of Cambridge, Douglas House, 18b Trumpington Road, Cambridge, CB2 8AH, UK
[e] Department of Sports Medicine, Norwegian School of Sports Sciences, PO Box 4014, Ullevål Stadion, 0806 Oslo, Norway

ARTICLE INFO

Available online 4 February 2013

Keywords:
Adolescent
Physical activity
Self-monitoring
Pedometer
Reactivity

ABSTRACT

Objective. To examine whether wearing a pedometer was associated with higher objectively-measured physical activity (PA) among adolescents independent of other behavior change strategies, and whether this association differed by sex or day of wear.

Method. In a parallel-group population-based cohort study, 892 adolescents (43.4% male, mean ± SD age, 14.5 ± 0.5 years) from Eastern England were recruited. PA was measured (in 2005–2006) by accelerometry over four days; a sub-group (n = 345) wore a pedometer coterminously with the accelerometer. Three-level (individual, day of wear and school level) multiple linear regression was used to examine the association between accelerometry (counts/min, cpm) and pedometer wear, stratified by sex and adjusted for weekday/weekend.

Results. For the entire cohort, there was a significant decline in cpm over four days ($p<0.01$). Girls wearing pedometers had higher mean cpm than those not wearing a pedometer, independent of BMI z-score, socio-economic status, weekday/weekend, and school clustering ($\beta = 5.1$; 95% CI: 0.8 to 9.5, $p = 0.02$). This association was not seen in boys.

Conclusion. Pedometer wear was associated with higher PA among adolescent girls, but not boys. Findings may support sex-specific intervention strategies. In addition to pedometer monitoring, additional strategies may be required to promote PA levels, especially among boys.

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Introduction

Insufficient physical activity (PA) among young people is associated with increased risk of obesity and related metabolic disorders (Ekelund et al., 2012). Rapid decreases in PA occur during adolescence (Dumith et al., 2011) and track into adulthood (Telama et al., 2005). Thus, adolescence is a critical period for promoting PA (Corder et al., 2010).

Adolescent PA promotion interventions are often ineffective (Camacho-Miñano et al., 2011; Kriemler et al., 2011; van Sluijs et al., 2011); the reasons for this are largely unknown. One possibility is that adolescents are not aware that they are insufficiently active and therefore are not susceptible to PA promotion (Corder et al., 2011). A promising avenue of PA promotion among adolescents is self-monitoring of behavior (Michie et al., 2009) which may improve awareness of (inadequate) PA levels (Corder et al., 2011).

Pedometers are low cost and provide an interpretable estimate of steps taken with potential for wide scale public health use (Tudor-Locke et al., 2011). Pedometers are often used for self-monitoring PA (Lubans et al., 2009) and as motivational tools (Kang et al., 2009). A recent review examining self-monitoring using pedometers in PA promotion reported a positive association in 3 of the 5 studies among adolescents (Lubans et al., 2009); most included studies combining multiple behavior change strategies together with self-monitoring. Among a small number of young adolescents, viewing pedometer step counts was associated with more steps/day compared to a sealed condition (Shimon and Petlichkoff, 2009), although this study did not use an objective measure to quantify PA. To our knowledge, there is little evidence of how recording pedometer step counts among a large population-based sample of adolescents is associated with objective PA independent of other behavior change strategies.

We hypothesize that wearing a pedometer and recording steps may increase adolescent awareness of their physical activity and therefore be associated with physical activity levels between groups who are wearing and not wearing a pedometer. In the current study we examined whether wearing a pedometer was associated with

* Corresponding author at: Centre for Diet and Activity Research (CEDAR), Box 296, Institute of Public Health, University of Cambridge Forvie Site, Robinson Way Cambridge, CB2 0SR, UK. Fax: +44 1223 330316.
E-mail address: klc29@medschl.cam.ac.uk (K. Corder).

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http://dx.doi.org/10.1016/j.ypmed.2013.01.015

higher objectively-measured PA and whether this association differed by sex or day of wear.

Methods

In the ROOTS study (Goodyer et al., 2010), adolescents from Cambridgeshire and Suffolk schools, UK were recruited at age 14 years to be reassessed with repeat measures of PA and mental health. Between April 2005 and December 2006, 27 secondary schools were approached, and 18 agreed to participate. Study information and consent forms were sent to parents of children aged 14 via schools. Body composition and PA were assessed between November 2005 and July 2007. Of 1185 participants originally agreeing to participate, 998 adolescents and parents (84%) completed postal assent and informed consent for the PA assessment and 931 (93%) attended a school measurement session. The ROOTS study was approved by the Cambridge Local Research Ethics Committee.

Physical activity measurement

Free-living PA was assessed in 931 participants using the Actiheart combined heart rate and movement sensor (CamNTech, UK). The monitor which has been validated to assess PA in youth (Corder et al., 2005, 2007), is attached to the torso using two standard electrocardiogram electrodes and collects heart rate data and includes a uniaxial accelerometer. Data were recorded in 30 s epochs and participants were instructed to wear this waterproof monitor continuously for 24 h, for the remainder of the testing day and then four consecutive days, including a weekend. Participants were fitted with the monitors at the measurement session, and asked to return them one week later.

Overall PA was expressed as mean counts per minute (cpm) for each day of wear. Only movement data were used as we wanted to capture all movement including light-intensity PA; for which heart rate monitoring may have accuracy-related limitations (Livingstone et al., 2000). A custom program removed data recorded after 11 pm and before 6 am; periods of $\geq$60 min with continuous zero counts and days with $<$600 min of recording. To derive time spent in moderate and vigorous PA (MVPA) accelerometry data were transformed for comparability with the Actigraph (Actigraph counts = Actiheart counts $\times$ 5) (Ridgway et al., 2011). Time (min/d) in MVPA was derived using 2000 (Actigraph) cpm on the transformed data as the lower threshold which has been used previously (Riddoch et al., 2004) and is equivalent to walking at 4 km/h (Ekelund et al., 2003). Eight participants had incomplete anthropometric data, leaving 892 individuals with accelerometry data.

Pedometers

A sub-group ($n = 376$) wore a pedometer (OMRON HJ-109) coterminously with the accelerometer. Of those, 373 participants provided at least one day of pedometer data. Subgroups were selected opportunistically on a block basis; if there were enough pedometers for every participant in a measurement session then participants were given pedometers. A mean(SD) of 43.1(23.5)% of students per school wore a pedometer. This pedometer model demonstrates good interreliability between units and accuracy of less than 5% error at walking speeds above 1.56 m/s (Baker et al., 2010; Ryan et al., 2006). Participants were fitted with both monitors in the same measurement session. Pedometers were worn at the waist for four consecutive days, starting the day after the measurement session, and were taken off during sleep and water-based activities. Participants were given pedometer diaries and asked to record the following for each day of wear: the time the pedometer was put on and taken off, the duration of time the pedometer was off during the day (if any), and the total step count when the pedometer was removed at night.

Daily pedometer wear time was calculated by subtracting any time removed during the day from total wear time. If the pedometer was taken off for less than 10 min during a single day, this was ignored. Pedometer and accelerometer data were synchronized by date, participants with at least one matched day of data were included in the final analysis in the pedometer group ($n = 345$). The decision to include one day of data was based on pedometer data from 11,669 5- to 19-yr-olds where the first measurement day provided good reliability relative to the whole week (ICC = 0.79) (Craig et al., 2010).

Biological and social variables

Age and sex were self-reported. Height was measured to the nearest 0.1 cm (Leicester Height Meter; Invicta Plastics, Leicester, UK). Weight was measured to the nearest 0.1 kg (TBF-300A; Tanita, Tokyo, Japan) in light clothing without shoes and socks. BMI was calculated and z-scores derived (Cole, 1997). Previously validated and published equations were used to derive body fat percentage (Tyrrell et al., 2001). Waist circumference was measured horizontally 1 cm above the umbilicus using a fiberglass d-loop tape measure. The 'A classification of residential neighborhoods' index was used as a proxy for area-level socio-economic status, which categorizes UK postcodes into one of five categories using 125 demographic and 287 lifestyle variables (ACORN). Data are presented in three categories: high SES (wealthy achievers, urban prosperity), middle SES (comfortably off) and low SES (moderate means and hard-pressed). Where postcodes are missing and SES data were unavailable ($n = 10$), the school mean was used.

Statistical analysis

Analyses were carried out using STATA 11.0 (Statacorp, College Station, TX, USA). Participant characteristics were described by sex and for participants with and without pedometer data. Data were summarized using means and standard deviations for normally distributed variables and medians and inter-quartile ranges for skewed data. Students T-tests were used to compare characteristics between pedometer groups, stratified for sex. Tests for trend (Wilcoxon rank sum test (Cuzick, 1985)) were used to examine patterns of mean daily accelerometry counts per minute (cpm) over the four days of wear separately by sex and by pedometer wear. Three-level multiple linear regression (day of wear, child and school level) was used to quantify the association between accelerometry cpm and pedometer status over all days of wear. All models were run separately by sex and adjusted for BMI z-score, SES, weekend/weekday and school-level clustering. Wald statistics were used to assess model fit. The reliability of MVPA per participant when including one and four days of data was examined using large one-way ANOVAs. A sensitivity analysis was done removing the 11 participants with only one day of matched pedometer and accelerometer data and results were not materially changed.

Results

Descriptive characteristics are summarized in Table 1. At least one day of complete date-matched pedometer and accelerometry data was available for 892 adolescents and 345 wore a pedometer. No significant differences in MVPA ($p = 0.50$), BMI ($p = 0.88$) or SES ($p = 0.93$) were found between participants who wore pedometers and those who did not. Reliability of MVPA did not markedly differ according to the number of days of matched pedometer and accelerometer data: $>$1 day $r = 0.78$ and 4 days $r = 0.80$.

Mean counts per minute (cpm) by day of wear for pedometer-wear groups are shown separately by sex in Fig. 1 with tests for trend showing PA declines for each group over the four days of measurement. Compared to weekdays, weekend PA (88.4 vs. 75.6 cpm

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