Pedometer step guidelines for physical education settings

Terry Magias <i>Flinders University</i> <i>terry.magias@flinders.edu.au</i>	Kate Ridley <i>Flinders University</i> <i>kate.ridley@flinders.edu.au</i>
Shane Pill <i>Flinders University</i> <i>shane.pill@flinders.edu.au</i>	

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Abstract

The role of Physical Education (PE) in Australia is multifaceted, with physical activity (PA) participation recognised as the means by which a variety of learning outcomes are achieved. There is evidence to suggest that PA accrued during PE has the potential to be health enhancing. It may also be the only opportunity for some children, especially those from low socio-economic backgrounds to accrue PA. This paper identifies criterion-referenced pedometer step guidelines as a valid, reliable, unobtrusive, and cost-effective means by which PA can be objectively quantified in PE settings. With the current state of the Health and Physical Education national curriculum area in focus, the application of pedometer step guidelines in PE settings are outlined.

Introduction: Physical activity and the curriculum

The Australian Curriculum for Health and Physical Education (ACHPE) suggests that Physical Education (PE) should be a foundation for lifelong physical activity (PA) participation. It also recommends appreciation of the significance of PA in society locally and globally (Australian Curriculum, Assessment and Reporting Authority, 2014). Brooker and Clennet (2005) suggested that although government and public expectations of PE to realise PA participation outcomes has served to narrow the scope of health and PE, few would argue that PA participation is not inherent to Australian PE. The Australian Council for Health, Physical Education and Recreation (ACHPER) (2009) acknowledge this position in a statement that is intended to inform the development of the Australian Health and Physical Education (HPE) Curriculum:

Contexts of physical activity and sport are therefore central to HPE (ACHPER, 2009, p. 3-4) [...] “Students should be provided with HPE learning experiences that will enable them to” (ACHPER, 2009, p. 5-6).

Although PA participation is recognised as the means by which PE learning outcomes can be realised and that PA appreciation and participation beyond the PE setting “now and in the future” is a goal rather than PE’s primary statement of learning content, PA is intrinsic to Australian PE contextually and pedagogically.

Physical activity in physical education

Several studies have shown that PA accrued in PE settings is associated with improved health outcomes in children and adolescents weight status (Datar & Sturm, 2004; Sollerhed & Ejlertsson, 2008; Wardle, Brodersen & Boniface, 2007) bone health (Weeks, Young & Beck, 2008) and blood pressure (Mc Murray et al., 2002). Some evidence also indicates that engagement in PE during childhood is associated with long-term positive effects on PA level, attitudes toward PA, and perceptions of barriers to PA during adulthood. Additionally, review papers have identified associations between curricular-PA or PE and academic performance. The contribution PE-based PA makes in relation to total daily PA levels or meeting Moderate to Vigorous Physical Activity (MVPA) recommendations is potentially considerable. Upper primary and lower secondary school students have been found to acquire approximately 11- 33% of daily MVPA during PE lessons (Fairclough & Stratton, 2005; Wickel & Eisenmann, 2007). In relation to total daily PA levels, children aged 11-13 years have been found to accumulate 15.6%– 23.7% (boys) and 14.9%-17.2% (girls) of total daily pedometer step counts during PE lessons 45-50 minutes in duration (Flohr, Todd & Tudor-Locke, 2006; Reed, Metzker & Phillips, 2004). Smaller step contributions (boys = 8.7%, girls = 11.4%) have been found for 30-minute PE classes among children of a similar age (boys = 8.7%, girls = 11.4%) (Tudor-Locke, Lee, Morgan, Beighle & Pangrazi, 2006). There is some indication that children who are among the least active of their peers on most school days are likely to gain greater proportional increases (+18%) in PA from school days with PE compared to children who are consistently more active (+9-13%) (Morgan, Beighle & Pangrazi, 2007). For the school day, PE has been identified as being the largest contributor of PA (as measured via pedometers) for girls (14.3%) and the second largest for boys (12.7%) behind lunchtime (Brusseau et al., 2011).

Despite the potential health, academic and lifelong engagement benefits of PA in PE settings, a specific PA duration & intensity guideline has not been recommended in Australian PE curricula, or developed by a professional organisation. Outside Australia, PA time guidelines that relate to PE settings exist. For example, United States (US) guidelines recommend that adolescents (grades 7-12) spend 50% of PE class time engaged in PA (Physical Activity Guidelines Advisory Committee, 2008). A separate guideline developed by the American Heart Association recommends that all school children and youth should engage in at least 30 minutes of MVPA during school hours (including PE class time) per day (Pate et al., 2006). Presently, no other PA time guidelines specific to PE settings have been developed.

Measuring physical activity in physical education settings (pedometry)

A variety of PA measurement methods and instruments are used by researchers and practitioners to measure PA type, duration, intensity and frequency (Welk, 2002). Each method can be classified into a validity/reliability hierarchy containing three categories. These are criterion, objective and subjective PA measures (Sirard & Pate, 2001). Criterion measures are considered the most accurate assessment method and are often used to validate the ability of objective and subjective instruments in measuring PA (Welk, 2002). Each measure possesses strengths and limitations underpinned by its feasibility, reliability and validity in PA contexts.

Pedometry and the direct observation instrument, the System for Observing Fitness Instruction Time (SOFIT) have been used widely to measure PE-based PA for research purposes, though both measures pose limitations. For example although pedometry is cost-effective (Welk, 2002) it is unable to assess intensity, frequency, and duration of PA (Corder, Ekelund, Steele, Wareham & Brage, 2008). Conversely, while SOFIT has been proven to be valid and reliable (McClain, Abraham, Brusseau & Tudor-Locke, 2008) in measuring PE-based PA, the direct observation method itself is time intensive with regard to collecting data and training

observers (Welk, 2002). Criterion referenced pedometer steps/min scores that are associated with various levels of PA provide an objective and validated option for measuring PA in PE. Therefore, they may be helpful as a practical, valid and reliable means by which PA levels can be measured in PE settings for research purposes. They may also be used as a reference point by which the effectiveness of PE programs can be assessed in terms of their ability to engage students in PA.

Three mechanism types are available for electronic pedometers including spring-levered, those that contain a magnetic reed proximity switch and piezo-electric models. The piezo-electric mechanism has been identified as possessing superior step-counting accuracy among children, undercounting steps -0.2% - 4.2% compared to spring-levered designs which have shown accuracy discrepancies upwards of 25% (Nakae, Oshima, & Ishii, 2008). Accuracy differences are particularly pronounced at slower walking speeds, likely due to the vertical acceleration forces produced during slower speeds falling short of the 0.35g of force needed in order for steps to be registered in spring-levered models (Duncan, Schofield, Duncan, & Hinckson, 2007).

Pedometer steps per minute guidelines in physical education settings

While raw pedometer step counts do not provide information on PA intensity, frequency, or duration (Corder et al., 2008) six studies have developed pedometer steps/min intervals criterion-referenced by the direct observation instrument SOFIT, that equate to spending one third to a half of PE class time engaged in MVPA. The one third guideline was adapted from the Centre for Disease Control and Prevention and the Council for Physical Education and Children (cited in Scruggs, 2007a) who stipulated that students in the United States in grades K-6 should spend a significant proportion of PE lesson time engaged in PA. The United States Department for Health and Human Services recommendation that students in grades 7-12 spend 50% of PE class time engaged in PA (US Department of Health and Human Services, 2009). For the one third MVPA criteria, similar pedometer steps/min intervals were found across four studies ranging from 60.8-65.0, mainly among primary children aged between 6.9 and 13.8 years old (Scruggs et al., 2003, Scruggs, Beveridge, Watson, & Clocksin, 2005, Scruggs 2007b, Scruggs 2013b). For spending half of PE class time engaged in MVPA as recommended by The United States Department for Health and Human Services (2009), two studies found greater steps/min ranging from 79.1-88.0 for youth aged 12.5-15.5 years (Scruggs 2007a & Scruggs, Mungen & Oh, 2010). A follow up study sought to identify optimal steps/min intervals for both 33.33% and 50% MVPA criteria from combined data sets from previous research (Scruggs, 2013b). The findings of the study indicated that it was possible for common steps/min intervals to be set for students in 1st through to 12th grade Physical Education (United States). Steps/min intervals of 59.5-61.8 and 82.5-88.1 were identified for the 33.33% and 50% MVPA criteria respectively (Scruggs, 2007a; 2007b; 2013a; 2013b; & Scruggs et al., 2010).

The present study aimed to expand upon previous research by assessing external validity of previously developed pedometer steps/min intervals and identify those most accurate for invasion sport games in lower PE grade settings. Invasion sports were considered to be land-based games that require students to maintain possession of a ball by passing, receiving and supporting (Griffin & Butler, 2005). The PE lesson context was delimited to those scheduled for 30-45 minutes, mixed gender, and involved netball gameplay. The piezo-electric New Lifestyles NL-1000 pedometer was used in this study. The NL-1000 has shown promise for research applications in being considerably more accurate in counting steps amongst youth (Nakae et al., 2008) and adults (Clemes, O'Connell, Rogan, & Griffiths, 2010) compared to

spring-levered pedometers, particularly at slower walking speeds. Because no PE specific PA guidelines exist in Australia that relate to intensity, both the 33.33% and 50% of PE class time spent in MVPA recommendations were quantified in the present study.

Methods

A correlational explanatory/prediction design was applied. The explanatory aspect relates to determining the strength of the relationship between pedometry and time spent in MVPA correlate. The prediction aspect relates to cross-validating previously established pedometer steps/min intervals for primary and secondary school students to the present study and identifying which steps/min score best predicts lower secondary school students as meeting recommendations of spending one third to a half of PE class time engaged in MVPA.

Participants ($n = 37$) were adolescent males ($n = 15$) and females ($n = 22$) aged between 12-14 years ($M = 14.1$, $SD = 0.6$ y.) undertaking PE at one of two South Australian independent secondary schools selected for the study. Participants were in school year levels 8 ($n = 26$, $M = 13.9$, $SD = 0.4$ y) or 9 ($n = 11$, $M = 14.8$ y, $SD = 0.5$ y).

At the time the data collection occurred, the lower secondary co-educational PE class groups were involved in an 'invasion' sport unit. To enable assessment of the effectiveness of steps/min cut points to accurately classify PA levels of boys and girls, co-educational class groups were sought as PA differences have been noted on the basis of gender in PE settings (Scruggs, 2007b). Class duration (i.e. active teaching between teacher and students) was between 25 and 27 minutes in duration. Non-probability convenience sampling was applied. Although a representative sample (with respect to potentially influencing factors such as height and weight) was not acquired, lower secondary PE students were not sampled on any specific characteristic (i.e. schools randomly allocated students into PE classes at these grade levels). Hence, pedometer steps/min scores are still likely to be valid in lower secondary PE contexts similar to that of the present study.

The direct observation instrument SOFIT was used as the PA measure for this study. The original SOFIT version requires observers to observe a single participant for 10 seconds and manually record codes that represent observations for PA behaviour, lesson context, and teacher behaviour in another 10 second interval. This version of SOFIT was adapted for the purposes of this study. Firstly, only PA behaviour data were recorded to meet study objectives. PA duration data was collected for lying, sitting, standing, walking, and vigorous PA behaviours as per the original SOFIT version (McKenzie, 2009). Walking is considered a moderate PA behaviour whilst vigorous behaviours are those that require more energy to be expelled than what would be required for ordinary walking (i.e. jogging and jumping) (McKenzie, 2009).

SOFIT was also combined with the computer program Dartfish which allowed for data on PA duration to be coded on a continuous basis via a stopwatch button system. Four video cameras were strategically positioned to video record the PE lessons. Video footage was then uploaded into the Dartfish computer program. Within Dartfish, SOFIT PA behaviour categories were allocated to a computer keyboard key (e.g. walking = # 1, vigorous PA = #2). Retrospective, continuous observation analysis allowed for total time spent in PA behaviour categories to be more accurately determined as opposed to the 10 second observe/record intervals.

Statistical analysis was performed using IBM SPSS Statistics 18.0.2. Three primary statistical tests were undertaken on collated data to address the proposed research objectives. Given the focus of this paper for practitioners, these tests and their results are synthesised into the discussion section of this paper. This study was approved by Flinders University Social and

Behavioural Research Ethics Committee in 2010. The project was given final approval following school (site) research approval. This study's narrow delimitations (i.e. lower secondary school students participating in netball games) and small sample size limits the generalisability of identified steps/min intervals. A strength of the study was the synthesis of SOFIT with a duration recording computer program (Dartfish). Specifically, duration recording allowed for observed PA behaviours to be recorded continuously rather than within 10 second observe/record intervals.

Results and discussion

A primary objective of this study was to correlate PA measures of pedometer steps/min and directly observed MVPA. Pedometer steps/min was found to have a strong and statistically significant correlation with %MVPA time ($r = 0.82$, $p < 0.001$; $n = 37$). This finding is consistent with previous research on the topic in which similarly high correlations ranging from $r = 0.74 - 0.99$ ($p \leq 0.05$) were identified with six of eight coefficients being $r = 0.80$. Physical Educators can therefore be confident in using pedometers to assess PA levels over time or compare groups of students of similar age and anthropometrical characteristics.

Known factors impacting upon pedometer accuracy, were considered in the study design which may have contributed to the strength of the relationship between pedometry and directly observed MVPA. These included the placement of pedometers at the anterior midline of the right thigh as recommended (Horvath, Taylor, Marsh, & Kriellaars, 2007) and the use of piezo-electric pedometers which have demonstrated superior step counting accuracy compared to other mechanism types. In particular, piezo-electric pedometry has demonstrated accuracy at slower gait speeds (i.e. walking) compared to those of a spring-levered design (Nakae et al., 2008). This may have been significant given that participants spent a significant amount of time in moderate activity which included light walking movements during netball gameplay (41.4%). The use of elastic waist-bands to secure pedometers in an upright position may have also helped to reduce pedometer tilt angle which may result in undercounting of steps due to the nature of the counting mechanism within pedometers (Nakae et al., 2008).

Diagnostic efficiency of pedometer step per minute guidelines

Pedometer step per minute guidelines corresponding to spending one third of PE lesson time in MVPA

An interval of 52-64 steps/min was found to correspond to spending one third of PE class time engaged in MVPA for this study. Sensitivity and specificity for 52-64 steps/min was high, ranging from 0.91-1.00 indicating a high probability of correctly classifying participant compliance and non-compliance for this MVPA criteria. This interval classified 0.91%-100% of cases correctly in relation to meeting the 33.33% MVPA criteria. A linear regression equation found a similar result at 58 steps/min to predict 33.33% MVPA time. Four previous studies identified similar steps/min intervals with 58-65 steps/min among samples ranging from $M = 6.9-13.8$ years (Scruggs et al., 2003; 2005; 2007b) compared to $M = 14.1$ years in the present study. Scruggs (2013b) analysed data from previous studies for the 33.33% MVPA criteria and identified 59.5-61.8 steps/min as being optimal for children in 1st to 7th grade PE (mean age for samples ranged from 6.9-13.8 years). The lower limit of the 52 steps/min found in the present study likely fell short of Scruggs' lower limit of 59.5 steps/min due to the small sample size and high compliance in meeting the 33.33% MVPA criteria.

Although the present study focused on the team-based invasion sport of netball gameplay only, the studies by Scruggs and colleagues relating to the 33.33% MVPA criteria involved a variety of activities that required a significant amount of movement that is non-bipedal in

nature. This would have increased variability relating to compliance and non-compliance with MVPA criteria (i.e. sensitivity and specificity). These activities included archery, hoola-hoop exploration, ball gymnastics, rope courses, stunts, tumbling & fitness stations (Scruggs et al., 2003; 2005).

Pedometer step per minute guidelines corresponding to spending 50% of physical education lesson time in moderate to vigorous physical activity

As may be expected, a greater interval in 73-76 steps/min was identified from sensitivity and specificity statistics as being diagnostically efficient in corresponding to 50% of PE class time engaged in MVPA. Linear regression produced a similar steps/min score of 72. The 73-76 steps/min interval classified 86.48% - 94.59% of participants as correctly meeting or not meeting the 50% MVPA recommendation. However, previously established steps/min scores did not align with these results. Scruggs found greater steps/min intervals for the 50% MVPA recommendation of 79-86 among participants of a similar age (12.9 – 13.8 years in Scruggs 2007a & Scruggs 2013b). A higher steps/min interval of 80-88 steps/min was found in another study among older participants (16.5 years in Scruggs et al., 2010). It is unclear what may account for the difference in steps/min intervals identified between the present study and Scruggs' research. Given the focus of the PE lessons being entirely on netball gameplay, higher steps/min scores may be expected. One possibility is that the high levels of compliance in meeting the 50% MVPA guideline (i.e. 78.4%) meant that fewer false positive classifications were made (i.e. specificity). With reduced false positive classifications, specificity values would hold a higher value at lower steps/min intervals, thus influencing the selection of optimal steps/min guidelines.

Sensitivity and specificity values for 73-76 steps/min in the present study (0.86-0.89) were lower than that achieved for 79-86 steps/min (≥ 93.66 -98.59) identified in Scruggs' 2013b study, which analysed data for the 50% MVPA criteria from previous research. Scruggs 79-86 steps/min interval classified 91.11% - 96.89% of participants correctly within the studies from which they were identified (Scruggs et al., 2007a; 2010), but only classified 48.64% - 78.37% of participants in this study correctly in meeting the 50% MVPA recommendation. This finding presents several points of interest. This difference in classification accuracy may be due to the present study focusing on netball gameplay only, whereas lesson themes in Scruggs' studies were highly diverse ranging from individual sports (i.e. archery), activities that contained a significant non-bipedal component (i.e. gymnastics, rope courses and tumbling) in addition to some invasion based team-sports (i.e. flag football, lacrosse, ultimate frisbee, and basketball). This may indicate that steps/min scores should not be applied outside the context from which they are developed (i.e. if Scruggs steps/min scores were applied to netball gameplay only, classification accuracy may be low - 48.64% - 78.37%, as indicated in the present study). Pedometer steps/min guidelines in general may be more appropriate for large scale monitoring of PA levels across multiple lessons. Future studies with sufficiently large sample sizes should be undertaken to assess the reliability of identified pedometer steps/min intervals to assess the influence PA type and lesson composition (i.e. teacher instruction, skill drills, gameplay) has on the reliability of steps/min intervals in predicting %MVPA time. For the physical educator, it may be more appropriate to have steps/min guidelines sets for activity categories (e.g. invasion sports, net/wall games, target games). Despite comparatively moderate sensitivity and specificity levels for 73-76 steps/min in this study, overall diagnostic efficiency was high with AUC = 0.90. Scruggs found greater AUC values of ≥ 0.97 (Scruggs, 2007a; Scruggs et al., 2010; Scruggs, 2013b) in relation to the same MVPA recommendation. For the studies that quantified 50% MVPA, mean PE lesson time was greater (33.2 ± 3.01 min, Scruggs, 2007a; 49.69 ± 19.77 min in Scruggs et al., 2010; 38.23 ± 16.36 min in Scruggs, 2013a) compared to the present study (26.3 ± 3.5 minutes).

The application of a piezo-electric pedometry was a strength of the present study given its superior step counting accuracy compared to spring-levered models (Nakae et al., 2008) and resilience to inaccuracy associated with pedometer tilt (Crouter, Schneider & Bassett, 2005). The application of the direct observation instrument SOFIT as the comparative measure was also a strength given its established validity against accelerometry and indirect calorimetry (Honas et al., 2008) in PE settings. Moreover, the synthesis of SOFIT with a duration recording computer program (Dartfish) meant a more rigours approach could be taken in assessing pedometer validity. Specifically, duration recording allowed for observed PA behaviours to be recorded continuously rather than within 10 second observe/record intervals. In the latter, the assumption is made that what is seen during the observe interval characterises behaviour occurring during the record interval. Although SOFIT was designed to record data in real-time whereby observers manually record behaviours from several participants to capture group PA levels, retrospective analysis via recorded video footage was employed. This meant that each participant's PA behaviour was able to be analysed for PE lessons in their entirety, allowing for a more accurate assessment of the relationship between PA measures. Additionally, recorded video footage was reviewed at half-speed so that recorded PA behaviours could be more accurately coded with respect to duration.

Conclusion

As PA is a central focal point by which learning outcomes are realised in the Australian HPE Curriculum (ACARA, 2014), the application in which pedometry may be used to assess PA levels will vary depending on the needs and structure of school PE programs.

We have suggested that a pedometer PA guideline will encourage the development of school and community based PA programs for young Australians (Trost, 2005) and PE as an opportunity for children and adolescents to accrue MPVA towards meeting this PA guideline. PA participation is not an independent objective of PE in itself but the means by which a variety of learning objectives are achieved. While PA participation is one facet of PE, for some children particularly those from low socio-economic backgrounds school PE may be the only setting in which MVPA is accrued and important generalisable movement skills developed (McKenzie, 2010).

The strong correlation between pedometer steps/min and %MVPA time in this study align with Scruggs' research to support pedometer steps/min as an accurate indicator of %MVPA time for young people in PE settings. Physical Educators can therefore be confident in using pedometry as a valid indicator of student PA levels. An interval of 52-64 was found to be diagnostically efficient in quantifying 33.33% MVPA among lower secondary PE students aged 12-14 years. This was similar to previous studies that collectively found 58-65 steps/min among youth aged 6.9-13.8 years (Scruggs et al., 2003; 2005). A steps/min interval of 73-76 corresponding to 50% MVPA did not align with previous research previously identified 79-86 among youth of a similar age and older (12.9 - 16.5 years in Scruggs 2007a; Scruggs et al., 2010 & Scruggs 2013b). The findings of this study support 55-64 but not 79-86 steps/min in quantifying 33.33% and 50% of PE lesson time, respectively as previously discussed.

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