TITLE: A monitoring system to provide feedback on student physical activity during physical education lessons.

RUNNING HEAD: Physical activity monitoring system

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Abstract

School-based physical education (PE) provides opportunities to accumulate moderate-to-vigorous physical activity (MVPA), but many students are insufficiently active during PE lessons. Providing teachers with feedback regarding their students' physical activity may increase the effectiveness of PE for achieving MVPA goals, but existing physical activity monitoring technologies have limitations in class environments. Therefore, the purpose of this study was to develop and validate a system capable of providing feedback on PE lesson MVPA. Equations for translating step counts to %MVPA were derived from measures in 492 students who concurrently wore an ActiGraph GT3X+ (ActiGraph, USA) and Yamax pedometer (Yamax, Japan) during a PE lesson. To enhance feedback availability during PE lessons we then developed a bespoke monitoring system using wireless tri-axial pedometers (HMM, Germany) and a smart device app. After developing and testing the monitoring system, we assessed its validity and reliability in 100 students during a PE lesson. There was a strong correlation of 0.896 between step counts and accelerometer-determined %MVPA and quantile regression equations showed good validity for translating step counts to %MVPA with a mean absolute difference of 5.3 (95% CI, 4.4-6.2). The physical activity monitoring system was effective at providing %MVPA during PE lessons with a mean difference of 1.6 ± 7.1 compared with accelerometer-determined %MVPA (7% difference between the two measurement methods). Teachers and students can use a smart device app and wireless pedometers to conveniently obtain feedback during PE lessons. Future studies should determine whether such technologies help teachers to increase physical activity during PE lessons.

Keywords: Physical education, moderate-to-vigorous physical activity, MVPA, accelerometer, step counts, ActiGraph

1. INTRODUCTION

School-based physical education (PE) provides opportunities for children and adolescents to accumulate a portion of the recommended target of 60 minutes per day of moderate-to-vigorous physical activity (MVPA).[1,2] In recognising the value of PE settings for physical activity, the US Center for Disease Control and Prevention and the United Kingdom's association for Physical Education recommend that school students engage in MVPA for at least 50% of PE lesson time.[3,4] Systematic reviews have identified that this target is rarely achieved, with the mean lesson time spent in MVPA ranging between 34% and 45%.[5-7] Being insufficiently active during PE is a missed opportunity for achieving MVPA goals and increasing physical activity in children and adolescents. However, teachers can use strategies such as focusing on class organization, management and instruction, and supplementing usual PE lessons with targeted high-intensity activities to increase physical activity during lessons.[8]

Quantifying and providing teachers and students with feedback on physical activity may be a valuable approach to increase the proportion of lesson time spent in MVPA.[9-11] Measurement and feedback are critical components of behavior change techniques that underpin successful physical activity interventions. The types of measurement and feedback obtained from pedometer-based programs for example, facilitate self-monitoring, personalized feedback, and self-selected incremental goal setting and have been shown to contribute to behavioral change.[12,13] While many acceptable objective accelerometery and heart rate-based methods exist to quantify physical activity, most are not feasible or cost-effective for long-term monitoring in school environments and few are able to provide feedback in a practically useful time-frame.[14] Recent developments in physical activity monitoring device technology have created opportunities for individuals to track physical activity using accelerometer and pedometer devices that are increasingly affordable and convenient. There has been a rapid uptake of these devices and a growing body of evidence that the feedback available to users can modulate physical activity among healthy and clinical populations.[15-19] However, the classroom is a unique environment where physical activity opportunities are primarily modulated by the teacher who cannot easily be provided with feedback on group, or individual student performances during the lesson. Obtaining and aggregating individual students' physical activity measurement at the end of a lesson is often impractical and feedback might only available at a later time after appropriate processing of individual student raw data.

Therefore, opportunities to determine the efficacy of physical activity monitoring and feedback in school settings to increase PE lesson physical activity are limited because most existing monitoring technologies either provide only individual user feedback or are not compatible with the constraints of class environments. Since providing feedback on physical activity may increase the effectiveness of PE for achieving MVPA goals the purpose of this study was to develop and validate a physical activity monitoring system capable of providing group and individual feedback on the proportion of PE lesson time that students spend in MVPA (i.e. PE lesson %MVPA).

2. METHODS

2.1 Study design and participants

Four hundred and ninety-two grade eight students (13.5 ± 0.5; 49% girls) from seven public secondary schools and one-hundred grade three and four students (10.6 ± 0.7; 56% girls) from two public primary schools participated in this study. The study took place in class settings and measurements were obtained from students participating in PE lessons under the supervision of their teacher. Teachers delivered usual PE lessons but were asked to incorporate a variety of activities including invasion games and games involving fundamental movement skills such as skipping, throwing, and catching. No additional instructions were provided to teachers or students so that the class physical activity monitoring system could be developed and evaluated in an ecologically valid setting. The study was conducted in accordance with the Australian Catholic University Human Research Ethics Committee requirements (reference: 2014185N). School principals agreed to the proposed study and students and parents provided written informed consent.

2.2 Translation of step counts to %MVPA

Step counts can easily be obtained during PE lessons from inexpensive pedometers but in order to provide feedback on PE lesson %MVPA, step-count data need to be translated into %MVPA. Step counts are strongly correlated with accelerometer MVPA for a range of population ages and activity types and have previously been successfully translated to MVPA estimates with acceptable convergent validity in studies of free-living adults[20] and children.[21-26] Step-count cut-points for meeting or not meeting 50% MVPA during PE lessons have also previously been established.[27-29] For example, in seventh and eighth grade students Scruggs et al. determined the optimum step-count cut-point for achieving 50% MVPA during a PE lesson to be 82-88 steps per minute.[28] However, these equations only provide binary level feedback and were not

available to translate step counts into PE lesson %MVPA. Therefore, the relationship between PE lesson step counts (predictor measure) and accelerometer %MVPA (criterion measure) was used to derive equations for translating step counts to %MVPA. Four hundred and ninety-two students concurrently wore an ActiGraph GT3X+ (ActiGraph, Florida USA) and Yamax Digi-Walker SW pedometer (Yamax, Tokyo Japan) on an elastic belt secured across their hips during PE lessons ranging between 40 and 110 minutes in duration. Prior to data collection, ActiGraph accelerometers were initialized and set to record using a 60Hz epoch. ActiGraph data were processed using Actilife software (Version 6, ActiGraph, Florida USA) with 1 second vertical axis data[30] used to classify activity intensity according to Evenson cut-points (moderate-to-vigorous activity >2296 counts per minute).[31] A cut-point for excluding participants was set at < 2 steps per min (n = 7 excluded). This roughly equates to the 1000 steps per day cut-point proposed by Rowe et al. for excluding pedometer data in children.[32] We used a one-third, leave-one-out cross-validation technique[33] on the remaining 485 participants. Participants were randomly assigned to a training sample (n = 323) or a hold-out validation sample (n = 162). We developed regression equations using the training sample and then used the hold-out validation sample to test the accuracy of those equations for estimating %MVPA.

2.3 Class physical activity monitoring system

To enhance feedback availability during PE lessons we developed a bespoke physical activity monitoring system that allows a teacher to measure and conveniently obtain feedback on PE lesson %MVPA of all students participating in a lesson. Each student wears a pedometer (SmartLAB® move+, HMM, Dossenheim Germany) on their waistband which wirelessly communicates with a custom designed mobile device application (app) to provide group and individual feedback on %MVPA achieved during the lesson. SmartLAB® move+ pedometers are commercially available piezoelectric tri-axial pedometers. We chose to develop the monitoring system using these devices because they are small (12 grams), battery operated, tamper proof and inexpensive with a cost of approximately 20 USD per device. We designed a mobile device app to communicate with the pedometers via an ANT+ wireless sensor network. ANT+ wireless networks are capable of sending and receiving multiple wireless signals at the same time which allowed the system we developed to connect and upload physical activity data from a whole class to the mobile device in just a few seconds. On shared mobile devices there is an option for teachers to create a password protected user account. The account also allows teachers to manage previously tracked lessons via a 'Lesson history' function. After signing in to their account, teachers are able to use the app to create a new

lesson. This can be done by pressing 'start' and 'stop' in the app at the beginning and end of a lesson or by manually entering a lesson start and finish time in the app. Once a lesson duration has been designated in the app, the pedometers will begin uploading their data to the mobile device. A screen in the app confirms that each pedometer has uploaded its data and proceeding to the 'Lesson result overview' allows teachers and students to view individual and group summary feedback on physical activity levels achieved during the lesson. The app screens can be viewed in Appendix 1.

2.4 Validity and reliability of the class physical activity monitoring system

After developing and testing the useability of the app and wireless communication system, we assessed the validity and reliability of the monitoring system during usual PE lessons with classes of up to 23 students at a time. ActiGraph was used as the criterion measure of %MVPA and compared against %MVPA determined by the class physical activity monitoring system. One hundred students wore an ActiGraph GT3X+ and SmartLAB® move+ pedometer on an elastic belt secured across their hips during PE lessons ranging between 35 and 50 minutes in duration. A sub-sample of 60 students wore two SmartLAB® move+ pedometers during the lesson to assess inter-instrument reliability. Lesson start and end times were recorded in minutes to ensure total lesson time was synchronously matched between the class physical activity monitoring system and the processed ActiGraph data. Additional laboratory testing assessed the technical reliability of the SmartLAB® move+ pedometers and results of these tests are available in Appendix 2.

2.5 Statistical analysis

Descriptive data are presented as means ± SD. To test the assumptions of the leave-one-out cross-validation method an independent t-test compared differences between the training and hold-out validation samples. We used Pearson r correlation and ordinary least squares (OLS) linear regression to explore the relationship between pedometer step counts and accelerometer %MVPA. A Breusch-Pagan test confirmed the presence of heteroscedasticity ($P < 0.0001$). Therefore, to improve the regressions used for translating step counts to %MVPA, we used a quantile regression approach. In order to explore the effects of the independent variable on the dependent variable for a wide range of the frequency distribution, we used equal quantiles at 0.1 intervals in the quantile regression model. We retained quantile regression coefficients that were different from zero and different from the OLS coefficient and tested these equations on the hold-out validation sample. We calculated mean absolute difference and 95% confidence

intervals for regression derived %MVPA and accelerometer-determined %MVPA. We assessed reliability, convergent validity and agreement between the class physical activity monitoring system and ActiGraph using a Bland-Altman approach including 95% limits of agreement. Data were further examined using regressions and sensitivity analyses. A two-one sided test regression (10% equivalent region) assessed equivalence between the class physical activity monitoring system and ActiGraph %MVPA. Inter-instrument reliability was determined using coefficient of variation ($\%CV_{INTER}$). We analyzed data using Microsoft Excel 2010 and R software 3.4.1 (BlandAltmanLeh, ICC, equivalence). Significance was set at an alpha level of $P < 0.05$ for all tests performed.

3. RESULTS

Demographic and physical activity descriptive characteristics of participants are shown in Table 1. There were no statistically significant differences in the means of the training and hold-out validation samples.

TABLE 1 Mean ± SD demographic and physical activity measures during PE lessons.

	Training sample	**Validation sample**	**Convergent validity**
n	323	162	100
Age (yrs)	13.5 ± 0.5	13.5 ± 0.5	10.6 ± 0.7
Lesson (min)	68.7 ± 22.2	67.6 ± 21.6	47 ± 6
Steps	2950 ± 1491[a]	3025 ± 1516[a]	2136 ± 851[b]
Steps·min^{-1}	43.5 ± 17.8	44.9 ± 17.7	45.4 ± 8.3
%MVPA	23.8 ± 8.9	24.2 ± 8.6	24.2 ± 10.7

[a]Step counts from Yamax pedometers. [b]Step counts from SmartLAB® move+ accelerometers. Steps·min^{-1}, total steps divided by lesson time; %MVPA, percent moderate-to-vigorous physical activity from ActiGraph GT3X accelerometers.

3.1 Translation of step counts to %MVPA

There was a strong positive correlation of 0.896 (95% CI, 0.875-0.914; $P < 0.0001$) between step counts and accelerometer-determined %MVPA. The OLS regression coefficient for estimating %MVPA from step counts was 1.35 ($P < 0.0001$; 95% CI, 1.19-1.51). Quantile coefficients for quantile 0.1 (coefficient = 1.16; 95% CI, 1.15-1.17) and quantile 0.7 (coefficient = 1.56; 95% CI, 1.55-1.58) were different from the OLS model and were retained (Table 2). Using only the OLS coefficient, mean absolute difference for measured vs. predicted %MVPA was 7.5 (95% CI, 6.4-8.6). Applying the 0.1, 0.7 quantile regressions significantly improved the predicted %MVPA in the hold-out validation sample with the mean absolute difference reducing to 5.3 (95% CI, 4.4-6.2).

TABLE 2 Regression analysis estimates for %MVPA based on step count data obtained during physical education lessons.

	OLS Regression	Quantile Regression at 0.1 quantile	Quantile Regression at 0.7 quantile
%MVPA	1.35	1.16	1.56
Intercept	11.25	1.58	13.43

%MVPA, percent moderate-to-vigorous physical activity; OLS, ordinary least squares.

Table 3 shows the regression equations used for corresponding values of steps per minute during PE lessons. There was a moderate but not significant correlation of 0.598 (95% CI, 0.282-0.932; $P = 0.156$) between steps per minute and %MVPA for steps per minute below 10. Therefore, regression equations could not reliably estimate %MVPA when steps per minute were less than 10. For all other ranges of steps per minute, the equations in table 3 can be used to translate steps per minute to PE lesson %MVPA.

TABLE 3 Equations for converting steps per minute to PE lesson %MVPA.

Condition	Equation
IF steps per minute ≥ 10 and < 20	%MVPA = (steps$\cdot$min^{-1} − 1.58)/1.16
IF steps per minute ≥ 20 and < 53	%MVPA = (steps$\cdot$min^{-1} − 11.26)/1.35
IF steps per minute ≥ 53	%MVPA = (steps$\cdot$min^{-1} − 13.43)/1.56

Steps$\cdot$min^{-1}, total steps divided by lesson time; %MVPA, percent moderate-to-vigorous physical activity

3.2 Validity of the class physical activity monitoring system

Convergent validity was assessed by determining the bias (mean difference between measures) and 95% limits of agreement between %MVPA from the class physical activity monitoring system and ActiGraph-determined %MVPA (see Bland-Altman plot in Figure 1A) during usual PE lessons. There was a small bias of 1.6 ± 7.1 with 95% limits of agreement -12.3-15.5. Equivalence testing (95% CI, 0.48-2.84) indicated that %MVPA estimated using the class physical activity monitoring system was equivalent to ActiGraph-determined %MVPA. A regression of class physical activity monitoring system and ActiGraph %MVPA revealed a cluster of outliers. These were determined to be from a single class of 20 students. After excluding these outliers, we performed a sensitivity analysis on the remaining participants (n = 80). This analysis produced an even smaller mean bias of 0.07 ± 5.8 and narrower 95% limits of agreement -11.2-11.4 than results from the entire sample.
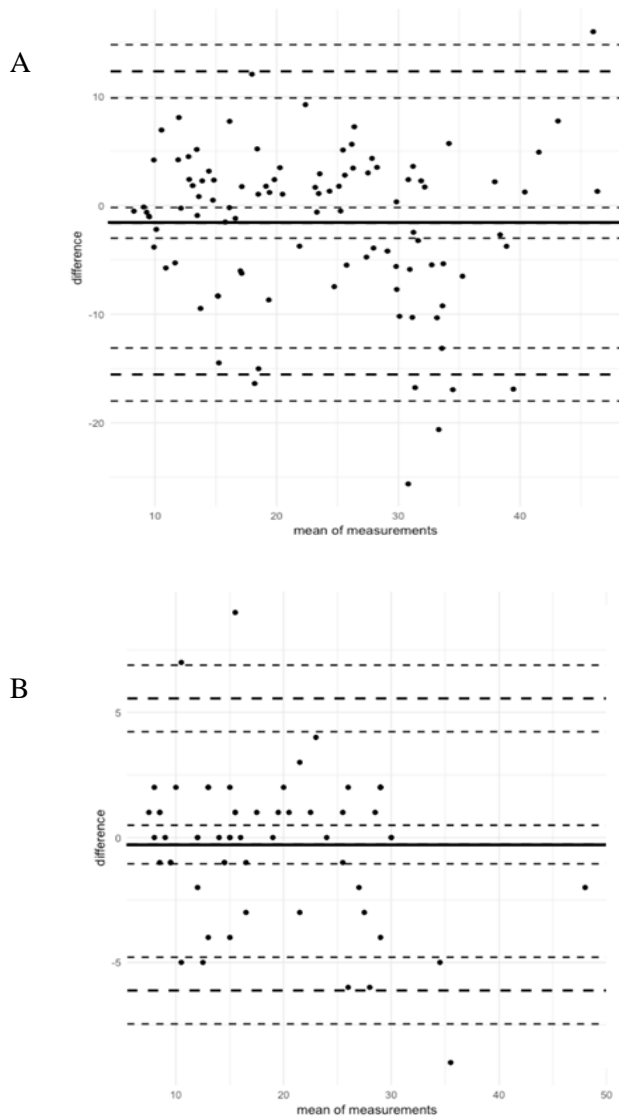
Figure 1. (A) Bland-Altman plot representing differences between class physical activity monitoring system %MVPA and ActiGraph-determined %MVPA. Mean of two measurements plotted against difference. (B) Bland-Altman plot of the reliability of the class physical activity monitoring system during PE lessons. Mean of two SmartLAB® move+ devices plotted against difference Solid line is bias, bold dotted lines show 95% limits of agreement, and light dotted lines show 95% confidence intervals.

3.3 Reliability of the class physical activity monitoring system

The Bland-Altman plot (Figure 1B) shows a small bias of -0.28 (SD = 2.98) with narrow 95% limits of agreement -6.12-5.55 for the reliability of the class physical activity monitoring

system in a sub-sample (n = 60) of students wearing two SmartLAB® move+ pedometers during PE lessons. The intra-instrument coefficient of variation for %MVPA from two devices was 6.2% ± 6.8.

4. DISCUSSION

The purpose of this study was to develop and validate a physical activity monitoring system capable of providing group and individual feedback on the proportion of PE lesson time students spend in MVPA. Quantile regression equations showed good validity for translating step count data to %MVPA during PE lessons. These equations are available in Table 3 and could theoretically be used on their own to translate steps per minute to PE lesson %MVPA for any valid pedometer. For anyone wishing to do so, step counts can be manually entered into the following Google sheet (https://bit.ly/2I3JJbq) to conveniently calculate PE lesson %MVPA. Because the time required to do this may be prohibitive for many teachers, we developed a wireless monitoring system to enhance the ease with which this feedback can be obtained. The ability of the monitoring system to obtain measurements and generate feedback was assessed in usual PE lessons with class sizes of up to 23 students. In these experiments, there were no difficulties using the app or obtaining summary feedback at the end of the lesson. Moreover, because the ANT+ wireless network used to communicate data from the pedometers to the smart device app has no limit for the number of devices in range it can pair with, class sizes larger than those evaluated in the present study could theoretically be monitored using the system. This study demonstrated that the class physical activity monitoring system can provide feasible and valid estimates of %MVPA during PE lessons. The mean difference (bias) between the class physical activity monitoring system and ActiGraph accelerometers was 1.6 %MVPA where the average %MVPA during lessons was 24.2%. This equates to a 7% difference between the two measurement methods. Mean differences within ±10% of the criterion measure of physical activity have previously been suggested to represent an acceptable level of agreement.[34,35]

While testing the validity of the physical activity monitoring system we detected a group of outliers from a single class for whom the system did not perform optimally in estimating %MVPA. There is no clear explanation for this observation. The relationship between step counts and %MVPA is sensitive to the type of activities undertaken and also the filtering thresholds for converting tri-axial acceleration outputs to step counts.[36] However, since all classes engaged similar types of activities during their lessons, we were unable to determine

the source of the discrepancy in this single class. Additional studies may be required to establish specific activity types or classroom contexts which may contribute to poorer than expected measurement accuracy of the class physical activity monitoring system. Notwithstanding data from this single class, overall the results from the analysis of all participants indicate that the class physical activity monitoring system has excellent validity for measuring PE lesson %MVPA at a group level.

The limits of agreement for the measurement of %MVPA between the class physical activity monitoring system and ActiGraph were relatively wide (-15.5, 12.3). Individual error in accelerometery estimates of physical activity is generally large[37] and no single accelerometer is considered a gold-standard.[38] This creates some difficulty in assessing the accuracy of individual estimates of %MVPA relative to the criterion device selected (ActiGraph). Considering errors in individual estimates of %MVPA could arise from predictor and criterion measurements in this study, there was reasonable agreement in individual measures of %MVPA. PE lesson %MVPA differed by less than 5 in 58% of participants and less than 10 in 86% of participants. Nevertheless, these differences may represent large absolute errors and individual estimates of %MVPA and individual results from the class physical activity monitoring system should be interpreted with caution.[39]

One of the purposes of this study was to develop a monitoring system capable of conveniently providing physical activity feedback during PE lessons. There are now a few commercially available systems capable of providing group and individual level feedback in group-based exercise environments, such as during PE lessons. To the best of our knowledge only systems that measure heart rate exist. There are of some advantages of heart rate as a measure of physical activity,[40] but these systems are expensive and have other limitations for feasibly providing feedback in class environments. Based on two commercially available heart rate monitoring systems (Polar, GoFit system and Adidas, IHT spirit system), we estimate the cost of these systems to be approximately five times greater than the cost of the monitoring system developed in this study. A second challenge with existing group-exercise monitoring systems is that they can be inconvenient to set up at the start of each lesson. Most wireless technologies require individual devices to pair (establish a wireless communication link) with a secondary device, one device at a time. This is time consuming and might have limited the application of wireless monitoring technologies in group exercise environments such as PE lessons. The class physical activity monitoring system was thus designed to overcome these specific limitations.

By using ANT+ wireless network technology, the monitoring system has the ability to simultaneously pair multiple devices and only requires a wireless link once at the end of a lesson for data to be uploaded to a smart device for processing via the app. In practice, this means pedometers can be distributed to students at the start of a lesson with no requirement to establish a wireless link. Once the end of the lesson is designated via the app, all pedometers used in the lesson automatically upload their data to the smart device in approximately five seconds with feedback available immediately thereafter. These features may prove advantageous for long-term usability of the system in classrooms where time and convenience can be barriers for teachers incorporating such technologies into their lessons but this needs to be determined in future studies that specifically explore the usability of the system by teachers in classrooms.

The availability of this technology presents a number of opportunities for interventions that seek to increase physical activity in classroom or other group-based exercise environments. However, very little is known about how practicable it is to integrate such technologies into a classroom. Future studies will need to address these questions by exploring the feasibility of such systems in the classroom and evaluating the impact of feedback on physical activity. For example, randomised control trials may be required to establish whether feedback available via activity monitoring systems can be used by students and teachers to identify factors associated with meeting or not meeting lesson %MVPA goals and more importantly, if this can lead to increased PE lesson physical activity. Limitations of the current study include that equations for translating step counts to %MVPA are unlikely to be generalizable to populations or activity settings other than those tested in this study. Furthermore, regressions were developed and validated using secondary students and tested in primary students. While this did not appear to practically impact the results of this study, it may be possible to refine regressions for greater accuracy by using narrower age ranges.

5. PERSPECTIVES

Providing feedback on physical activity may increase the effectiveness of PE for achieving MVPA goals and contribute to increasing physical activity in children and adolescents. We successfully developed a physical activity monitoring system capable of seamlessly providing valid feedback. Teachers and students can use smart devices and inexpensive wireless pedometers to obtain feedback during PE lessons. The monitoring system described in this paper addressed some of the limitations of using existing physical activity monitoring

technologies in class environments and has cost and convenience advantages over existing group-based physical activity monitoring technologies. Advances in monitoring technologies expand opportunities to implement strategies to increase physical activity in class environments. Studies are now needed to determine whether such technologies can be advantageous for long-term adherence and behavior modification in large scale interventions that seek to increase physical activity during PE lessons.

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Appendix 1

Title: Physical activity monitoring system app

Description: Images of the app screens

Application Locked

User

admin@iplay.org.au

Password

UNLOCK

LOGIN AS ANOTHER USER

Class Activity Tracker

Instructions

Press 'Start' to begin the lesson.
Press 'Stop' to end the lesson and see results.
Press 'Manual time entry' if you forgot to press start or stop.

00:00:00

START

STOP

MANUAL TIME ENTRY

Current User
admin@iplay.org.au

← **Manual Time Entry**

TIMES

Date	Thu 27 Oct 2016
Start Time	11:25 AM
End Time	12:25 PM

DONE
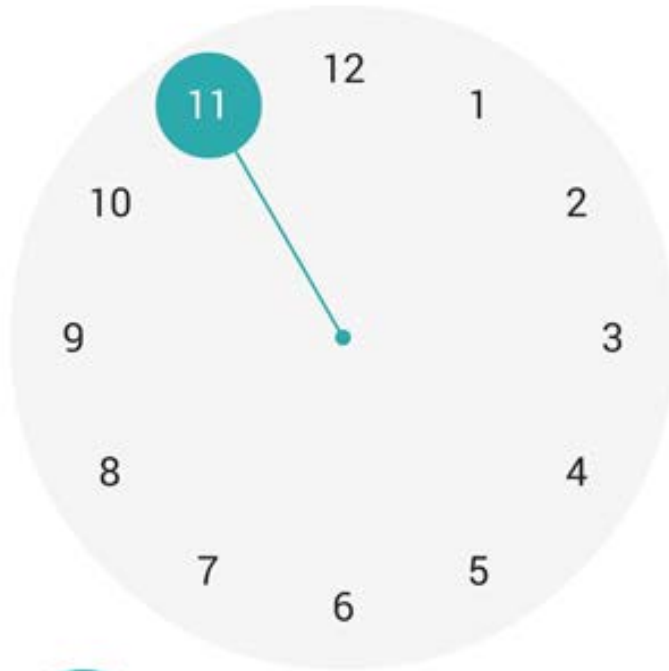
Waiting for pedometers...

Waiting for pedometer data to upload.

🟥 Pending   🟧 Uploading   🟩 Uploaded

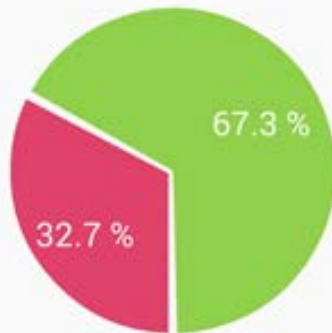| 1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Shake a pedometer to make it connect.

IGNORE PENDING PEDOMETERS
PROCEED TO LESSON RESULT OVERVIEW

Average Amount of Time Students are Active

■ Inactive ■ Active

67.3 % equates to 7 minute(s) of the 11 minute(s) lesson time spent in moderate to vigorous physical activity.

Lesson Time	Highest MVPA
11 minutes	76.0 %
Lesson average steps/min	Lowest MVPA
119.8	49.0 %

MVPA GRAPH

EMAIL RESULTS

← **Detailed Lesson Summary**

Touch bar to select individuals

% of Lesson Time in Moderate to Vigorous Physical Activity

Goal

| 90 % | 80 % | 70 % | 60 % | 50 % | 40 % | 30 % | 20 % | 10 % | 0 % |

1 2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
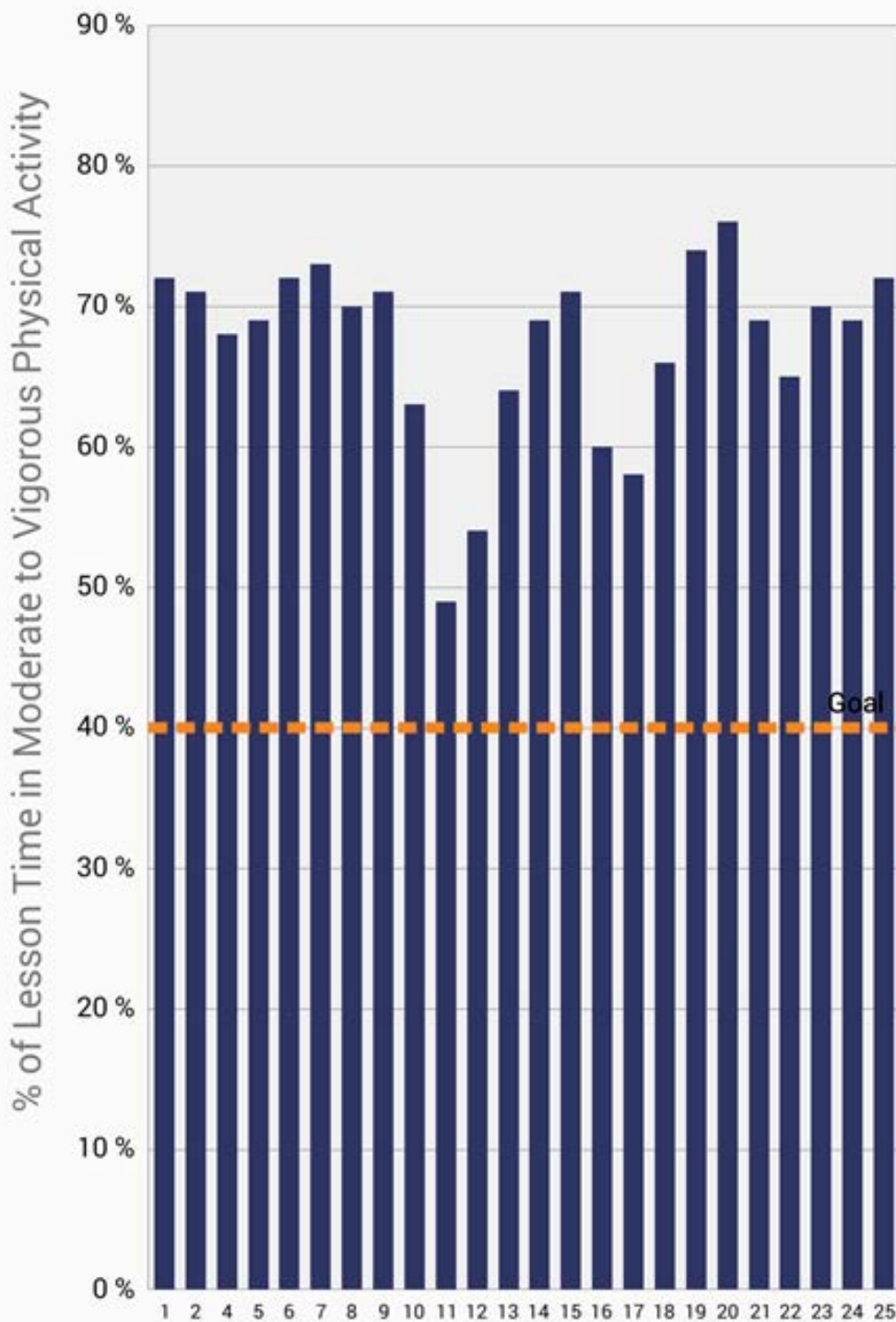
Appendix 2

Title: Technical reliability of SmartLAB® move+ accelerometers

Description: Laboratory testing of SmartLAB® move+ accelerometers on a mechanical shaker.

Technical reliability of SmartLAB® move+ pedometers.

Experimental protocol

Intra- and inter-instrument technical reliability was assessed in the laboratory using a mechanical shaker table. We mounted 15 SmartLAB® move+ pedometers onto a metal plate and fixed that plate to a mechanical shaker. We positioned pedometers vertically to standardize the output from the piezosensor. Driven by an orbital electric motor, the mechanical shaker produced oscillations with a fixed amplitude. Mechanical shakers have previously been used to determine the technical reliability of research quality accelerometers by manipulating oscillation frequency and amplitude (1). Since smartLAB® move+ pedometers produce only step counts, we only assessed the reliability of step counts at a fixed amplitude and frequency at a step per minute rate approximately corresponding to fast running ($10 \text{km} \cdot \text{h}^{-1}$). The mechanical shaker measured step counts for 15-minute test periods. The middle 10 minutes (i.e., from 2min30s to 12min30s) were retained for analysis and we repeated the test ten times to determine the intra-instrument reliability.

Statistical analysis

SmartLAB® move+ pedometers intra- and inter-instrument technical reliability was using coefficient of variation % (CV_{INTRA} and CV_{INTER}).

Results

Table 1 displays the results of the technical reliability testing performed on the SmartLAB® move+ pedometers in the laboratory. The intra-coefficient of variation (%) for ten trials using fifteen accelerometers ranged between 1.2 and 6.8 with a mean coefficient of variation of 2.1 (SD = 1.5). The inter-coefficient of variation (%) ranged between 3.0 and 5.7 with a mean of 4.1 (SD = 0.7).

Table 1. SmartLAB® move+ pedometer technical reliability. Data are mean (± SD).

	Steps per min	%CV$_{INTRA}$	%CV$_{INTER}$
Mechanical shaker	163	2.1 (1.5)	4.1 (0.7)

%CV$_{INTRA}$, coefficient of variation intra-instrument. %CV$_{INTER,}$ coefficient of variation inter-instrument.

References

1. Esliger DW, Tremblay MS. Technical reliability assessment of three accelerometer models in a mechanical setup. Med Sci Sports Exerc. 2006;38(12):2173-81.