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Using the ActivPAL Monitor to Quantify Time Spent Sitting, Standing and Stepping at School: A One-day Snapshot

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Authors' contributions

This work was carried out in collaboration between all authors. Author EAH, SA and SD conceptualized the study design. All data were collected by authors KW, SA and SD performed the statistical analysis. Author SA drafted the manuscript. Authors EAH and SD reviewed the manuscript and SA edited it. All authors read and approved the final manuscript.

Short Research Article

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ABSTRACT

Background: Our understanding of the amount of time children spend sitting, standing and stepping during a typical school day is limited. The ActivPAL monitor, which can differentiate between sitting and standing, was used in this study to objectively assess free-living activities in children.
Aims: The main purpose was to objectively quantify the time children spend sitting, standing and stepping in a typical school day. A secondary purpose was to compare the ActivPAL monitor step counts with those obtained from Actical accelerometers.
Study Design: Pilot observational study.
Place and Duration of Study: Elementary school in Auckland, New Zealand, July 2010.
Methodology: A total of 78 elementary school children (age 8.4±1.4 years; mean ± SD) participated in the study for one school day in July 2010. Within-day differences in the proportions of time spent sitting, standing and stepping were assessed using ANOVA. The effect of sex and age on mean scores was also evaluated, using independent-samples t-tests and one-way between-groups ANOVA respectively. Bland and Altman analyses were used to estimate the agreement in step counts between devices.

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Results: From an average of 303±6 minutes, children spent 170±35 min (56%) sitting, 77±24 min (25%) standing, and 56±19 min (18%) stepping. Most of children's sitting time occurred in class (149±10 min; 49%). Boys and girls accumulated similar proportions of sitting, standing and stepping. On average, 33% more steps recorded by the Actical accelerometer compared to the ActivPAL.
Conclusion: Our results suggest that children spend over half of their time at school sitting. Furthermore, the ActivPAL monitor steps are not equivalent to the Actical accelerometer steps.

Keywords: Children; physical activity; measurement; sitting; ActivPAL.

1. INTRODUCTION

Substituting time spent sitting with standing or stepping may be a practical solution to reducing the childhood obesity epidemic [1]. This strategy may provide children with more opportunities to be physically active and, as a result, maintain healthy weight [2,3].

While accelerometers offer an objective method for assessing physical inactivity in children [4,5] they are unable to differentiate between sitting and standing behavior. The ActivPAL monitor overcomes this limitation by distinguishing between sitting and standing [6] because of its placement on the thigh. The device objectively measures time spent sitting, standing and stepping, along with step counts across multiple days [7-9].

The primary purpose of this study was to objectively quantify children's sitting, standing and stepping time during a typical school day using the ActivPAL monitor. The secondary purpose was to compare step counts between the ActivPAL and Actical monitors.

2. METHODOLOGY

2.1 Participants

Seventy-eight (61.9%) of 126 eligible children aged 5-11 years (35 boys and 43 girls) from an elementary school in Auckland, New Zealand, participated in the study in July 2010. Demographic data were collected from the school roll. Ethical approval was granted by the Institution's Ethics Committee. Written informed assent and consent was also gained from children and parents respectively.

2.2 Instruments

The ActivPAL (PAL Technologies Ltd, Glasgow, UK) uni-axial accelerometer classifies postural changes as sitting/lying, standing and stepping, and counts steps based on the inclination of the thigh for a maximum of eight days [7]. The ability of the ActivPAL to measure posture or step counts has been validated in preschoolers [10,11], children [12,13] and adults [7,8,14-18]. The 53 x 35 x 7 mm units were attached on the thigh in line with the manufacturer's guidelines using physiotherapy adhesive tape (Underwrap Tape, TheraFIX, PhysioMed, Auckland, NZ). Prior to attaching the units, barrier film (Cavilon, No Sting Barrier Film, St Paul, MN, USA) was sprayed on the area to protect the skin when removing the adhesive tape.

The Actical accelerometer (Mini-Mitter Co., Inc., Bend, OR, USA) is an omni-directional accelerometer with a piezoelectric sensor mounted for maximum sensitivity to bodily movement of 0.5 to 3 Hz covering activity from sedentary to vigorous intensities [19]. In children, Actical step counts have been validated against direct observation (r=0.92, p<.001) [20]. The Actical units were attached to an elasticized belt that was worn above the iliac crest on the right hip.

2.3 Protocol

Researchers fitted the participants with the ActivPAL and the Actical monitors at the beginning of the school day (~9:00am). At the end of the school day (~3:00pm) the units were removed from the children. When removing the units, research officers confirmed with each child that the unit had remained in place, as well as visually making sure that each unit was still attached to its correct position. Data were excluded if the units became detached during the day.

2.4 Statistical Analyses

Descriptive statistics were presented as means, and standard deviations. One-way repeated measures ANOVA was used to compare minutes spent sitting during different periods of the school day: Early morning class, Morning break, Late morning class, Lunchtime and Afternoon class. Difference in mean scores for boys and girls in time spent sitting, standing and stepping, and step counts was determined using independent-samples t-tests. The effect of age on time spent sitting, standing and stepping, and step counts in children was detected by one-way between-groups analysis of variance (ANOVA). Participants were divided into six age groups according to their grades. Post-hoc comparisons using the Tukey HSD test were performed to locate significant differences among the groups at the p<.05 level (95% Confidence Limit). Bland and Altman analyses were used to estimate the agreement between the ActivPAL and the Actical step counts. All analyses were performed on SPSS Version 18 (SPSS Inc., Chicago IL, USA).

3. RESULTS

Fig. 1 shows the minutes spent sitting, standing and stepping during different periods of the school day. From an average of 303±6 minutes, children spent 170±35 min (56%) sitting, 77±24 min (25%) standing and 56±19 min (18%) stepping.

Significant (p=0.01) differences in time spent sitting, standing and stepping were observed in different periods of the day. However, there was no significant difference between time spent sitting, standing and stepping in Early morning class and Afternoon class; (41±13, 12±9, 5±5 min) and (42±11, 15±8, 6±3 min) respectively.

During a school day, children spent 149±10 min (49%) of their time sitting in class, which was highest in Morning class; 107±10 min (35%). Time spent sitting and standing was lowest in Morning break due to the relatively short time period; 5±5 min (2%) and 8±3 min (3%) respectively. Most stepping was observed during Lunchtime; 24±8 min (8%).

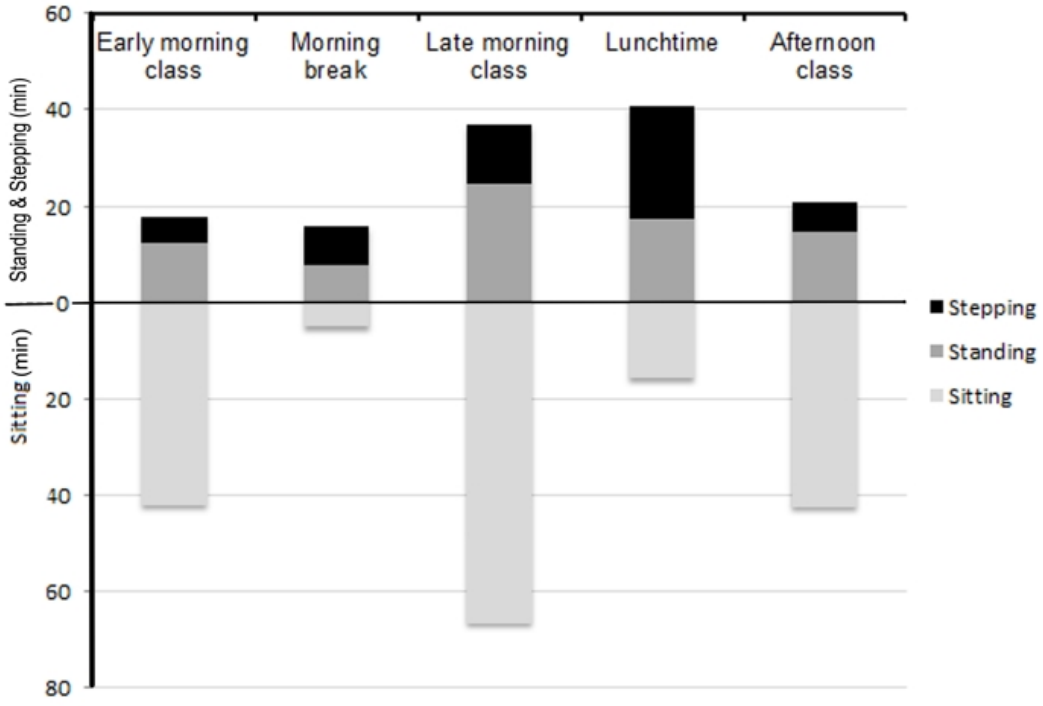

Fig. 1. Sitting, standing and stepping during different periods in a school day
Early morning class, 09:30-10:24; Morning break, 10:25-10:45; Late morning class,10:46-12:29; Lunchtime, 12:30-13:25; Afternoon class, 13:26-14:30

There was no statistically significant difference in mean scores of total time spent sitting, standing and stepping, or in total step counts between boys and girls Table 1.

Table 1. Time spent sitting, standing and stepping, and total steps for boys and girls (mean ± SD)

	All N=78	Boys N=35	Girls N=43	MD[a] 95% CI[b]	*P* Value
Sitting (min)					
ActivPAL	170±35	169±39	171±32	-2.83	0.72
Standing (min)					
ActivPAL	77±24	76±26	78±23	-2.15	0.7
Stepping (min)					
ActivPAL	56±19	60±20	53±17	6.67	0.12
Step Counts					
ActivPAL	4423±1653	4725±1799	4177±1500	548.38	0.15
Actical	6055±2508	6072±2404	6040±2623	31.73	0.96

[a]*Mean Difference,* [b]*Confidence Interval*

In contrast, significant differences in total time spent sitting and stepping but not standing (p=.40) were observed between grades. Step counts varied by grades for the ActivPAL monitor (p=.01) but not the Actical accelerometer (p=.06); Table 2.

Table 2. Time spent sitting, standing and stepping, and total steps for each Grade level (mean±SD)

Grades[a]	Sitting (min)	Standing (min)	Stepping (min)	Step Counts	
				ActivPAL	Actical
All	170±35	77±24	56±19	4423±1653	6055±2508
Grade 0	191±22*	76±20	38±9*	2804±740*	4437±1755
Grade 1	189±22*	66±14	52±12	3938±1053	5693±2315
Grade 2	153±26*	80±25	68±16*	5493±1326*	7324±1947
Grade 3	148±33*	85±27	68±18*	5503±1515*	6602±3050
Grade 4	189±28*	70±18	49±17*	3797±1523*	5230±2171
Grade 5	167±43	79±30	50±19*	4054±1724	6188±2818

[a]All, 5-11 yr; Grade 0, 5.6 ± 0.2 yr; Grade 1, 6.7±0.1 yr; Grade 2, 7.6 ± 0.2 yr; Grade 3, 8.6 ± 0.2 yr; Grade 4, 9.8±0.2 yr; Grade 5, 10.8 ± 0.2 yr

**The mean difference is significant at the .05 level; see text below for the relevant comparison.*

A one-way between-groups analysis of variance explored statistically significant differences in the ActivPAL time spent sitting (F=5.1, p=.01) and stepping (F=6.9, p=.01) and also step counts (F=7, p=.01) for the six age groups (grades).

In sitting time, Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Grade 0 was significantly different from Grades 2 (p=.04) and 3 (p=.02). Grade 1 was significantly different from Grades 2 (p=.05) and 3 (p=.03). Grades 2 and 3 were significantly different from Grade 4 at the level of p=.02 and p=.01 respectively. Grade 5 (M=167, SD=43) did not differ significantly from other grades.

Post-hoc comparisons by the Tukey HSD test also showed that in stepping time, the mean score for Grade 0 was significantly different from Grades 2 (p=.01) and 3 (p=.001). Grade 2 was significantly different from Grades 4 (p=.01) and 5 (p=.02). Grade 3 was significantly different from Grade 4 (p=.02) and Grade 5 (p=.04). Grade 1 (M=52, SD=12) did not differ significantly from other grades.

In addition, steps mean scores for Grades 0 and 4 were significantly lower than Grades 2 (p=0.01 and p=0.02) and 3 (p=0.01, p=0.02) respectively, using the Tukey HSD test. However, grades 2 and 6 did not differ significantly from other grades.

Fig. 2 shows the Bland and Altman plot used to assess agreement in step counts between the ActivPAL and Actical devices. When compared to ActivPAL step counts, the Actical recorded an average of 1,480 fewer steps, with 95% limits of agreement of -2,680 and 5,640 steps.

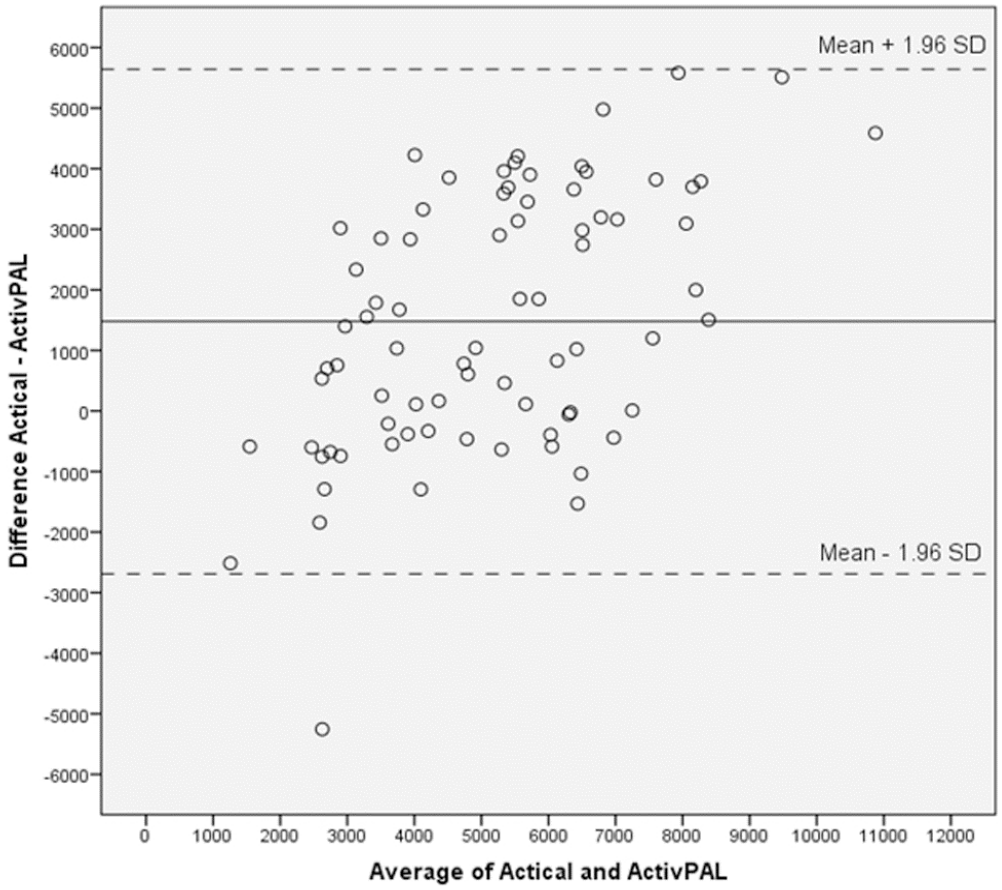

Fig. 2. Bland and Altman plot depicting the agreement between ActivPAL and Actical step counts

4. DISCUSSION

The purpose of this study was twofold: to objectively quantify sitting, standing and stepping time in children during a typical school day; and to compare the ActivPAL step counts with the Actical accelerometer steps.

Our findings revealed that children spent more than half of a school day sitting; however about half of children's sitting time was in class and small amount in break time (Morning break and Lunchtime). Similar results were found in a recent study with older children aged 8-12 years [9], when children's sitting time was measured by the ActivPAL monitor for two school days. These results show that children's sitting time varies across a school day and that classroom sitting is common in schools. Therefore, schools may be an appropriate setting for interventions to reduce sitting time.

Our results also showed that step counts measured by the ActivPAL monitor were significantly lower than the Actical step counts. The difference is possibly owed to the ActivPAL recording a step based on forwards or backwards movements of the upper leg, while the Actical records a step in response to a greater vertical force for a given threshold.

This means that the ActivPAL is measuring steps in the strictest sense, whereas the Actical is measuring jolting movements like jumping on the spot. Therefore, caution is needed when comparing ActivPAL step counts to prior accelerometer-based assessments.

5. CONCLUSION

As expected, our results suggest that during a typical school day, children spend a relatively high proportion of their time sitting, particularly in class. Sitting, standing and stepping time were highest in the Morning class, Late morning class and Lunchtime respectively. The proportions of sitting, standing and stepping in boys and girls were similar. Children in grades 0, 1 and 4 spent more time sitting during a school day. In contrast, children in grades 2 and 3 showed higher stepping time than other age groups.

Additional research in a larger sample over longer periods in more than one school is needed to establish normative values for sitting, standing and stepping time in children. This will provide researchers with a basis to promote sustainable behavior change by implementing effective and relevant interventions.

ETHICAL APPROVAL

Ethical approval sought from the Institution's Ethics Committee. Potential participants (children) and their parents received verbal and written information about the study in line with the principles of informed consent and confidentiality. Non-invasive procedures were used to make sure that there were no perceived physical and psychological risks for participants. If required, authors will be ready to submit a scanned copy of Ethical Committee Approval to the Journal of Scientific Research and Reports at any stage of publication.

COMPETING INTERESTS

Authors have declared that no competing interests exist

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