



Original research

Validity of the Omron pedometer and the actigraph step count function in preschoolers



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ABSTRACT

Objectives: To validate the GT1M actigraph accelerometer step count function, and the Omron Walking Style Pro pedometer against accelerometer-based activity counts, and to compare pedometer-based and accelerometer-based steps in preschoolers.

Design: A sample of 41 preschoolers (21 boys, mean age 5.43 ± 0.63 years) from one preschool in Flanders, Belgium, was included in data analysis.

Methods: Accelerometer-based and pedometer-based steps were simultaneously collected in this Flemish sample of preschool children. Preschoolers wore two motion sensors (accelerometer and pedometer) for four consecutive days. Pearson correlations were calculated to compare accelerometer activity counts with accelerometer-based steps, accelerometer activity counts with pedometer-based steps and accelerometer-based steps with pedometer-based steps. Bland–Altman analysis was carried out to investigate the agreement between the pedometer-based and the accelerometer-based steps.

Results: Accelerometer-based steps correlated moderately high with accelerometer activity counts per hour ($r = 0.77$) and per day ($r = 0.82$). Pedometer-based steps correlated moderately high with accelerometer activity counts per hour ($r = 0.65$) and per day ($r = 0.64$). High correlations were revealed between steps from both devices (hourly: $r = 0.92$; daily: $r = 0.89$). The Bland–Altman analysis showed a bias of 221.81 (± 1679.78) and the limits of agreement ranged from -3070.57 to 3514.18 steps per day.

Conclusions: Both the accelerometer-based as pedometer-based step counts are valid estimates of preschoolers' physical activity levels during free-living activities based on group estimates. High agreement between both step counts justifies combining and comparing pedometer- and accelerometer-based step counts.

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1. Introduction

Physical activity (PA) has important psychological and physical implications in all age groups,¹ even in preschoolers,² and being physically active is an important healthy lifestyle habit that tracks into adulthood.^{3,4} Consequently, PA guidelines have been established for preschool children, and according to the most recent guidelines, preschoolers should accumulate 180 min of total PA throughout the day.^{5–7}

At the moment, accelerometers are the most widely-used validated monitoring devices to measure PA in preschool children.^{8,9} Accelerometers are light-weight, non-obtrusive motion sensors, mostly worn at the hip, that record detailed information about the intensity and frequency of PA throughout the measurement period by registering accelerations made by the participants,⁸ and can be used as criterion measure for assessing PA in preschool children.¹⁰ However, accelerometers also have some limitations: (a) the high cost ($\sim$ US \$249 or €190), (b) the fact that they cannot be used during water-based activities, (c) the underestimation of cycling, (d) the fact that the units of measurement (counts) have less intuitive utility compared to pedometer steps, and (e) that specific software and qualified researchers are needed to analyze and interpret the output.⁸

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The pedometer or step counter is another widely used instrument for measuring PA in all age groups, from preschoolers to older adults.^{11–13} Pedometers are small devices, usually worn at the hip, and they are of relatively low cost (~US \$99 or €74) compared to accelerometers. Pedometers use different mechanic or electronic motion sensors to quantify the amount of PA by accumulating steps.¹⁴ They are easy to use, and the outcome – a step count – is easily understood by adults and even by children.⁸ As pedometers monitor the total volume of PA, these devices can be used in preschool children as their PA guidelines prescribe to be physically active for three hours per day, irrespective of intensity^{5–7}. In addition, pedometer step counts provide an adequate assessment of PA in preschool children.⁹ However, further validation evidence is required before the suitability of using step counts with newer pedometer models in preschool children can be confirmed.¹⁵ Pedometers also have some disadvantages which are comparable with accelerometers: (a) water-based activities cannot be measured, (b) cycling is underestimated, and in contrast with accelerometers (c) it is not possible to quantify intensities, so a distinction between light PA and moderate PA cannot be made. In addition, specifically in young children, pedometers cannot capture some activities in this age group like crawling or swinging.

The older pedometer models (e.g. Yamax SW-200, Digiwalker™ DW-200) have the limitation that they do not yield information other than steps per measured period.¹⁶ Nowadays, advanced pedometer models (e.g. Omron Walking Style Pro (HJ-720IT-E2), Anazao Fitness Pedometer 360) are available that can measure the number of total steps per day as well as per hour (Omron) or per minute (Anazao).¹⁷ Consequently, the PA patterns throughout the day can be explored. It can be investigated when preschoolers are most active, for example during the time at preschool, the time at home or during after-school childcare. With pedometers being less expensive compared to accelerometers, this newly added feature of investigating PA patterns throughout the day opens up new possibilities to use this type of motion sensors instead of accelerometers in large-scale studies. Currently, in large-scaled European studies like HELENA, IDEFICS and ENERGY,^{18–20} accelerometers are used. However, due to the high cost, these devices are only used in subsamples. By using these new types of pedometers, large-scaled studies could objectively measure the PA levels and movement patterns of the entire sample.

Additionally, the accelerometer step count function has not yet been validated in preschoolers. In the study by Abel et al.,²¹ the accelerometer step count function proved to be a good measure to assess step counts in adults. Furthermore, the comparability between accelerometer and pedometer-based studies could be enlarged when the step count function of the accelerometers – used in the whole sample or in subsamples – is also activated.

The aim of the current study consists of three parts. Firstly, we aim to validate the ActiGraph GT1M accelerometer-based steps against accelerometer activity counts. Secondly, we wanted to validate step counts from the Omron Walking Style Pro pedometer against the accelerometer activity counts, since this type of pedometer provides PA patterns throughout the day, and can be used in large-scale studies due to the low cost. Finally, we wanted to compare the accelerometer-based step counts with the pedometer-based step counts. To our knowledge, there are no studies investigating the convergent validity of the ActiGraph GT1M step count function and the convergent validity of the Omron Walking Style Pro pedometer in preschoolers.

2. Methods

A randomly selected school in the city of Tielt (West Flanders; Belgium) was contacted for participation in this validation

study. Parents of all preschoolers between 4 and 6 years old were approached ($n = 73$), and parents of 64 preschoolers (88%) provided a written informed consent and agreed to participate. Twenty-three preschoolers did not have valid data for both measurement devices, resulting in a final study sample of 41 children (56%) with complete data. This study was conducted in May 2011 and was approved by the Ethical Committee of the Ghent University Hospital (EC/2010/037).

Preschoolers were asked to wear two monitoring devices simultaneously. The first device was the Omron Walking Style Pro pedometer (HJ-720IT-E2), which is lightweight (37 g), small (37 mm × 73 mm × 16 mm), and has the ability to measure steps per day as well as per hour. The pedometer has a dual-axis acceleration sensor which counts steps when it is placed horizontally or vertically. The device stores seven days of information on the display and stores 41 days in the memory. This type of pedometer does not allow inadvertently resetting of the step counts and can be worn at different positions on the body: at the hip, in the pocket or clipped to a bag.¹⁷

The second instrument was the Actigraph GT1M uniaxial accelerometer (Firmware 7.4.0), which is also lightweight (27 g), and small (38 mm × 37 mm × 18 mm). The accelerometer was initialized to measure the steps and activity counts in 15-s epochs, because of preschoolers' intermittent pattern of movement.²² These 15-s epochs were then transformed into one-hour epochs to facilitate the comparison with the pedometer step counts. Accelerometer activity counts were used as criterion measure for measuring PA in preschoolers.¹⁰

Preschoolers wore both the accelerometer and the pedometer simultaneously for four consecutive days. Colorful stickers of fun figures were attached to both devices, to make them more attractive to the children and to ensure that the devices were worn in a correct, upright position. A second purpose of the stickers was to cover the display of the pedometers, in order to ensure that preschoolers could not watch their own steps. Both devices were fit on the children by a researcher at preschool. The pedometer was placed on the right hip above the iliac crest, with the use of an adjustable elastic waistband. The accelerometer was placed on the left hip above the iliac crest, attached to the same elastic belt. Because preschool children are small, placing both measurement devices at the same hip would cause none of the measurement devices being placed above the iliac crest. Further, since Fairweather et al.²³ only found small and probably biologically unimportant differences between the accelerometer placement at the left and right hip in preschool children, it was decided to place the accelerometer at the left hip. The children were instructed to wear both devices during the complete day and to only remove them for water-based activities (e.g. bathing, swimming) and sleeping. On weekdays, steps taken between 7 AM and 8 PM were taken into account, while on weekend days data between 7 AM and 9 PM were included.²⁴ Preschoolers were included in the analyses if they had a minimum of five hours for a minimum of one day of concurrent accelerometer and pedometer data.²⁵ Parents were given an informational letter with instructions on how to handle the devices. After data collection, data were downloaded using the ActiLife version 5.5.5 software for the accelerometers and the Omron Health Management Software version E1.012 for the pedometers. Non-wear time was manually checked, and in the case that both monitors registered 0 steps or 0 counts per hour, this hour was deleted from the dataset.

The statistical analyses were performed using SPSS for Windows version 20.0. Pearson correlations were performed to quantify the linear relationship between the accelerometer counts (per hour and per day) and accelerometer-based steps (per hour and per day). Furthermore, Pearson correlations were executed to examine the relationship between the accelerometer counts (per hour

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