Effect of body composition on the validity and reliability of an electronic pedometer

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Abstract
This paper examines the effect of body composition and pedometer position on the validity and reliability of a pedometer. 52 adults (24F, 28M, BMI range 21-52kg/m²) participated. Body composition was measured by BMI, waist to hip ratio and percentage body fat and categorised as: 1.) normal, 2.) overweight, 3.) obese I, and 4.) obese II (BMI only). Participants wore 4 pedometers (front (2), side and back) on their right side at waist level. Participants completed a 40 metre walking course at a slow, moderate and brisk walk on two occasions. Pedometer steps were compared to steps recorded by direct observation. For normal weight participants no differences were found between observed and pedometer steps (p>0.01). Among overweight participants, there was a difference (p<0.01) between observed and pedometer steps during slow walking in the back position. Obese I and II participants had differences (p<0.01) between observed and pedometer steps during slow (and moderate for obese I) walking in the side position. No differences were found between pedometer steps recorded during test 1 and 2. In conclusion, no significant differences were found across all body compositions, and for all walking speeds, between observed and pedometer-measured steps when the pedometer was worn in the front position.

Keywords
Pedometer, Clinical populations, Body composition, Validity, Reliability.

Abbreviations
BMI = Body Mass Index

Introduction
Walking has been described as near perfect exercise (Morris and Hardman, 1997). It offers substantial health benefits to the general population and to people with chronic disease such as cardiovascular disease, cancer, stroke and diabetes. It has an immediate effect on blood glucose levels in people with Type 2 diabetes and offers long term benefits such as improvements in body composition, lipid profiles, insulin sensitivity and mental health (Walker et al, 1999). In an Italian study Di Loreto et al. (2005) identified significant economic benefit from a physical activity intervention which primarily promoted walking in people with Type 2 diabetes. Over a two year
period prescription costs were reduced by $259 and other health care cost by $298 per person per year.

Pedometers record the number of steps a person takes when walking and are useful devices for self monitoring physical activity levels or setting goals to increase the amount of walking a person does. A number of intervention studies have shown pedometers to be effective motivational tools to encourage people to walk more (Tudor-Locke et al, 2004a; Baker and Mutrie, 2007). As a result pedometers are increasingly being used within health promotion and clinical practice to promote physical activity. There are a number of reasons why it is important to establish the validity and reliability of pedometers across the population. Reasons include: to establish the true effect of pedometer based interventions; to identify if people wearing pedometers are receiving accurate feedback; and to potentially provide a cheap, but valid and reliable objective measurement of physical activity to track population trends in physical activity.

Pedometer validity has been confirmed in young healthy individuals with a normal body composition (Bassett et al, 1996). However, limited research has examined pedometer validity and reliability in older clinical populations, who are possibly more likely to be overweight or obese. These are often the individuals being encouraged to increase their level of physical activity with pedometers in community educational programmes and clinical practice. Swartz et al (2003) investigated the effect of Body Mass Index (BMI) on the accuracy of an electronic pedometer in healthy men and women. The results found no significant overall effect of BMI. However, when the BMI categories were combined a significant difference was recorded between observed counts and counts recorded from the front, side and back position at the two slowest speeds of 54m x min⁻¹ and 67m x min⁻¹. Although this study did record waist to hip ratio and percentage body fat, analysis was only conducted on BMI categories. Furthermore the group of participants had a limited range of waist to hip ratio (0.77 to 0.87). With the placement of the pedometer being at the hip region it could be suggested that waist to hip ratio would have a greater effect on the accuracy of a pedometer. The reliability of pedometers across variable body composition has not been addressed. This is important information for follow-up intervention studies and programmes to determine whether the change recorded is due to actual change or an unreliable measurement.
The purpose of this paper is firstly, to examine the effects of body composition, measured by BMI, waist to hip ratio and percentage body fat, on the validity and reliability of an electronic pedometer in people with variable body composition while walking at three self-selected walking speeds. The second aim was to examine the effect of different pedometer placement sites on the validity and reliability of the pedometer. The third aim was to investigate inter-instrument (i.e across different pedometers of the same model) reliability across walking speeds.

Methods

Participants
A convenient participant sample was recruited from University members of staff and participants in a structured exercise programme for people with cardiac disease or Type 2 diabetes. The Tayside committee on medical research ethics approved the study, and written informed consent was obtained from all participants.

Procedures
Each participant made one visit for study procedures where demographic and medical status was recorded and a number of measures of body composition were taken. Participants were then fitted with four pedometers (Yamax SW200, Tokyo, Japan). Two pedometers were fitted in position 1 = midline of thigh (front), one in position 2 = midaxillary line (side) and one in position 3 = posterior midline of thigh (back). All were positioned on the right side of the body at hip level. The same four pedometers were used on each participant to decrease inter-instrument variability. Participants were then asked to complete an indoor 40 metre walking course at three self selected walking paces of slow, moderate and brisk on two occasions (test 1 & test 2) during the same study visit. During each walk two researchers (CG, JH) counted the number of steps taken by direct observation. At the end of each walk the number of steps recorded by each pedometer was noted.

Measures
Body composition was measured by 1) Body Mass Index (BMI), 2) waist to hip ratio and 3) percentage body fat.
BMI was calculated by dividing body mass (kg) by height squared (m²). World Health Organization (WHO) categories were used to categorize participants into the following groups: 1.) Normal 20-24.9 kg/m² (n=11); 2.) Overweight = 25-29.9 kg/m² (n=15); 3.) Obese I = 30-34.9 kg/m² (n=13); and 4.) Obese II ≥ 35 kg/m² (n=13).

Waist to hip ratio was determined by measuring waist circumference at the navel in men and midway between the bottom of the ribs and top of the hip bone in women and measuring hip circumference at the widest point between the hips and buttocks in both men and women. WHO categories were used to categorize participants into the following groups: 1.) Normal <0.8 for women, 0.9 for men (n=17); 2.) Overweight 0.8 – 0.85 for women, 0.9 – 1.0 for men (n=12); and 3.) obese > 0.85 for women, >1.0 for men (n=23).

Percentage body fat was measured by Harpenden skinfold callipers at four placement sites (bicep, tricep, subscapular, suprailiac) and categorised using reference tables (Durnin and Womersley, 1973) into the following groups: 1) Normal (n=11), 2) Overweight, (n=15) and 3) Obese, (n=26).

Statistical analysis
To test validity, pedometer steps in each position were compared to steps recorded by direct observation and analysed across body composition categories and walking speed using a 3-way mixed analysis of variance design. To test reliability, repeated measures analysis of variance was conducted on the data generated from test 1 and test 2. Where a significant main effect was found, pairwise comparisons tests were conducted. To investigate the relationship between the two pedometers in the same position (position 1 and 2) Person Product Moment Correlation statistics were used. A p value of <0.01 indicated a significant difference.

Results

Participant characteristics
52 adults (24F, 28M) participated in the study. The normal waist to hip ratio category participants were significantly younger (mean 38.1 ± 19.0yrs) than the overweight (mean 61.3 ± 16.1yrs) and obese I (mean 59.7 ± 11.7yrs) group participants (p <
0.001). A similar trend was found for BMI (p = 0.04), but not percentage body fat (p > 0.1).

Pedometer validity across body composition and pedometer position

Body Mass Index Categories

Figure one illustrates the comparison of observed steps compared to pedometer steps at each position across BMI categories.

Analysis of variance identified a borderline main effect for the interaction of speed, position and BMI category (p = 0.05). Pairwise comparisons revealed the following differences. At BMI category 1 (normal weight) there was no significant differences between observed steps and pedometer steps during any walking speed and any pedometer position. At BMI category 2 (overweight) there was a significant difference between the observed steps and pedometer steps during slow walking at the back position (p < 0.01). At BMI category 3 (obese I) there was a significant difference between the observed steps and pedometer steps during brisk walking at the side position (p < 0.01). At BMI category 4 (obese II) there was a significant
difference between the observed steps and pedometer steps recorded at the side position at slow walking (p < 0.01).

Percentage Body Fat Categories

Figure two illustrates the comparison of observed steps compared to pedometer steps at each position across percentage body fat categories.

Figure two: Comparison of observed steps vs pedometer steps at each position across percentage body fat categories

Analysis of variance identified a borderline main effect for the interaction of speed, position and percentage body fat category (p = 0.05). Pairwise comparisons revealed the following differences. At percentage body fat category 1 (normal weight) there was no significant differences between observed steps and pedometer steps during any walking speed and any pedometer position. At percentage body fat category 2 (overweight) there was a significant difference between the observed steps and pedometer steps during slow walking at the side position (p < 0.01). At percentage body fat category 3 (obese I) there was a significant difference between the observed steps and pedometer steps during slow and moderate walking at the side position (p < 0.01).
Waist to Hip Ratio Categories

Figure three illustrates the comparison of observed steps compared to pedometer steps at each position across waist to hip ratio categories.

Analysis of variance identified a borderline main effect for the interaction of speed, position and waist to hip ratio category (p = 0.05). Pairwise comparisons revealed the following differences. At waist to hip ratio category 1 and 2 (normal weight and overweight) there was no significant difference between observed steps and pedometer steps at any walking speed and any pedometer position. At waist to hip ratio category 3 (obese I) there was a significant difference between the observed steps and pedometer steps during slow and moderate walking at the side and back position (p < 0.01).

Pedometer reliability across body composition and pedometer position
No significant differences (p > 0.01) were found when the pedometer steps from test 1 and test 2 were compared. This finding was consistent across position, walking speed and all body composition categories.

Inter-instrument reliability

Significant high correlations (p < 0.01) were found at all walking speeds (slow r = 0.84, moderate r=0.92, brisk r = 0.96) for steps recorded from the two pedometers in position 1.

Conclusions

From this research we can draw the following conclusions:

1. Pedometers, used properly, are valid and reliable measures of steps, therefore health professionals designing research and interventions can use them with confidence.

2. The front position (mid-line thigh, at hip level) was consistently valid, therefore it is recommended that pedometers should be used in this position where possible.

3. If there is any reason against using a pedometer at hip level for a person of ‘normal’ weight, then it is also valid to use it in a side or back position. However, this is not recommended for overweight or obese individuals.

4. The finding of intra-instrument reliability is important for practice as this indicates that as long as the same pedometer is used, changes which occur in pedometer steps within the same individual are most likely due to actual changes in physical activity and not instrument measurement error.

5. Significant high correlations recorded from both pedometers in position 1 indicate high inter-instrument reliability. This indicates that different pedometers of the same model record similar step counts for the same activity.

Previous research has identified that pedometers are less valid and reliable during slow walking speeds (Bassett et al, 1996). This inaccuracy results from smaller vertical movements of the hip which are below the specific pedometer threshold value and are therefore not recorded. Another limitation is that pedometers do not contain an internal clock, therefore it is not possible to determine the intensity or duration of activity performed. This limitation makes it difficult to determine the number of steps
per day required to meet existing physical activity guidelines of accumulating 30 minutes or more of moderate intensity physical activity over the course of most days of the week. Although pedometers report reasonable accuracy for measuring walking activities, research demonstrates they are less accurate for measuring activities of daily living. Based upon comparison with a 7-day physical activity recall interview the Yamax Digiwalker 500 significantly underestimated energy expenditure for physical activity by 48 percent (Leenders et al, 2000). Pedometers are designed to measure vertical movement at the hip during walking. Activity with little or no vertical movement of the hip will therefore not be recorded.

In summary pedometers are increasingly being used to promote physical activity in health promotion and clinical practice. This paper provides evidence based guidance on the positioning of pedometers across populations of variable body composition.

Bibliography


