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REVIEW ARTICLE (META-ANALYSIS)

Validity of Pedometers in People With Physical Disabilities: A Systematic Review

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Abstract

Objective: To review the literature for the criterion validity of pedometers for use in child and adult populations with physical disabilities.

Data Sources: Academic Search Premier, ERIC, SPORTDiscus, MEDLINE, AMED, Scopus, CINAHL, Web of Science, and EMBASE databases, searched from inception to September 7, 2011.

Study Selection: Studies were included if they were peer-reviewed articles, included populations with physical disabilities, and reported primary data for pedometer validity in comparison with direct observation. A consensus approach was used to apply the inclusion and exclusion criteria. Of the 163 articles identified in the database searches (excluding duplicates), 7 studies met the inclusion criteria.

Data Extraction: The quality of the studies was assessed independently by 2 reviewers, using a purpose-designed appraisal tool, with a consensus approach used to settle disagreement. A single reviewer extracted data relating to sample size, participant characteristics, pedometer model, main variables tested, duration of tests, and method of direct observation.

Data Synthesis: The methodologic quality of the studies was generally high; however, there was a wide variation of population and methodology between studies. The correlation between pedometer step counts and directly observed step counts was moderate to excellent (intraclass correlation coefficient, .52−.87), and percent errors ranged from 0.5% to 24.7%. Secondary variables reported included the effect of speed of movement, pedometer placement, comparison of pedometer makes/models, and test-retest reliability.

Conclusions: Available evidence suggests that pedometers are valid for use in clinical and research settings in people with physical disabilities. Further research examining the validity of pedometers in less heterogeneous populations of people with disabilities is warranted to determine validity for specific disability populations and to determine optimal pedometer placement.

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Physical activity is recognized as a public health issue because of compelling evidence of its wide-ranging health and psychological benefits, including reduced risk of heart disease, hypertension, type 2 diabetes mellitus, obesity, certain cancers, and some mental health problems.[1] Available evidence suggests physical activity affords these same or even additional benefits to people with physical disabilities.[2,3] Emerging evidence suggests that physical activity plays a vital role in ongoing management of people with disabilities, including maintenance of physical function and independence.[2,3]

In order to effectively monitor and increase physical activity, appropriate tools to measure levels of physical activity in people with and without disabilities are required. A wide variety of measurement tools are available, including direct observation, indirect calorimetry, heart rate telemetry, accelerometry, pedometry, and self-report measures.[4] These measurement tools vary in terms of the precise aspects of physical activity they detect, feasibility in research compared with clinical settings, cost, ease of use, and psychometric properties.[4,5]

Pedometers provide an objective measure of ambulatory physical activity. The key advantages of pedometers lie in their ability to measure activity in free-living situations, ease of use and noninvasiveness, and low cost with suitability to both clinical and research applications.[6] They also provide measurements that are easily interpreted by researchers, clinicians, and patients.[7] A pedometer's primary function is to record the number of steps taken by an individual; however, some models also record

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additional parameters, such as estimated distance traveled and energy expenditure.[8] Previous studies have shown high-quality pedometers to have strong validity in nondisabled adult and child populations. Bassett et al[9] compared the step counts of 3 different pedometer models to manually counted steps, for adults without disabilities during a 4.88-km walk, and reported mean percent errors between .35% and 7.8% for the 3 pedometers. Beets et al[10] conducted a similar study in children without disabilities, where the step counts of 2 pedometers were compared with manually counted steps, and reported an intraclass correlation coefficient (ICC) >.98, with mean percent errors less than 0.9%.

Physical disabilities are commonly associated with gait impairments. As such, it cannot be assumed that evidence regarding the validity of pedometers collected in people without disabilities would reflect the validity of pedometers when used in people with physical disabilities. Therefore, in recent years, studies have been conducted to examine the validity of pedometers when used in specific populations of people with disabilities.

This systematic review aimed to bring together evidence regarding the validity of pedometers in populations with physical disabilities. A research question within the population, intervention, comparison, outcome, study design (PICOS) framework[11] was formulated, with the population defined as all adults and children with physical disabilities; the comparison between pedometer step counts and step counts from direct observation; the outcome was validity data; and the study design was quasiexperimental or observational. As this was a question about validation of a measurement method, there was no intervention. The final systematic review question was, “How valid are pedometers compared to direct observation in counting the steps of adults and children with physical disabilities?”

Methods

This review was undertaken and reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[12]

Eligibility criteria

A list of common disabilities was generated from an Australian Government report on disability and a prominent South Australian Government website for childhood disability.[13,14] The research team reviewed the list to define the term “physical disability” using a consensus approach. For this review, physical disability was defined as a disability with primarily neurologic or physical origins that affected mobility. Disabilities of primarily medical origin (eg, cardiovascular disease), intellectual/mental origin (eg, Down syndrome or autism spectrum disorder), or defined by the presence of pain (eg, chronic back pain) were excluded from this definition of physical disability, to produce a reasonably homogenous population, which in turn would allow the results of the review to be meaningful and reproducible. Only peer-reviewed articles published in English were included, and no publication year limits were set.

List of abbreviations:

ICC	**intraclass correlation coefficient**
PRISMA	**Preferred Reporting Items for Systematic Reviews and Meta-Analyses**

Information sources

A systematic search was conducted in 9 databases: Academic Search Premier, ERIC, SPORTDiscus, MEDLINE, AMED, Scopus, CINAHL, Web of Science, and EMBASE. The last date searched was September 7, 2011. Where appropriate, authors were contacted to request further information to maximize the number of included studies. Searching of gray literature and hand searching were not done.

Search

The following search terms were entered into each database:

1. pedomet* AND
2. disab* OR “cerebral pals*” OR “spina bifida” OR “muscular dystroph*” OR “brain injur*” OR “head injur*” OR “spin* injur*” OR “spinal cord injur*” OR stroke OR CVA OR “cerebrovascular accident” OR “multiple sclerosis” OR paralysis OR “Parkinson* disease”

The abstract-title-keyword limit was used for Scopus. No limits were used for all other databases.

Study selection

Search findings were reviewed by the primary author in consultation with the coauthors. Studies were included if (1) the study population included adults or children with a physical disability; (2) they reported validity data for a pedometer in comparison with direct observation; and (3) they were peer-reviewed. Studies were excluded if (1) the population was nondisabled; (2) the population’s disability was of intellectual, medical, weight status, or pain origin; (3) only convergent pedometer validity data were reported (eg, the pedometer was compared with accelerometry or heart rate telemetry); and (4) the publication types were non−peer-reviewed articles, conference papers, or theses.

Where eligibility could not be determined from the title and abstract alone, the full text of the article was obtained. If a study met all the inclusion and exclusion criteria but did not adequately report the validity data, the author was contacted to request additional data to enable inclusion in this review. If data could not be supplied, the study was excluded.

Data collection process and data items

Data extraction was conducted by the primary author, using a standardized form developed for this review. Double checking was done to ensure accuracy of data extraction. Data relating to sample size, participant characteristics (population, age), pedometer model, main variables tested (validity, speed, pedometer location, test-retest reliability, model comparison), duration of tests, and method of direct observation were sought and recorded from each included article.

Risk of bias within studies

An appropriate, preexisting, risk of bias assessment tool to assess the methodologic quality of the included studies could not be found, despite extensive searching. The lack of availability of a tool may be due to the nonconventional study design of the included (primarily validation) studies. Therefore, a purpose-designed appraisal tool was developed, based on the McMaster Critical Appraisal Tool for

1. Was the aim(s) of the study clearly stated?
2. Was the relevant background literature reviewed?
3. Was the sample described in detail?
4. Was the sample size justified?
5. Were the inclusion/exclusion criteria clearly stated?
6. Was the model(s) of pedometer reported?
7. Was the placement of the pedometers reported?
8. Was intra- or inter-rater reliability reported for the direct observation component of the study?
9. Did the results clearly address the aims?
10. Did the study provide both point measures and measures of variability for at least 1 key outcome?
11. Were results reported in terms of statistical significance, where appropriate?

Fig 1 Risk of bias assessment tool.

Quantitative Studies[15] and aspects of the Physiotherapy Evidence Database Scale.[16] The scale consisted of 11 items (fig 1), in which each study was identified as either having satisfactorily met the criterion or having not satisfactorily met the criterion. Two reviewers independently rated the articles using the appraisal tool, and any difference in their results was resolved by discussion with a third team member until consensus was reached. Interrater agreement was calculated using Cohen's kappa coefficient.

Summary measures and synthesis of results

The primary summary measures for this systematic review were pedometer validity, reported as an ICC, percent error scores, or both. Data were extracted from the studies to enable comparison between studies. Some studies reported "percent of actual steps" (ie, the percent of directly observed steps counted by the pedometer). To aid comparison, percent of actual steps was converted to percent error using the following formula: percent error = 100 − percent of actual steps.

Some individual studies examined a variety of additional parameters, which were also extracted in this systematic review. These included the effect of speed, pedometer location, pedometer models, and test-retest reliability, recorded as percent errors, analysis of variance, *t* tests, and ICC. Because of the very small number of studies reporting each of these additional parameters, the data are presented in their original format (ie, no conversion of statistics was undertaken).

The reported outcome measures were assessed for consistency of reporting and homogeneity of study design to determine the feasibility of meta-analysis.

Results

Study selection

A total of 163 studies were identified during the database searching after removal of duplicates. The process for assessment of eligibility for inclusion in the review is summarized in figure 2. Seven articles reported data for validity of pedometers in appropriate populations and were included in this review.

Study characteristics

A summary of the key characteristics of included studies is presented in table 1. The publication dates spanned 8 years, from 2002 to 2009. Six of the 7 studies were for adult populations with varying disabilities (mainly neurologic), and one[17] included children with a variety of developmental disabilities, including some with physical disabilities.

In 3 studies,[17-19] the primary purpose was to report pedometer validity. Another 3 studies[20-22] compared the validity of accelerometry and pedometry, and 1 further study[23] addressed the effect of gait variability on pedometer validity. However, each study included validity data that satisfied this systematic review's inclusion criteria.

While studies varied considerably in methodology, all utilized a basic procedure in which participants wore 1 or more pedometers while walking for a defined duration or distance. The actual (criterion) number of steps taken by the participant was determined by direct observation (either in real-time using a hand tally counter[18,19,22,23] or from video playback[17,19-21]). The criterion step count was compared with the number of steps recorded by the pedometer(s), to determine validity of the pedometer.

Five different models of pedometer were used in the 7 studies. The Yamax Digi-Walker SW-200[a] was used in 4 studies,[18-20,23] and 4 other models—Yamax Digi-Walker SW-401,[a] Yamax Digi-Walker SW-700,[a] Walk4Life Duo,[b] and Elexis Trainer FM-180[c]—were each used in a single study. All studies reported different durations of testing; some were restricted by a time limit[18,19,22] and others by distance.[17,20,21] The shortest distance covered in a single test was 3m, and the longest 160m, while time limits ranged from 1 to 6 minutes.

Risk of bias within studies

Table 2 summarizes the risk of bias rating score for each included study. Methodologic quality was high, with all studies satisfying 8 to 10 of the 11 items; however, a consistent methodologic flaw was the absence of justification of sample size. In addition, interrater reliability for the criterion step counts (determined from direct observation) was reported in only 3 of the 7 studies. The interobserver agreement for assessing the methodologic quality of the studies was 93.5% (κ=.80), with only 5 instances of different scoring requiring discussion.

Results of studies

Results of studies are summarized in table 3. Pedometer validity was reported (or could be calculated) in terms of mean percent error scores in 6 of the 7 included studies (all except Elsworth et al[18]) and showed wide variability, ranging from 0.5% to 24.7%. Three studies[17,18,20] reported pedometer validity in terms of ICCs and showed moderate to excellent agreement, with ICCs ranging from .52 to .87.

The effect of speed on pedometer validity was considered in 3 studies[19,20,22] (see table 3). All reported a relative decrease in validity as walking speed decreased.

There were conflicting results in the 3 studies that examined whether pedometer validity varied depending on the location of the pedometer on the body. Beets et al[17] reported the front right hip and back left hip placements to have a significantly higher validity than the front left hip (P=.02). However, Dijkstra et al[20] reported

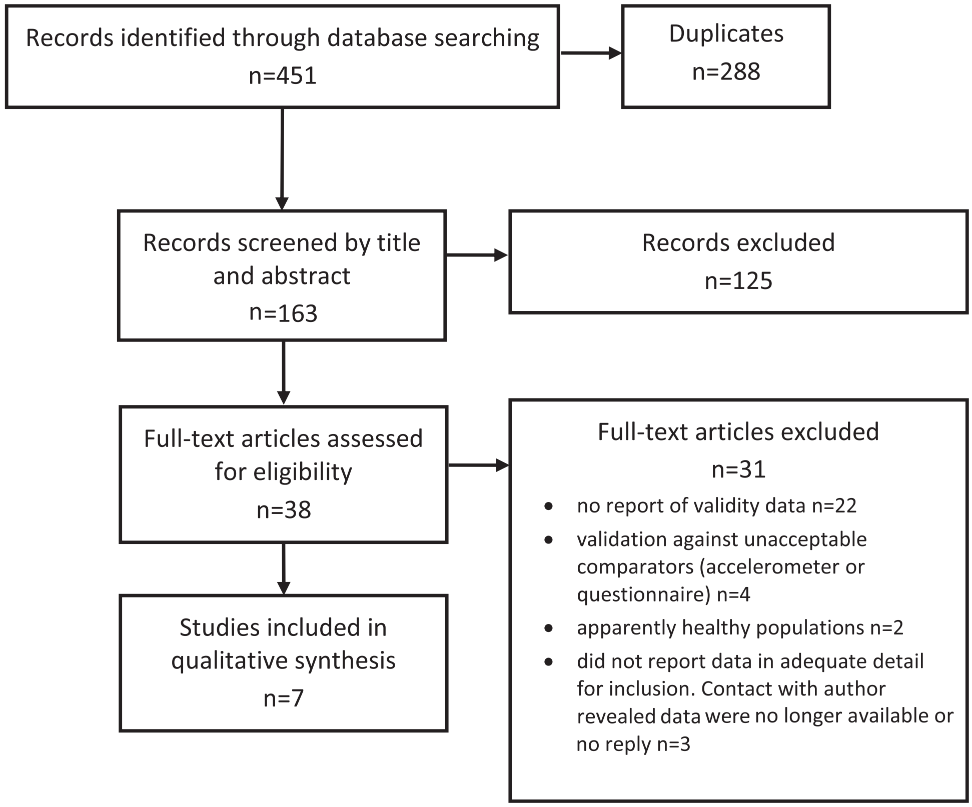

Fig 2 Results of systematic search.

a significant difference ($P<.05$) between error scores from left and right hip placement, with left hip placement more accurate than right. Manns et al[23] reported a strong agreement between left and right pedometers ($r=.87$), and did not report whether one side was more accurate than the other. No study considered the effect of location with respect to side of dominance, or affected/unaffected side in the case of asymmetric impairments.

The validity of 2 different pedometer models was compared in the study by Motl et al.[19] There was no significant difference found between the validity of the Yamax Digi-Walker SW-200 and Yamax Digi-Walker SW-401 models ($P>.05$).

Two studies investigated test-retest reliability by examining consistency of percent error between repeated trials. Beets et al[17] reported no significant difference between error scores of repeated trials ($P<.05$). However, Macko et al[22] showed only a moderate correlation between repeated trials (ICC$=.64$; $P<.05$).

Synthesis of results

It was initially intended that meta-analyses would be undertaken. However, given that only 7 eligible studies were identified, and they varied widely in terms of population and methodology, meta-analysis of the results was deemed to be inappropriate.

Discussion

Key findings

This systematic review showed that pedometer validity was moderate to excellent in populations of children and adults with a variety of physical disabilities. The validity coefficients reported in the included studies varied, and it was unclear whether this was due to variations in the specific types of disabilities among the studies, the models of pedometers used, or variations in the protocols used in the various studies. Results showed that pedometer validity was higher as the speed of locomotion increased. However, results regarding the optimal placement of the pedometer on the trunk were inconsistent.

The correlation between pedometer step counts and directly observed step counts was moderate to excellent (ICC, .52−.87), and percent errors ranged from 0.5% to 24.7%. The validity of the specific pedometer models in the included studies was compared with previously reported data for the same models in populations without disabilities (table 4). These comparisons show that only 1 study,[19] of adults with multiple sclerosis, showed the pedometer to have comparable validity to populations without disabilities. All other studies in various disability populations identified in this review reported validity notably lower than in nondisabled populations. Thus, it appears that the presence of a physical disability affects the validity of pedometers. This poorer validity may be explained by the gait abnormalities associated with physical disabilities. The altered gait patterns associated with physical disabilities may mean that hip acceleration thresholds that the pedometers require to count a step are not consistently reached in individuals with physical disabilities, resulting in poorer validity.

Results of this review showed that pedometer validity was higher as speed increased. This is consistent with previous studies[10,24,25] in people without disabilities. Given that people with physical disabilities are likely to have slower walking speeds than people without disabilities, the differences in validity between populations with and without disabilities may,

Table 1 Summary of included studies

Study	Sample	Pedometer Model(s)	Methods	Pedometer Placement	Criterion Measure
Elsworth et al,[18] 2009	43 adults with mixed neurologic disabilities,* 54±13y	DWSW-200	Walked at self-selected pace up and down walkway for 2min	1. R hip, midline of thigh	Hand tally counter
Dijkstra et al,[20] 2008	32 adults with Parkinson's disease, 67±7y	DWSW-200	Walked at preferred walking pace, slower than preferred and faster than preferred paces for distances between 3 and 15m	1. R hip 2. L hip	Video recording
Dudek et al,[21] 2008	20 adults with transtibial amputation and prosthesis, 59±11y	DWSW-700	Task 1: household simulation activities, included walking approximate total 43m at self-selected pace Task 2: walked at self-selected pace up and down gymnasium for 160m	1. Hip, affected side, midline of thigh	Video recording
Beets et al,[17] 2007	18 children with developmental disabilities,† 10±3y	W4L Duo	Walked at self-selected pace up and down 10-m hallway for 80m. Repeated 6 separate 80-m trials	1. Front R hip 2. Back R hip 3. Front L hip 4. Back L hip 5. Middle back at the spine	Video recording
Manns et al,[23] 2007	45 adults with mixed neurologic disabilities,‡ 54±14y	DWSW-200	Walked at self-selected pace for 100m	1. R hip, midline of thigh 2. L hip, midline of thigh	Hand tally counter
Motl et al,[19] 2005	23 adults with multiple sclerosis, 40±9y	DWSW-200 DWSW-401	Walked on treadmill at 5 different speeds (41, 54, 67, 80, 94m/min) for 5min per speed	1. Centered, nondominant hip	Hand tally counter (corroborated by video recording)
Macko et al,[22] 2002	16 adults with stroke, 67±7y	FM-180	Task 1: walked at (1) self-selected pace, and (2) fastest comfortable pace for 1min each Task 2: walked at self-selected pace for 6min, on 2 separate days	1. Nonaffected hip, midline of thigh	Hand tally counter

Abbreviations: DWSW-200, Yamax Digi-Walker SW-200[a]; DWSW-401, Yamax Digi-Walker SW-401[a]; DWSW-700, Yamax Digi-Walker SW-700[a]; FM-180, Elexis Trainer FM-180[c]; L, left; R, right; W4L Duo, Walk4Life Duo.[b]

* Included muscular dystrophy, multiple sclerosis, stroke, spinal cord injury, and acquired brain injury.

† Mental or physical impairment included autism, mild mental retardation, Down syndrome, traumatic brain injury, visual impairment, seizure disorder, and juvenile arthritis.

‡ Included stroke, cerebral palsy, Parkinson's disease, multiple sclerosis, and acquired brain injury.

Table 2 Results of analysis of risk of bias within studies

Criterion	Item	Description	Elsworth et al,[18] 2009	Dijkstra et al,[20] 2008	Dudek et al,[21] 2008	Beets et al,[17] 2007	Manns et al,[23] 2007	Motl et al,[19] 2005	Macko et al,[22] 2002
Purpose	1	Purpose	✓	✓	✓	✓	✓	✓	✓
Background	2	Background	✓	✓	✓	✓	✓	✓	✓
	3	Sample description	✓	✓	✓	✓	✓	✓	✓
Sample	4	Justification of sample size	×	×	×	×	×	×	×
	5	Inclusion/exclusion criteria	✓	✓	✓	×	✓	×	✓
	6	Pedometer model specified	✓	✓	✓	✓	✓	✓	✓
Methods	7	Pedometer placement specified	✓	×	✓	✓	✓	✓	✓
	8	Interrater reliability	×	✓	×	✓	✓	×	×
	9	Results match aims	✓	✓	✓	✓	✓	✓	✓
Results	10	Point variability measures	✓	✓	✓	✓	✓	✓	✓
	11	Reported statistical significance	✓	✓	✓	✓	✓	✓	✓

Abbreviations: ✓, item satisfied; ×, item not satisfied.

at least in part, be attributed to speed rather than altered walking patterns.

Each of the studies included in this systematic review varied in the protocol used, which may have influenced the validity coefficients obtained. The protocol variations included different ground surfaces versus treadmill walking, different durations of testing, and the use of self-selected versus controlled walking speeds.

A strength of this review was the reporting of the findings according to PRISMA guidelines,[26] which demonstrated a rigorous search strategy and data collection processes. A large range of databases with various disciplinary focuses were searched to maximize the number of studies identified. Furthermore, all studies achieved a high score on the critical appraisal of bias (8−10 of a maximum 11 points), indicating rigorous reporting in the included studies.

Study limitations

A limitation of the review was the heterogeneity (populations, pedometer models, protocols) of the identified studies. Because of the relatively small numbers of eligible studies, and variability in the statistics used between studies, there were insufficient numbers to allow meta-analysis. In addition, only a small subgroup of studies examined secondary variables such as the effect of speed, pedometer location, and pedometer model on validity. In particular, the findings for the effect of pedometer location were inconsistent, and the optimal location remains unclear.

It is important to consider the possibility of reporting bias. While extensive database searching was undertaken, only peer-reviewed journal articles published in English were sought, which may have reduced the number of results. Not uncommon in many systematic reviews is the risk of publication bias, where studies producing unfavorable results may be underreported in the literature. However, when compared with pharmacologic and intervention studies, this risk is likely to be relatively low in the current study.[27] Publication bias has also been shown to be more common in established fields of research.[27] This bias may therefore be reduced in the current study because validation of pedometers in populations with physical disabilities is a reasonably new field of research.

Clinical implications

There is no universally accepted cutoff for what is considered to constitute acceptable pedometer validity. However, Schneider et al[28] proposed that a pedometer model can be considered to have acceptable validity for use in clinical settings if the percentage error is less than 20% for self-selected walking speeds in adults without disabilities, and that for research purposes, the percentage error should be less than 3%. With the use of these cutoffs, all the studies in this review satisfied the 20% error cutoff for use in a clinical setting, but only 1 study[19] found validity high enough to justify pedometer use in a research setting (Yamax Digi-Walker SW-200 and Yamax Digi-Walker SW-401, in adults with multiple sclerosis).

Despite finding that most of the studies in this review had percent errors greater than 3%, pedometers may still be sufficiently valid to fill an important function in ambulatory physical activity research in populations with physical disabilities. Schneider[28] set these recommendations on the basis of data from nondisabled populations, in which numerous pedometer models satisfy the 3% error cutoff. Given that pedometer validity appears to be somewhat lower in populations with physical disabilities, and that pedometer models normally regarded as being highly accurate did not achieve the 3% error cutoff in most of the studies included in this review, it seems that a 3% error cutoff for research purposes may not be realistic for populations with disabilities. The broader field of physical activity measurement in populations with disabilities (including pedometers and other tools such as questionnaires) is relatively new, with very few psychometrically tested tools available. Of those that have been tested, validity is typically poor (eg, Maher et al[29] found the validity of a popular physical activity questionnaire [Physical Activity Questionnaire for Adolescents[30]] in adolescents with cerebral palsy was $r=-.21$ with reference to accelerometry and $r=.24$ with reference to pedometry). In light of this, the validity coefficients in the included studies (typically approximately 15% error, which represents 85% accuracy) seem quite acceptable. Therefore, we propose that pedometers with 10% to 15% error when used in populations with disabilities may be suitable for research purposes, provided the researchers are cognizant of their limitations.

The results of this review are unable to inform recommendations for use of a particular pedometer model in populations with

Table 3 Summary of results from included studies

Study	ICC (95% CI)	% Error (Mean ± SD)	Speed	Pedometer Location	Pedometer Models	Test-Retest Reliability
Elsworth et al,[18] 2009	.66 (.46–.80)	ND	ND	ND	ND	ND
Dijkstra et al,[20] 2008	.75 (.48–.85) (R) .87 (.76–.92) (L)	16.3±13.7 (R) 11.1±9.0 (L)	Validity decreased significantly as walking pace decreased ($P<.05$).	Left hip had significantly lower error score than right hip ($P<.05$).	ND	ND
Dudek et al,[21] 2008	ND	24.7±20.9 (Task 1) 6.2±6.7 (Task 2)	ND	ND	ND	ND
Beets et al,[17] 2007	.83 (.76–.88) (FR) .48 (.32–.61) (BR) .52 (.42–.67) (FL) .69 (.58–.77) (BL) .43 (.30–.59) (BM)	6.6±8.7 (FR) 9.5±16.7 (BR) 14.3±18.9 (FL) 6.7±12.4 (BL) 8.4±18.8 (BM)	ND	FR and BL hip significantly lower percent error than FL ($P=.02$). Nil difference for all other locations	ND	No significant difference of error scores between trials
Manns et al,[23] 2007	ND	11.2±24.6	ND	Agreement of left and right error scores ICC=.87	ND	ND
Motl et al,[19] 2005	ND	0.5±8.9 (DWSW-200, 80m/min) 2.1±11.1 (DWSW-401, 80m/min)	Slowest speeds (41 and 54m/min) detected significantly fewer steps ($P<.001$) than actual steps taken, for both models of pedometer.	ND	No significant difference of validity between DWSW-200 and DWSW-401 pedometers	ND
Macko et al,[22] 2002	ND	13.4±10.9 (Task 1a) 12.0±9.9 (Task 1b) 11.0±11.9 (Task 2)	Task 1a (self-selected) 13.4%±10.9% error* Task 1b (fast) 12.0%±9.9% error*	ND	ND	ICC=.64 ($P<.05$)

Abbreviations: BL, back left hip; BM, back middle of spine; BR, back right hip; CI, confidence interval; DWSW-200, Yamax Digi-Walker SW-200[a]; DWSW-401, Yamax Digi-Walker SW-401[a]; FL, front left hip; FR, front right hip; L, left; ND, no data; R, right.

* Significance not reported.

Table 4 Comparison of validity of pedometer models in populations with and without physical disabilities

	Disability Population			Nondisabled Population		
Pedometer Model	Study	Age Group (Mean Age ± SD; y)	Reported Validity	Study	Age Group (Mean Age ± SD; y)	Reported Validity
DWSW-200	Elsworth et al,[18] 2009	Adults (54±13)	ICC=.66	No study available with ICC values		
	Dijkstra et al,[20] 2008	Adults (67±7)	ICC=.75 (R)	No study available with ICC values		
			ICC=.87 (L)			
			16.3%±13.7% (R)	Le Masurier & Tudor-Locke,[25] 2003	Adults (29±5)	0.7%±2.4%*
			11.1%±9.0% (L)			
	Manns et al,[23] 2007	Adults (54±14)	11.2%±24.6%	Le Masurier & Tudor-Locke,[25] 2003	Adults (29±5)	0.7%±2.4%*
	Motl et al,[19] 2005	Adults (40±9)	0.5%±8.9%	Le Masurier & Tudor-Locke,[25] 2003	Adults (29±5)	0.7%±2.4%*
DWSW-700	Dudek et al,[21] 2008	Adults (59±11)	24.7%±20.9% (Task 1)	Schneider et al,[28] 2003	Adults (40±16)	0.1%±8.4%
			6.2%±6.7% (Task 2)			
W4L Duo	Beets et al,[17] 2008	Children (10±3)	ICC=.83 (R)	Beets et al,[10] 2005	Children (9±2)	ICC>.98
			ICC=.52 (L)			
			6.6%±8.7% (R)	Beets et al,[10] 2005	Children (9±2)	≤0.9%
			14.3%±18.9% (L)			
DWSW-401	Motl et al,[19] 2005	Adults (40±9)	2.1%±11.1%	No study available with error data		
FM-180	Macko et al,[22] 2002	Adults (67±7)	13.4%±10.9% (Task 1a)	No study available with error data		
			12.0%±9.9% (Task 1b)			
			11.0%±11.9% (Task 2)			

Abbreviations: DWSW-200, Yamax Digi-Walker SW-200[a]; DWSW-401, Yamax Digi-Walker SW-401[a]; DWSW-700, Yamax Digi-Walker SW-700[a]; FM-180, Elexis Trainer FM-180[c]; L, left hip; %, pedometer percent error; R, right hip; W4L Duo, Walk4Life Duo.[b]
* For treadmill speed 80m/min.

physical disabilities, as only 1 study[19] examined the validity of more than 1 model. Furthermore, the 2 models considered by Motl et al[19] were of the same brand and had very similar internal mechanisms. Comparison of models across the studies was not possible because the variation in validity coefficients reported between studies cannot necessarily be attributed to the pedometer model, given the lack of consistency between studies in methods used and populations studied. In the absence of more compelling evidence, researchers and clinicians wishing to use pedometers with people with physical disabilities should select pedometers that have been proven to be highly valid in nondisabled populations. Further research is needed to compare validity among multiple models and brands of pedometers in populations with disabilities.

The issue of optimal placement of pedometers on the trunk was unresolved because of contradictory results between studies. Interestingly, all 3 studies[17,20,23] that addressed pedometer placement compared placement side in terms of left versus right sides, without considering participants' handedness, side of dominance, or affected side for asymmetric impairments. Placement of the pedometer may be more meaningful when considered in terms of side of dominance, to account for left- and right-leg-dominant individuals in the sample. Similarly, for asymmetric impairments such as stroke or spinal cord injury, consideration of pedometer placement with regards to the affected/nonaffected side may provide more meaningful results. Thus, further research examining the effect of pedometer placement in relation to side of dominance and affected side would be beneficial.

Conclusions

Pedometers are useful tools for measuring ambulatory physical activity. This systematic review identified 7 studies investigating the validity of pedometers in a variety of populations with physical disabilities, including stroke, multiple sclerosis, Parkinson's disease, transtibial amputation, and children and adults with mixed neurologic disabilities. While the validity of pedometers appeared to be somewhat lower in populations with physical disabilities compared with populations without disabilities, the validity was still moderate to high. These findings provide preliminary evidence that pedometers may be used in clinical and research settings in populations with disabilities. Further research examining the validity of pedometers in less heterogeneous populations of people with disabilities, and particularly children, is warranted to determine validity for specific disability populations. In addition, future research should investigate pedometer reliability and optimal placement of pedometers with regard to dominant and nondominant sides and affected and nonaffected sides in populations with disabilities.

Suppliers

a. DWSW-200; Yamasa Tokei Keiki Co, Ltd, 1-5-7, Chuo-cho, Meguro-ku, Tokyo 152-8691 Japan.
b. W4L Duo; Walk4Life, 1981 Weisbrook Dr, Unit D, Oswego, IL 60543.
c. International Microtech, 9960 Bell Ranch Dr, Unit 103, Santa Fe Springs, CA 90670.

Keywords

Disabled persons; Physical activity; Rehabilitation; Reliability and validity

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