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White Paper: The Impact of Pedometers on Chronic Conditions – A Review of Reviews

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PREFACE

The VA Evidence-based Synthesis Program (ESP) was established in 2007 to provide timely and accurate syntheses of targeted healthcare topics of particular importance to clinicians, managers, and policymakers as they work to improve the health and healthcare of Veterans. QUERI provides funding for four ESP Centers, and each Center has an active University affiliation. Center Directors are recognized leaders in the field of evidence synthesis with close ties to the AHRQ Evidence-based Practice Centers. The ESP is governed by a Steering Committee comprised of participants from VHA Policy, Program, and Operations Offices, VISN leadership, field-based investigators, and others as designated appropriate by QUERI/HSR&D.

The ESP Centers generate evidence syntheses on important clinical practice topics. These reports help:

- Develop clinical policies informed by evidence;
- Implement effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures; and
- Set the direction for future research to address gaps in clinical knowledge.

The ESP disseminates these reports throughout VA and in the published literature; some evidence syntheses have informed the clinical guidelines of large professional organizations.

The ESP Coordinating Center (ESP CC), located in Portland, Oregon, was created in 2009 to expand the capacity of QUERI/HSR&D and is charged with oversight of national ESP program operations, program development and evaluation, and dissemination efforts. The ESP CC establishes standard operating procedures for the production of evidence synthesis reports; facilitates a national topic nomination, prioritization, and selection process; manages the research portfolio of each Center; facilitates editorial review processes; ensures methodological consistency and quality of products; produces “rapid response evidence briefs” at the request of VHA senior leadership; collaborates with HSR&D Center for Information Dissemination and Education Resources (CIDER) to develop a national dissemination strategy for all ESP products; and interfaces with stakeholders to effectively engage the program.

Comments on this evidence report are welcome and can be sent to Nicole Floyd, ESP CC Program Manager, at Nicole.Floyd@va.gov.

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INTRODUCTION

Physical activity is associated with improvement in many health conditions: obesity; reducing risk of cardiovascular disease, type 2 diabetes, and metabolic syndrome; some cancers; and mental health disorders.[1] Adequate physical activity also increases the chances of living longer.[1] Despite these known benefits and the well-documented evidence that physical activity is beneficial, a large proportion of adults are insufficiently active, and inactivity continues to be a significant public health concern.[2]

Epidemiologic and observational studies have used activity monitors to characterize activity intensity and daily activity patterns across diverse samples.[3-5] Pedometers have emerged as one such popular self-monitoring tool for motivating physical activity.[6,7] Pedometers are small, relatively inexpensive devices worn on the body that measure each time the wearer's hips move while taking a step, using a mechanical sensor to count the number of steps walked per day. The premise is that pedometers give immediate visual feedback of cumulative step counts and increase people's awareness of their activity and how their behaviors have an effect on physical activity.[8-10] Patients with diabetes, obesity, or musculoskeletal disease in particular derive significant benefits from regular physical activity, including favorable effects on blood sugar, weight control and body fat distribution, blood pressure, lipid profiles, joint swelling and pain, and psychological well-being.[11]

Many systematic reviews have been published describing the benefits of using pedometers for these conditions. Thus the primary purpose of this paper was to provide a review of these reviews in order to evaluate the association between pedometer use, physical activity, and other key health outcomes among adults with chronic medical illnesses commonly seen in the Veteran population seeking healthcare through VA medical facilities.

METHODS

SEARCH STRATEGY

In consultation with an expert librarian, we searched PubMed, Embase, CINAHL, SPORTDiscus and the Cochrane Library for English-language systematic reviews published from January 1, 2007, to the present. We used Medical Subject Heading (MeSH) terms and selected free-text terms for "pedometers" specifically and the conditions of interest.

ELIGIBILITY

Eligibility criteria included systematic reviews evaluating the use of pedometers by adults with type 2 diabetes, arthritis, hypertension, heart disease, or weight loss. To be a systematic review, an article must have included a methods section that described all of the following: (1) search strategy, (2) eligibility criteria, and (3) an *a priori* approach to synthesizing the data. For studies including a broader sample of chronic medical conditions, we specified that ≥80% of participants must have one of the conditions of interest. The systematic reviews had to describe the use of pedometers to increase physical activity, but could use any active or inactive comparator. Outcomes of interest included were change in physical activity behaviors (*eg*, total steps, total activity); cardiorespiratory fitness; hemoglobin A1c; arthritis pain and physical function; blood pressure; weight change (kg, lb, body mass index); and cholesterol levels. We accepted the outcome timing specified in the reviews' eligibility criteria. We excluded validation studies that reviewed the accuracy of a pedometer to capture physical activity. We also excluded reviews of worksite wellness interventions.

STUDY SELECTION

Using the inclusion and exclusion criteria, a single trained investigator assessed titles and abstracts for relevance. Full-text articles identified by one investigator as potentially relevant were retrieved for further review and examined by another investigator against the eligibility criteria.

DATA ABSTRACTION

Data from included articles were abstracted into a customized database by a trained investigator. Data elements included date of publication, sample size, study location, intervention/exposure details, descriptors to assess applicability, quality elements, and outcomes. Key population and device characteristics abstracted were age, sex, chronic medical illness status, type of adjunctive interventions (*eg*, behavioral weight management strategies, physical activity education) adherence to use of measurement device, and duration and frequency of intervention.

STUDY QUALITY

One investigator assessed the quality of the review using criteria adapted from the AMSTAR measurement tool.[12] The key criteria included that the review assesses a focused clinical question, search methods are adequate for replication and are comprehensive, selection bias is avoided, data are abstracted reliably, characteristics of primary literature are reported and quality is assessed appropriately, results are synthesized using appropriate methods, publication bias is assessed, conflict of interest is reported, and conclusions are supported by results. Based on these criteria, reviews were categorized as good, fair, or poor quality. Poor-quality reviews were excluded.

DATA SYNTHESIS

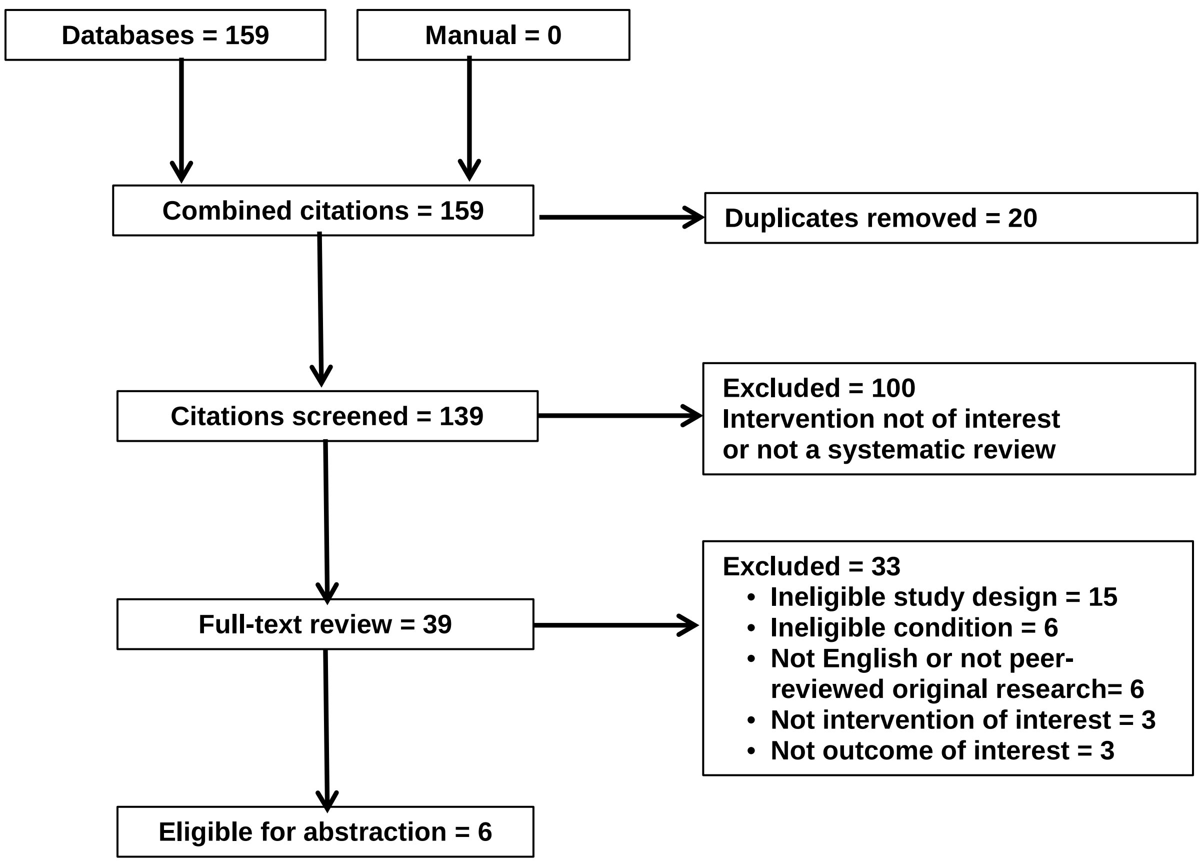
Quantitative analysis of the reviews was not possible due to the limited number and diversity of the included studies; instead we present qualitative descriptions. We grouped reviews by chronic medical illness and then summarized the key characteristics and findings. If findings or conclusions differed importantly across reviews, we analyzed potential reasons for discrepancies such as review inclusion/exclusion criteria, the primary studies included, differences in outcome definition, and analytic approach. When synthesizing results, we gave more qualitative weight to recent reviews of higher overall quality (*eg*, good vs fair) and to reviews that included higher quality study designs (*eg*, randomized controlled trials vs retrospective observational studies).

RESULTS

LITERATURE FLOW

The flow of articles through the literature search and screening process is illustrated in Figure 1. A combined search of PubMed (n=58), Embase (n=35), CINAHL (n=30), SPORTDiscus (n=16) and the Cochrane Library (n=0) yielded 139 citations. There were no MeSH terms for the intervention of interest, so we searched text words in the title and abstract for terms such as pedometer, step, and counter to locate all relevant citations. We limited the search to systematic reviews and meta-analyses published between January 1, 2007, and December 12, 2014. After applying inclusion and exclusion criteria at the title-and-abstract level, 39 full-text articles were retrieved for further evaluation. Of these, 33 were excluded at the full-text screening stage, leaving 6 articles describing 6 unique systematic reviews for data abstraction.

Figure 1. Literature Flow



PEDOMETER-BASED INTERVENTIONS FOR WEIGHT LOSS

We identified one good-quality eligible systematic review[13] that evaluated pedometer-based walking interventions for weight loss among a mixed population of obese, overweight, and sedentary participants. This review searched 5 computerized databases for eligible RCTs and cohort studies published through September 12, 2006. The review included 4 RCTs and 5 cohort studies.

The review authors used the Downs and Black quality-scoring system. The overall results for quality assessment were used as a covariate for meta-regression analysis. Publication bias was assessed with funnel plots and heterogeneity assessed with Cochran's Q statistic. Mixed-effects meta-regression was used to examine changes in the effect size of weight change using the covariates of quality assessment and study duration.

The eligibility criteria specified that participants were sedentary and overweight or obese (BMI >25 kg/m2) at baseline. The intervention required the use of a pedometer as a motivational tool to increase walking, including step-count goal-setting and continuous self-monitoring. The included studies did not include a concurrent dietary intervention. The outcomes of step count and weight were extracted for each included study. The authors had sufficient information to conduct summary estimates of treatment effects using a random-effects meta-analysis with Stata 9.0 (Stata Corp., College Station, TX). Data on adverse effects were not reported.

The review included 4 RCTs that randomized 92 sedentary, overweight, or obese adult participants who were either healthy (n=31) or had comorbid conditions (n=15 with hypertension, n=46 with type 2 diabetes). Also included were 5 cohort studies that enrolled 215 sedentary and/or obese participants with a variety of baseline conditions (*ie*, breast cancer survivors, healthy, or type 2 diabetes). Studies were not excluded due to author-rated quality. The sample size ranged from 15 to 106 participants. The majority of included participants (73%) were women (Table 1).

Table 1. Characteristics of Systematic Review Evaluating Pedometer Interventions for Weight Loss

Characteristic	Richardson, 2008[13]
Systematic review quality	Good
Population description	Age: 30 to 60+ years Gender: 73% women Conditions: Type 2 diabetes (n=4), sedentary (n=4), breast cancer survivor (n=1)
Study designs included	4 RCTs 5 cohort studies
Sample size range by design	Sample size: 15 to 106 for a total of 307 participants RCT: n=92 Cohort: n=215
Analytic approach	9 studies included meta-analysis and meta-regression
Impact of pedometers on physical activity	Range of weight change for the 9 cohorts was +0.30 to -3.70 kg with an unadjusted mean weight change of -1.42 kg.
Search date	January 1, 1995, through July 8, 2005; updated September 12, 2006 (without EMBASE)
Databases searched	CINAHL, Embase, MEDLINE, PsycINFO, SPORTDiscus, Web of Science

Table 2 presents the intervention duration and behavioral counseling methods used in these studies. The duration of the interventions ranged from 4 weeks to 1 year with a median duration of 16 weeks. Pedometers were not used as a standalone technique in most studies; nearly all of the studies used a variety of other motivational enhancements such as behavioral counseling. The use of a pedometer with step-count goals was the motivation method used in 3 studies. Coaching or counseling in groups or individual sessions was used in 4 studies. One study did not report the details of the behavioral counseling program. Goal-setting used a combination of methods. In 3 studies the participants were allowed to choose individualized step-count goals. Three studies assigned step goals to participants, and 3 studies used 10,000 steps per day as the final goal. The majority of studies utilized a written or web-based activity log to report step counts. Only one study used a pedometer with a 7-day memory to record step counts. Dropout rates were >20% to 40% in 3 studies, >0% to ≤10% in 3 studies, and 0% in one study. Two studies did not report dropout findings, and no details were provided about whether dropouts were differentially higher in the intervention arm for any included study.

Table 2. Description of Studies Included in Review by Richardson et al.[13]

Characteristic	Studies (n=9)
Type of counseling	
Individual	1
Group	4
Pedometer and step-count instruction only	3
Not reported	1
Treatment duration	
≤12 weeks	4
>12 to 24 weeks	3
>24 weeks	2
Method of goal-setting	
Individualized	3
Assigned	3
Goal of 10,000 steps	3
Method of logging and reporting step counts	
Written or web-based activity log	7
Pedometer memory download	1
Not reported	1
Dropouts	
0%	1
>0% to ≤10%	3
>10% to ≥20%	3
Not reported	2

The majority of included studies (n=8) reported a small decrease in weight. The range of weight change for all 9 studies was +0.30 to -3.70 kg with an unadjusted weight change across the studies of -1.42 kg. Weight changes were statistically significant in 5 of the studies. Step counts increased in all but one study, which did not report a preintervention step-count. Increases in step count ranged from 1,827 to 4,556 steps/day; the median increase was 3,750 steps/day. The pooled summary effect estimate for weight change was -1.27 kg (95% CI -1.85 kg to -0.70 kg) with significant heterogeneity. Funnel plot analysis suggested an absence of publication bias. In meta-regression analysis, a significant linear association (beta -0.05, p=0.03) was found between longer duration interventions and greater weight change. This would represent a weight reduction of 0.05 kg per week.

We rated this review[13] as having good methodological quality with some limitations. Although random effects meta-analysis was used, due to significant statistical heterogeneity, the clinical differences in the populations enrolled and the study designs utilized challenges generalizability. Dropout rates were high in several studies; however, no subgroup analysis was conducted to determine if this might have had a significant influence on pooled study estimates.

Summary of Findings for Weight Loss

We identified one recent, good-quality systematic review.[13] Overall this study suggests a potential benefit of pedometer-based walking interventions for weight loss. The amount of weight loss was related to the duration of the intervention program. However, the average amount of weight loss was small and may not be a strong motivating factor for participation in this type of intervention. A pedometer-based walking intervention appears to be a reasonable treatment option for weight loss; however, since these studies did not include a concurrent dietary intervention, pedometers alone may not be sufficient for significant or sustained clinically important weight reduction. The included RCTs were small, and the review authors did not provide details of individual study quality; therefore, larger, good-quality RCTs with long-term outcomes are needed.

PEDOMETER-BASED INTERVENTIONS FOR TYPE 2 DIABETES

We identified 2 good-quality[14,15] and one fair-quality[16] eligible systematic reviews that evaluated pedometer use in patients with type 1 and type 2 diabetes (Table 3). The review and meta-analysis by Russell-Minda et al[16] included RCTs only. The review by Funk et al[15] included both RCTs and quasi-experimental designs. Two reviews[14,15] focused on use of pedometers in patients with diabetes. The other review[16] included studies that used pedometers and multiple other types of health technologies for monitoring and managing diabetes. Eligibility criteria limited the study population to participants with a diagnosis of type 2 diabetes, required at least 5 participants per arm, step-counter use lasting at least 8 weeks, and reported changes in steps per day or hemoglobin A1c, or both.

Table 3. Characteristics of Systematic Reviews Evaluating Pedometer Interventions for Diabetes

Characteristic	Qiu, 2014[14]	Funk, 2013[15]	Russell-Minda, 2009[16]
Systematic review quality	Good	Good	Fair
Population description	Outpatients with type 2 diabetes	Adults ≥18 years of age with type 2 diabetes	Adults, adolescents ≥14 years of age, and youth 7 to 13 years of age with diabetes, type 1 or 2
Intervention and comparator descriptions	Interventions used step counters as motivating and monitoring tools compared with controls	Interventions between 6 and 24 weeks designed to increase physical activity	Interventions between 6 weeks and 6 months using pedometer to increase walking and/or

Characteristic	Qiu, 2014[14]	Funk, 2013[15]	Russell-Minda, 2009[16]
	exposed to usual care or step counters used only for counting steps. Step counter use had to be at least 8 weeks.	(walking) using pedometers to motivate and measure compared with various controls including coaching, nonpedometer groups, usual care, or waitlist.	health; compared 2 goal-setting strategies (steps/day vs bouts of steps).
Timing of outcome assessment	3 to 12 months	6 weeks to 24 weeks	6 weeks to 6 months
Study designs included	11 RCTs	9 RCTs, 1 quasi-experimental study	4 RCTs
Sample size range by design	RCTs (n=147 to 861)	RCTs (15 to 60), quasi-experimental (26)	RCTs (30 to 70)
Geographical location	3 Belgium, 2 Britain, 1 Norway, 2 America, 1 Canada, 2 Australia	2 Canada, 1 Australia, 5 USA, 1 Norway, 1 Belgium	2 USA, 1 Norway, 1 Canada
Analytic approach	Meta-analysis	Systematic review	Systematic review
Impact of pedometers on physical activity	In general, pedometers were associated with increased physical activity (+1,800 steps/day). Combined with goal-setting, steps increased to >3,000 steps /day. A few studies showed no effect of pedometers.	Pedometer-based walking interventions led to increases in physical activity.	There was conflicting evidence among the 4 RCTs included regarding the pedometer's role in increasing steps/day.
Search date	January 1994 through June 2013	2004 through 2011	1985 through May 2008
Databases searched	PubMed, Web of Science, Cochrane Library	MEDLINE, CINAHL, SPORTDiscus, ERIC, Academic Search Premier	CINAHL, Cochrane Library, Embase, MEDLINE, PsycINFO, SPORTDiscus, Scirus,

Abbreviation: RCTs=randomized controlled trials

Our discussion focuses on the good-quality review and meta-analysis by Qiu et al,[14] which searched 3 databases for RCTs published between January 1994 and June 2013. RCTs (n=11) utilizing step counters as tools to monitor and motivate increased physical activity were included. Active interventions were compared with a usual care control arm or a control arm given step counters exclusively for counting steps.

The review authors rated 4 RCTs as having low risk of bias, 6 RCTs as having high risk of bias, and 1 as unclear risk of bias. Three RCTs reported adherence of 75% to 80%. Four RCTs did not report on adherence. Dropout rates ranged from 2.3% to 24.9%. All studies had blinded assessment of outcomes. No significant publication bias was detected by Begg's test (p=0.368) or Egger's test (p=0.147).

Trials used a combination of intervention strategies, including setting personal goals to increase physical activity, cognitive behavioral therapy, behavioral modification with telephone support, and intensive dietary intervention. No major adverse events secondary to step counter use were reported. A random-effects model was used to analyze summary estimates (Stata version 11.0, College Station, TX). Heterogeneity, inconsistency and publication bias were measured among studies. All studies reported use of cointerventions with pedometer use. Cointerventions consisted of diary use (n=9), self-set goals (n=3), and prescribed step goals (n=2).

Eleven RCTs met criteria for inclusion in the meta-analysis; however, only 7 trials (861 participants) reported data for steps per day (Table 4). All trials enrolled adults; median age ranged from 52.5 to 68.3 years. Three RCTs used usual care as comparator. Two RCTs used an enhanced usual care (usual care plus phone calls) as comparator. The control group received postcards in one RCT. In another, the control group received standard physical activity education materials.

Table 4. Description of Studies Included in Review by Qiu et al.[14a]

Characteristic	Studies (n=7)
Type 2 diabetes	7
Population age	
Adults	7
Older adults (≥65 years of age)	6
Sample size	
25 to 50	2
>50 to 100	2
>100	3
Type of intervention	
Pedometer only	0
Adjuncts to pedometer intervention	
Goal-setting	4
Behavioral counseling	5
Peer support	Not reported
Physical activity education	1
Nutrition education	Not reported
Cognitive behavioral therapy	2
Treatment duration	
≤3 months	0
3 to 6 months	5
>6 months weeks	2
Timing of outcome assessment[b]	
≤3 months	3
4 to 6 months	3
7 to 11 months	0
≥12 months	1

[a] Eleven studies are represented in the review; however, only 7 reported results on the outcome of interest (change in steps/day).
[b] Some studies assessed outcomes at multiple time points. Here we report on the longest interval reported per study.

The meta-analysis associated an increase in steps per day with step counter use versus control (mean difference [MD] 1,822; 95% CI 751 to 2,894 steps per day). However, there was significantly high heterogeneity in the result ($I^2 = 85.9\%$, $p<0.001$). A meta-regression analysis showed heterogeneity was partially explained by goal-setting. Sample size, intervention duration, diary use, and study quality did not explain the heterogeneity observed. Step counter use paired with a physical activity goal (4 studies) increased physical activity versus control (MD 3,200; 95% CI 2,053 to 4,347 steps per day) with low to moderate heterogeneity ($I^2=40.3\%$, $p=0.170$). Step counter use did not change physical activity significantly for the intervention group compared with control in 3 studies where there was no defined physical activity goal (MD 598; 95% CI -65 to 1,260 steps per day) with moderate heterogeneity ($I^2 = 63.1\%$, $p= 0.067$). The authors concluded that these results indicate the use of a physical activity goal is an important predictor of increased physical activity. There was no significant difference in physical activity in studies comparing step counter use defined by a set goal of 10,000 steps per day versus an individualized physical activity goal (p=0.300). Last, increased physical activity was associated with the use of a step diary (MD 2,186; 95% CI 962 to 3,411 steps per day).

The review by Russell-Minda et al[16] differed from Qiu et al[14] in 2 major ways: (1) children and adults with type 1 and type 2 diabetes were included and (2) all types of self-monitoring devices were included. Only one of the 4 studies overlaps with the 11 studies included in the review by Qiu et al. This is likely because the review by Russell-Minda was published in 2009 and therefore predated many of the studies included in Qiu et al. Despite differences in inclusion criteria, the results of the review are similar to the results of the other 2 reviews. Specifically, the review by Russell-Minda et al concluded that, "Although our research synthesis found limited levels of evidence supporting the effectiveness of pedometer-based interventions for improving overall fitness levels and metabolic control (based on our quality assessment methods), pedometers can still be an effective method of motivation for patients with diabetes to make these necessary lifestyle changes and increase their daily steps."

Summary of Findings for Type 2 Diabetes

Overall we conclude that the use of pedometers in lifestyle interventions for adults with type 2 diabetes is associated with an increase in physical activity. Further, there is reasonable evidence that setting a physical activity goal or using a step diary in addition to a pedometer are associated with an additional increase in physical activity. There is limited evidence to suggest that use of pedometers is associated with sustained increased physical activity (greater than 6 to 12 months). Future research could assess sustainability of changes in physical activity associated with accelerometer use. Without additional studies, further systematic reviews are not needed.

PEDOMETER-BASED INTERVENTIONS FOR MIXED POPULATIONS WITH CHRONIC MEDICAL CONDITIONS

We identified 2 eligible systematic reviews[17,18] that evaluated pedometer interventions among mixed populations of adults with chronic medical conditions or among older adults (Table 5). Both reviews included RCTs and observational studies. One good-quality review focused on a broad range of populations mostly selected for a chronic medical illness (*eg*, diabetes, obesity) or physical inactivity.[18] The other, a fair-quality review, focused on older adults and other special populations living with a disability or chronic illness that may limit physical endurance.[17]

Table 5. Characteristics of Systematic Reviews Evaluating Pedometer Interventions for Mixed Populations with Chronic Medical Conditions

Characteristic	Bravata, 2007[18]	Tudor-Locke, 2011[17]
Systematic review quality	Good	Fair
Population description	Obese/overweight (2 studies) Overweight &diabetes (1 study) Diabetes (2 studies) Hypertension (1 study) Arthritis (1 study) Sedentary (7 studies) Adults selected for other medical illnesses (5 studies) General adult population not selected for illness (7 studies)	Older adults (13 studies) Special populations (33 studies: 10 cancer, 3 chronic obstructive pulmonary disorder, 2 coronary artery disease, 15 diabetes, 3 muscle or joint disorders)
Intervention and comparator descriptions	Intervention: unblinded pedometer with various adjunctive interventions (*eg*, physical activity or diet counseling, step diaries, goal-setting for step count) Comparator: usually blinded pedometer or attention control condition without pedometer Mean duration of intervention: 18 weeks; range 3 to 104 weeks	Intervention: unblinded pedometer with various adjunctive interventions not well-described (*eg*, education or counseling, goal-setting for step count) Comparator: not described Duration of intervention Older adults: range 2 to 11 weeks Special populations: range 4 to 52 weeks
Timing of outcome assessment	Variable; immediately post-intervention	Variable; immediately post-intervention
Study designs included	8 RCTs (n=277) 18 observational studies (n=2490)	Older adults: 4 RCTs (n=324; pedometer arms only) 9 quasi-experimental (n=1091) Special populations: 23 RCTs (n=991; pedometer arms only) 9 quasi-experimental (n=403)
Sample size range by design	RCTs: range n=21 to 62 Observational studies: range n=12 to 927	Older adults: RCTs: range n=34 to 190; pedometer arms only Quasi-experimental: range n=12 to 340 Special populations: RCTs: range n=8 to377; pedometer arms only Quasi-experimental: range n=9 to 220
Geographical location	2 Australia, 2 Europe, 2 Japan, 20 United States/Canada	Older adults: 10 United States/Canada, 1

Characteristic	Bravata, 2007[18]	Tudor-Locke, 2011[17]
		Japan, 2 Europe Special populations: 2 Australia/New Zealand, 23 United States/Canada, 1 Japan, 26 Europe
Analytic approach	Meta-analysis	Qualitative
Impact of pedometers on physical activity	Overall: pedometer users increased physical activity by 27% over baseline RCTs: users increased 2,491 steps/day (p<0.001) compared with control Observational studies: users increased 2,183 steps/day (p<0.0001) over baseline	Older adults: pedometers increased physical activity by 775 steps/day Special populations: pedometers increased physical activity 2,215 steps/day
Search date	May 2006 February 2007 (MEDLINE updated)	January 2000
Databases searched	MEDLINE, Embase, SPORTDiscus, PsycINFO, Cochrane Library, Thompson Scientific	CINAHL, ERIC, MEDLINE, PsycINFO, SocINDEX, SPORTDiscus

We focus our discussion on the most recent, good-quality review by Bravata et al.[18] This review searched 6 computerized databases for eligible RCTs and observational studies published through February 2007. The review included 8 RCTs and 18 observational studies that evaluated the association between pedometer use, physical activity, and other health outcomes among adults in outpatient settings. Eligibility criteria allowed for a range of populations from those with comorbidities including diabetes, hypertension, and arthritis to adults with no *a priori* chronic illnesses. Studies were included if they assessed pedometer use, reported change in steps per day, and included studies with at least 5 participants. When there were sufficient studies, the review authors computed pooled estimates of both mean difference in steps per day and standard mean difference of treatment effects using a random-effects meta-analysis. Study authors conducted assessments of publication bias but found no evidence as observed by visual inspection of funnel plots.

The majority of studies were conducted in the United States or Canada (n=20), and the mean age of participants was 49. Most participants were active at baseline (mean steps per day=7,473). Most studies used an unblinded pedometer with various adjunctive interventions (*eg*, physical activity or diet counseling, step diaries, step-count goal-setting) compared with a blinded pedometer. All intervention approaches included additional strategies to promote physical activity in addition to study-provided pedometers. Nearly all studies (88%) included a goal-setting component. The mean duration of the interventions was 18 weeks (range 3 to 104 weeks). Descriptions of included studies are in Table 6.

Eight RCTs (n=277 participants) were included in the random effects meta-analysis. Intervention participants randomized to wearing unblinded pedometers statistically significantly increased their physical activity (MD=2,491 steps/day; 95% CI 1,098 to 3,885; p<.001); however the pooled effect exhibited very high heterogeneity (I^2=91%). Among the 18 observational studies (n=2490 participants), the pedometer-wearing group statistically significantly increased their baseline steps (MD=2,183 steps/day; 95% CI 1,571 to 2,796; p<.001) which translates to a 27% increase over baseline. Again, results exhibited very high heterogeneity (I^2=89%). Review authors concluded that high heterogeneity was likely due to differences in intervention approaches across the included studies. In addition to change in steps per day, this review also reported on change in the following outcomes: BMI, blood pressure, cholesterol, and fasting glucose. This review found that pedometer use was associated with a favorable, statistically significant change in these outcomes: BMI, systolic blood pressure, and diastolic blood pressure (Table 6).

Review authors also conducted meta-regression to evaluate participant and intervention characteristics associated with increases in physical activity. Studies of younger pedometer wearers and those with lower baseline activity levels had the most increases in physical activity but these did not reach statistical significance. For intervention characteristics, interventions that included goal-setting statistically significantly increased steps per day (10,000 steps/day goal = 2,998 increase in steps; other steps goals=2,363 increase in steps/day). Moreover, studies that did not require use of a step diary (n=3 studies) did not see increases over baseline physical activity levels, but studies that did reported a mean change over baseline steps of 2,649 steps per day (p<.001).

Table 6. Description of Studies Included in Bravata et al[18]

Characteristic	**Studies (n=26)**
Population age	All adults (n=26 studies; 2,767 participants) Mean age (SD): 49(9)
Sample size ≤50 50 to 100 >100	 15 8 3
Type of intervention Pedometer only Adjuncts to pedometer intervention Goal setting Behavioral counseling Peer support Physical activity and/or nutrition education	 0[a] 23 7 1 19
Treatment duration[b] ≤12 weeks 12-24 weeks >24 weeks	 13 10 3

Characteristic	Studies (n=26)
Changes in other health outcomes (n; MD; 95% CI; p)	
BMI	n 18; MD -.38; CI -0.05 to -0.72; p=0.03
Blood pressure	
Systolic	n 12; MD -3.8; CI -1.7 to-5.9; p<0.001
Diastolic	n 12; MD -0.3; CI -0.02 to -0.46; p=0.001
Cholesterol	
Total	n 7; MD -0.09, CI -0.32 to 0.15; p=0.50
HDL	n 7; MD 0.06, CI -0.012 to 0.14; p=0.10
LDL	n 7; MD -0.06, CI -0.25 to 0.13; p=0.50
Fasting glucose	n 7; MD -0.03, CI -0.11 to 0.11; p=0.70

[a] All studies included some form of adjunctive intervention along with the study-provided pedometer. Seven studies included just pedometers and goal setting.
[b] Some studies assessed outcomes at multiple time points. Here we report on the longest interval reported per study.
Abbreviations: BMI=body mass index; CI=confidence interval; HDL=high-density lipoprotein; LDL=low-density lipoprotein; MD=mean difference; SD=standard deviation

One other systematic review [17] summarized the pedometer intervention literature among older adults or those with physical disorders or illnesses. This review included RCTs and quasi-experimental designs. The study authors identified 13 studies among older adults, aged 55 and over, and 33 studies among special populations of adults with conditions that limit physical activity (*eg*, muscle and joint disorders, diabetes, cancers). Like Bravata (2007), there was great heterogeneity in intervention duration. Among older adults, interventions ranged in duration from 2 weeks to 11 months; for special populations, from 4 weeks to 12 months. Review authors computed pooled changes in step counts. Among older adults, the weighted mean difference in steps per day was 775 or an overall effect size of 0.26 which translates to a small effect. For special populations with physical limitations, change in steps per day ranged in size from 562 for those with COPD to 2840 step/day for those with coronary artery disease (CAD). Weighted effect sizes ranged from 0.21 (small effect) for the COPD group to 1.21 (large effect) for the CAD group. This review did not provide any additional information on intervention characteristics that may enhance effects of pedometer-based interventions.

Summary of Findings for Mixed Populations with Chronic Medical Conditions

Overall, we conclude the evidence suggests a potential benefit of pedometer-based interventions for older adults and composite populations of those with several chronic physical conditions (*eg*, diabetes, arthritis, cancers) that may limit ability to be physically active. However, effects are generally lower for populations including older or sicker populations. We were not able to assess the independent contribution of providing pedometers alone; nearly all studies outlined in these systematic reviews provided additional supports. Yet results of the authors' meta-analyses support that goal-setting appears to be a key behavioral strategy to enhance the effectiveness of pedometer-based interventions.

DISCUSSION

Regular physical activity helps improve overall health and fitness, and reduces the risk for many chronic diseases. Physical activity is particularly important for conditions such as obesity, type 2 diabetes, and composite conditions such as musculoskeletal pain and arthritis. Physical activity plays a critical role in controlling weight, managing type 2 diabetes, and reducing risk of developing type 2 diabetes as well as in keeping bones, joints, and muscles healthy. Despite the proven benefits and widespread public health and clinical calls to increase physical activity, sedentary behavior has proven difficult to change. While sedentary behavior is difficult to change, self-monitoring has been shown to lead to increased physical activity in some populations.

Self-monitoring is a key behavioral strategy to increase physical activity, and objective self-monitoring—as opposed to self-report—is considered the gold standard. Pedometers are a cost-effective and popular tool and are increasingly used for self-monitoring physical activity and as a motivational tool. This review thus sought to identify and summarize the evidence on the use of pedometers on weight loss, type 2 diabetes, and composite conditions.

We conclude that the evidence supports association between the use of pedometers and increases in physical activity for adults seeking to lose weight, adults with type 2 diabetes, and those with composite chronic medical conditions. There is some evidence of weight loss associated with using pedometers, which can have a positive impact across all of these conditions. There is also reasonable evidence that setting a physical activity goal or using a step diary in addition to using a pedometer can further increase physical activity. However, the evidence is limited on the sustainability and duration of usefulness that pedometers have on physical activity beyond 6 months. Pedometers may also have more limited applicability to older or sicker populations.

Future research should consider good-quality RCTs, prospective cohort studies, stepped and adaptive trial designs, and the sustainability of changes in physical activity associated with pedometer use. Moreover, future trials will need to compare pedometers against accelerometers. Accelerometers are quickly becoming the self-tracking tool of choice. Accelerometers have improved functionality over pedometers; they measure vertical acceleration rather than simply responding to vertical acceleration. Accelerometers are more versatile in terms of placement and position, can be used in various places on the body, and therefore can count better than pedometers, particularly for users who are overweight and obese. Perhaps the greatest advantage of accelerometers is that they are increasingly embedded into cell phones, which people carry directly on their body and are a part of their everyday life. This increases the likelihood of use and allows for the collection of data automatically and longitudinally via cellular transmission.

LIMITATIONS

Our study, and the literature, have limitations: (1) the number of evaluated systematic reviews is small, (2) there were design limitations in the evaluated studies, (3) our literature search was limited to English-language publications, (4) we did not perform meta-analyses across all reviews, and (5) only a single reviewer screened citations, performed full-text reviews, and extracted data from the reviews.

CONCLUSIONS

Overall, this review of reviews found that pedometer use is associated with an increase in physical activity and decrease in weight across various chronic conditions. The extent to which increases in physical activity are sustainable over the long term is unknown. Future trials will need to compare pedometers against accelerometers, as they are rapidly becoming the self-tracking tool of choice.

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