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The effectiveness of a brief intervention using a pedometer and step-recording diary in promoting physical activity in people diagnosed with type 2 diabetes or impaired glucose tolerance

Susan Furber
South Eastern Sydney & Illawarra Area Health Service

Claire Monger
NSW Department of Health

Lisa Franco
South Eastern Sydney & Illawarra Area Health Service

Darren Mayne
South Eastern Sydney & Illawarra Area Health Service, dmayne@uow.edu.au

Lauren A. Jones
Children's Hospital, Westmead

See next page for additional authors

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Abstract
Issue addressed: To evaluate the effectiveness of a brief intervention using a pedometer and step-recording diary on promoting physical activity in people with type 2 diabetes or impaired glucose tolerance (IGT). Methods: People with type 2 diabetes or IGT who attended the Illawarra Diabetes Service were invited to participate. Participants in the intervention group received a pedometer and a diary to record their daily steps for a two-week period. Both the intervention and comparison group received advice on physical activity. Physical activity levels were measured using the Active Australia Survey at baseline, and at two and 20 weeks. Results: A total of 226 participants were recruited. At two-week follow-up the mean self-reported minutes of walking was significantly higher in the intervention group than the comparison group (223 minutes versus 164 minutes; p=0.01), as was the percentage of intervention participants achieving recommended levels of moderate-intensity physical activity (63.5% versus 41.8%, p=0.02) and the percentage of intervention participants achieving adequate levels of total physical activity (68.9% versus 48.0%, p=0.04). There were no differences between study groups for any physical activity measure at 20-week follow-up. Conclusions: A pedometer and a step-recording diary were useful tools to promote short-term increase in physical activity in people diagnosed with type 2 diabetes or IGT. Future studies need to examine whether a longer intervention, individualised physical activity counselling and support for achieving step goals could result in increasing physical activity over the long term.

Keywords
promoting, glucose, diary, recording, step, pedometer, intervention, brief, effectiveness, impaired, diabetes, 2, type, diagnosed, people, activity, physical, tolerance

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Authors
Susan Furber, Claire Monger, Lisa Franco, Darren Mayne, Lauren A. Jones, Rachel Laws, and Louise Waters

The effectiveness of a brief intervention using a pedometer and step recording diary on promoting physical activity in people diagnosed with type 2 diabetes or impaired glucose tolerance

Running Heading: A pedometer-based intervention for people with type 2 diabetes

Susan Elizabeth Furber (***Corresponding author***)

BSc (Hons), MPH, PhD, Grad Dip App Epi

South Eastern Sydney & Illawarra Area Health Service

Division of Population Health and Planning

Locked Mail Bag 9

Unanderra NSW 2526 Australia

Telephone: +61 2 42216700; Facsimile: +61 2 4221 6722

Email: susan.furber@sesiahs.health.nsw.gov.au

Claire Kathleen Monger

BAppSc (Phty) (Hons), MPH(Hons), Grad Dip App Epi

Public Health Officer Training Program, NSW Department of Health, Sydney, New South Wales

NSW Department of Health, Locked Mail Bag 961, North Sydney, NSW, 2059

Telephone: +61 2 9391 9951; Facsimile: +61 2 9424 5994

Lisa Franco

BSc, MSc (Nutrition & Dietetics)

South Eastern Sydney & Illawarra Area Health Service

Bulli Community Health Centre

322 Princes Highway, Bulli 2516

Telephone: +61 2 4284 0355; Facsimile: +61 2 42852480

Darren Mayne

BA (Psych) (Hons)

South Eastern Sydney & Illawarra Area Health Service

Division of Population Health and Planning

Locked Mail Bag 9

Unanderra NSW 2526 Australia

Telephone: +61 2 42216700; Facsimile: +61 2 4221 6722

Lauren A Jones

BH (Health Promotion/Health Services Management)

The Children's Hospital at Westmead

Locked Bag 4001

Westmead NSW 2145

Telephone +61 2 9845 3559; Facsimile +61 2 9845 3562

Rachel Angela Laws

BSc (Nutrition), MSc (Nutrition & Dietetics)

Centre for Primary Health Care, School of Public Health & Community Medicine, UNSW Sydney, NSW 2052 Australia

Telephone: +61 2 93851488, Facsimile: +61 2 93851513

Louise Waters

BSc (Nutrition), MPH

Centre for Health Behaviour & Communication Research, University of Wollongong, NSW

Past institutional affiliation: Bulli Community Health Centre, SESIAHS, NSW

CHBCR, University of Wollongong, NSW, 2500

Telephone: +61 2 4221 5810; Facsimile: +61 2 4221 3370

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Abstract

Issue addressed:

To evaluate the effectiveness of a brief intervention using a pedometer and step recording diary on promoting physical activity in people with type 2 diabetes or impaired glucose tolerance (IGT).

Methods:

People with type 2 diabetes or IGT who attended the Illawarra Diabetes Service were invited to participate. Participants in the intervention group received a pedometer and a diary to record their daily steps for a two week period. Both the intervention and comparison group received advice on physical activity. Physical activity levels were measured using the Active Australia Survey at baseline, and at two and twenty weeks.

Results:

A total of 226 participants were recruited. At two week follow-up the mean self-reported minutes of walking was significantly higher in the intervention group than the comparison group (223 minutes versus 164 minutes; p=0.01), as was the percentage of intervention participants achieving recommended levels of moderate-intensity physical activity (63.5% versus 41.8%, p=0.02) and the percentage of intervention participants achieving adequate levels of total physical activity (68.9% versus 48.0%, p=0.04). There were no differences between study groups for any physical activity measure at 20 week follow-up.

Conclusions:

A pedometer and a step-recording diary were useful tools to promote short term increase in physical activity in people diagnosed with type 2 diabetes or IGT. Future studies need to examine whether a longer intervention, individualised physical activity counselling and support for achieving step goals could result in increasing physical activity over the long term.

Key words: physical activity, pedometer, step-recording diary, type 2 diabetes, impaired glucose tolerance

So what? Interventions are needed to increase physical activity among people with type 2 diabetes or IGT. Use of a pedometer and step-recording diary for a two week period were successful in increasing physical activity in the short-term, however the effect was not maintained at 20 weeks.

Introduction

While regular physical activity has been shown to improve insulin sensitivity and glycaemic control in people with type 2 diabetes,[1-2] the majority of these people are not achieving the targets for physical activity recommended in national physical activity guidelines.[3] Lifestyle modifications, such as increasing levels of physical activity, have been shown to delay or prevent the onset of type 2 diabetes in those with impaired glucose tolerance (IGT).[4-7]

A recent systematic review demonstrated that pedometer use is associated with increasing physical activity amongst different populations.[8] Pedometer-based interventions that use sound theoretical frameworks such as social cognitive theory have demonstrated improvements in physical activity in people with type 2 diabetes[9] and healthy individuals[10]. A pedometer provides feedback about the number of steps taken and can be used as a self-monitoring, goal-setting and motivational tool for promoting physical activity.[9,11] Feedback from a pedometer on the number of steps taken daily is an objective measure of performance, which can be influential in increasing self-efficacy, which is a central construct of Bandura's social cognitive theory[12].

While studies have demonstrated that pedometer-based intervention are effective in increasing physical activity in people with type 2 diabetes,[9,13,14] the effectiveness of the intervention could be related to the level of intensity and the multi-strategic nature of the intervention, such as the inclusion of goal setting, physical activity counselling, regular support for participants, and the

duration of the intervention. Interventions that use multiple strategies and are implemented over a long period of time are resource intensive and are potentially more difficult to incorporate into the routine practice of a diabetes service in comparison to simpler interventions. As such, research is needed on the effectiveness of short term, simple and inexpensive physical activity interventions for people with type 2 diabetes and IGT that could be easily implemented by diabetes services. The aim of the present study was to evaluate the effectiveness of a brief intervention using a pedometer and step recording diary on promoting physical activity in people with type 2 diabetes or IGT, and to determine the acceptability of the intervention in the short and longer term.

Methods

Setting and participants

The study was conducted in an Australian diabetes service. People diagnosed with type 2 diabetes or IGT were referred to the service and were invited to attend a group education session, which included information about their condition and management strategies. Participants for this study were recruited at the group education sessions over an 18 week period during 2005. Companions of those attending the group sessions were also invited to participate. All people attending the education sessions were eligible to participate in the study provided they gave written consent.

Study design

The study used a cohort design with an intervention group and a comparison group which received usual care. Study participants self-selected into an education session which was then allocated to either the intervention or comparison arm (i.e. sessions were allocated to treatment arms and not individuals). Education sessions were generally allocated to alternate study groups. Group allocation for each session was not made known in advance to those referring to the service, taking bookings or those attending the session. Participants in both study groups were told that the aim of the study was to examine ways of increasing physical activity for people with diabetes or IGT.

Comparison Group (Usual care)

Separate two hour group education sessions were held for those with type 2 diabetes and those with IGT. A diabetes nurse educator facilitated a one hour session on the basic physiology of diabetes, its possible complications and self management practices including home blood glucose monitoring, foot care, eye checks and the role of physical activity. During the study period, one of the researchers (either LF or LW) provided a 15 minute talk on physical activity; the talk covered the same information that was usually provided by the diabetes nurse educator. The talk covered the benefits of physical activity for those with type 2 diabetes and IGT, and people were encouraged to undertake at least thirty minutes of moderate-intensity activity on all or most days of the week based on national physical activity guidelines[15]. A diabetes dietitian then facilitated a one hour session on the basic principles of the nutritional management of diabetes.

People with type 2 diabetes are offered individual appointments at the service with the diabetes nurse educator one to two weeks after the education session and with the dietitian within four weeks after the session, followed by a combined appointment with both the nurse educator and the dietitian three months later. After the education session, people with IGT are advised to see their general practitioner.

Intervention Group

The intervention group received the same 15 minute talk on physical activity as given to the comparison group by one of the researchers (LF or LW), and in addition the researcher spent an extra ten minutes discussing the use of a pedometer and step diary. Participants were given a pedometer (Yamax Digi-Walker) and a diary to record the number of steps taken each day, and time and type of physical activity undertaken. The model of pedometer used has been found to be reliable and accurate.[16] Participants were asked to use the pedometer and record their steps and time spent being physically active each day for the two weeks following the education session; the two week period was chosen as the aim of our study was to evaluate a brief intervention. The diary contained information on the amount of physical activity that is needed for health benefits, instructions on pedometer use, and advice on preparation for walking. Participants were encouraged to set their own physical activity goals such as an increase in their daily pedometer recorded steps or a time-based target as recommended in the national guidelines[15]. The intervention materials and procedures were based on the social cognitive theory construct

of self-efficacy as goal setting and self-monitoring can increase an individual's beliefs about their ability to perform the behaviour[17].

Data collection measures

Participants completed a written baseline questionnaire when they attended the education session in the presence of a researcher who was available to answer questions. The same baseline questionnaire was used for participants in intervention and comparison groups. The questionnaire included questions from the Active Australia Survey about physical activity,[18] as well as questions on socio-demographic status.

The Active Australia Survey captures self-reported data on the number of sessions of different types of physical activity undertaken and the total time spent in these activities in the last week.[18] The question on walking asked about the number of times and the amount of time that was spent walking continuously, for at least 10 minutes, for recreation, exercise or to get to or from places. Similar questions were asked about number of times and the amount of time spent doing moderate physical activity (eg gentle swimming, social tennis, golf); vigorous exercise (eg jogging, cycling, aerobics, competitive tennis) and vigorous gardening or heavy work around the yard. This instrument has been shown to have acceptable levels of reliability.[19]

Follow-up questionnaires were administered to participants via telephone two weeks and twenty weeks after their attendance at the education session. The Active Australia questions were repeated and in addition, the intervention

group were asked about the usefulness of the pedometer and diary and how many days during the two week intervention period that they used the pedometer.

Data analysis

The primary outcome measures of interest were the differences between study groups in mean self-reported minutes of walking during the previous week, and numbers of participants undertaking at least 150 minutes of moderate-intensity activity in five or more sessions over the previous week. The secondary outcome measure of interest was the difference between study groups in the numbers of participants that undertook adequate total physical activity as measured by participation in 150 or more minutes of moderate or vigorous-intensity physical activity during the previous week in five or more sessions; total physical activity was calculated by adding the time spent in walking and other moderate activity and twice the time spent in vigorous activity (vigorous gardening or heavy work around the yard were not included in calculations).[18] Primary and secondary outcomes were assessed for two and twenty week follow-up points.

Analysis of covariance (continuous outcomes) and logistic regression (dichotomous outcomes) adjusting for baseline levels of physical activity and gender were used to examine the difference between study groups for primary and secondary outcomes. For a given outcome, participants with any missing data on any of the items required to calculate the outcome were excluded from the analysis for that outcome. All analyses were undertaken on

a ‘complete case’ basis: subjects with complete outcome data were included in the analysis in the study group to which they were allocated, regardless of compliance with the intervention.

Statistical models were originally fit with random intercept terms to allow for clustering of responses within education sessions. However, any variation initially attributed to education sessions was wholly explained by individual baseline levels of physical activity, so final models only included fixed effects. Final analyses were undertaken in SAS Version 9.1.3 using the MIXED and GENMOD procedures.[20]

This project was approved by the University of Wollongong/Illawarra Area Health Service Human Research Ethics Committee.

Results

Response rate

During the recruitment period 40 education sessions were held, 24 for people with type 2 diabetes and 16 sessions for those with IGT. A total of 352 people (clients and companions) attended these sessions, with a mean of 9 people (SD=2.7) attending each session and a range of 4 to 14 people. Overall, amongst clients and companions the participation rate was 74%, with 34 companions and 226 clients agreeing to participate in the study (260 of 352). The exact participation rate could not be calculated because the breakdown of clients and companions amongst non-participants was unknown. However,

sensitivity analyses suggested a participation rate in clients of 74-80%. Companions were invited to participate, but their data were not included in the analysis.

There was no significant difference in mean age between participants and non-participants at baseline; however there were a higher proportion of females and people with type 2 diabetes in the non-participant group. The most common reasons given for not participating were health reasons, such as musculoskeletal problems and respiratory illnesses, followed by “already active”. Other reasons included limited time or commitments.

Follow-up rate

Two hundred and twenty-six eligible clients completed the baseline questionnaire; 210 clients completed the two-week follow-up questionnaire (a follow-up rate of 92.9%) and 184 completed the 20 week questionnaire (a follow-up rate of 81.4%).

Baseline demographics and characteristics

There were no significant differences in demographic or other characteristics of the participants by study group except for age (Table 1). Participants in the intervention group were on average 3.3 years younger than the comparison group; however, correlation analyses using Pearson’s coefficient and controlling for baseline activity showed no associations between age and levels of walking at two (r= -0.005, p=0.9) and 20 (r= 0.007, p=0.9) weeks, or

age and total physical activity at two (r= -0.05, p=0.5) and 20 (r= 0.11, p=0.1) weeks. *(Insert Table 1 here)*

Time spent walking

There were 198 paired observations for analysis at two week follow-up and 174 for analysis at 20 week follow-up. Self-reported minutes of walking were significantly higher in the intervention group than the comparison group at two week follow-up, after adjusting for minutes of walking at baseline; however there was no significant difference between study groups at 20 week follow-up (Table 2). Effect modification analyses indicated that there was no significant interaction between diagnosis (i.e. type 2 diabetes or IGT) and study group (p=0.5); and no independent relationship between diagnosis and the outcome (p=0.6). *(Insert Table 2 here)*

Moderate-intensity physical activity

Complete moderate-intensity physical activity data were available for 181 and 156 participants at two and twenty week follow-up. The percentage of participants in the intervention group achieving the recommended amount of moderate-intensity physical activity at two week follow-up was significantly higher than the comparison group (Table 3). As for minutes spent walking, there was no interaction between study group and diagnosis (F=0.00, p=0.94) and no independent effect of diagnosis (F=0.06, p=0.80). No effect of intervention was found at twenty week follow-up with similar percentages of participants in treatment and control groups reporting 150 or more minutes of

moderate intensity physical activity over five or more sessions during the previous week (Table 3).

(Insert Table 3 here)

Total physical activity

Missing data on the six variables used to calculate the percentage of participants that undertook adequate total physical activity resulted in 173 and 150 paired observations for analysis at two and twenty weeks follow-up, respectively. The percentage of intervention group participants that undertook adequate total physical activity at two weeks follow-up was significantly higher than in the comparison group (Table 3). This effect was not modified by diagnosis ($F=0.44$, $p=0.51$) nor was there a difference in the percentages of IGT and type 2 diabetes participants that that undertook adequate total physical activity ($F=0.00$, $p=0.98$). At twenty weeks follow-up there was no difference between study groups in the percentage of participants that undertook adequate total physical activity (Table 3).

Acceptability of the pedometer and step recording diary

Of those in the intervention group who completed the 2 week follow-up questionnaire, almost two-thirds reported using the pedometer for the full 14 days after the group education session (Table 4). Only one person reported not using it at all. While the intervention group was only requested to use the pedometer for a 2 week period, at the 20 week follow-up more than one third of participants had used their pedometer in the last 2 weeks (Table 4). The majority of participants in the intervention group at the 2 and 20 week follow-

up reported that they would use a pedometer again and would recommend it to a friend or family member (Table 4). The diary was also reported to be useful by most of participants at the 2 week follow-up (Table 4). *(Insert Table 4 here)*

Responses in the open question regarding participants' comments on pedometers at the 2 and 20 week follow-up indicated that many participants found the pedometer to be a motivator and also a useful monitor of the number of steps taken. However, some participants felt that the pedometer was inaccurate and also had problems with the clip and with keeping it on. In an open question on the usefulness of the diary, participants stated that the diary was useful for recording the number of steps they have taken and that recording them daily acted as a motivator.

Discussion

The present study found that a pedometer in conjunction with a step-recording diary was an effective intervention to promote short term improvements in the time spent walking and numbers of people adequately physically active in people with type 2 diabetes and IGT. At the 2 week follow-up, the intervention group had spent an average of 58 minutes per week more walking than the comparison group and were two times more likely to be adequately physically active than the comparison group, however this improvement was not maintained at the 20 week follow-up. Several overseas studies have also reported short-term benefits of pedometer-based interventions in promoting physical activity with people with type 2 diabetes. [13,14] A six week randomised

control trial of 30 people with type 2 diabetes reported that those in the intervention group that received a pedometer and were recommended to walk 10,000 steps per day were more than 69 percent physically active than the control group.[13] A study of 24 hospitalised type 2 diabetes patients found that the walking and diet group of patients who were asked to do at least 10,000 steps per day over a six to eight week period did substantially more steps and had a greater improvement in body weight and insulin sensitivity compared with the diet only group.[14] Few studies have examined the effectiveness of pedometer interventions with type 2 diabetes patients in the long term. The study by Tudor-Locke et al.[9] of 47 people with type 2 diabetes recruited from a diabetes service found that while the pedometer-based intervention was effective in increasing walking in people with type 2 diabetes on average 30 minutes each day during the 16 week intervention period, the effect was not sustained at the 24 week follow-up period. In contrast to the generally positive findings of these studies of pedometer-based interventions with people with type 2 diabetes, [9,13,14] an Australian study of people with type 2 diabetes recruited by a local media campaign found that while a coaching intervention was effective in increasing physical activity, there was no extra benefit for people who also used a pedometer.[21]

The step-recording diary was considered to be useful by the majority of participants in the present study. The study by Gleeson-Kreig,[22] which involved participants keeping daily activity records for six weeks, reported that self-recording daily physical activity was an acceptable intervention in a study of people with type 2 diabetes. This study found that daily physical activity self

monitoring improved self-efficacy in people with type 2 diabetes. While physical activity levels increased in both intervention and control groups, there was no difference between study groups.

A meta-analysis based on eight randomised controlled trials and 18 observational studies in healthy individuals and those with disabilities and chronic illnesses demonstrated that pedometer use was associated with increasing physical activity by 26.9 percent, and decreasing body mass index by 0.38 kg/m^2 and systolic blood pressure by 3.8 mmHg.[8] The average length of the interventions included in the meta-analysis was 18 weeks with a range of 3 to 36 weeks. The authors found that the studies with interventions that included a step diary were associated with an increase in physical activity compared to studies with no diaries. They also reported that step goals, such as 10 000 steps per day or an individualised step goal, was a predicator of increased physical activity. Physical activity counselling was not found to be a predictor of increased physical activity, however the authors stated that this could have been due to the heterogeneity of the counselling provided. While intervention duration was also found not to be a predictor of increased physical activity, the authors state that one of the limitations of their analyses was the relative short length of the interventions.

The rationale for selecting a 2-week period for the intervention in the present study was based on the feasibility for the diabetes service to incorporate this brief and simple intervention within the structure of its routine practice. As clients with type 2 diabetes meet with the diabetes nurse educator two weeks

after the group session, they could discuss their physical activity levels at this appointment. However as the intervention was effective only in the short term, the intervention could be strengthened by the addition of a few simple strategies that would still enable the intervention to be delivered as part of the routine practice of the diabetes service. For example, as clients with type 2 diabetes also have a routine three month follow-up appointment at the diabetes service, the intervention could be strengthened by requesting clients to use their pedometer and step recording diary for a longer period, and by providing clients with brief individualised physical activity counselling (which has been shown to an effective intervention for increasing physical activity levels in people with type 2 diabetes [23,24]) as well as support on achieving their step goals at their routine two week and three month appointments.

The present study has several limitations. The design could have been strengthened by random allocation of groups to intervention or comparison. However, the lack of randomisation is unlikely to have lead to any major selection biases as staff from the diabetes service were unaware of which study group an education session would be allocated to, final group characteristics were very similar, and no clustering was observed. Some differences were found in the age structure of the groups but this was not associated with the study outcome measures and thus was unlikely to cause confounding. The additional questions asked of participants in the intervention group regarding pedometer use made blinding of the interviewers to allocation impractical. While the intervention was based on the self-efficacy construct of Bandura's social cognitive theory,[12,17] our aim was to keep the intervention

simple, so we did not include strategies based on other constructs of social cognitive theory such as self-management strategies or outcomes.

There are a number of sources of potential measurement error when self-report is used. Participants may not accurately recall their physical activity patterns for the previous week or could overstate their level of physical activity to give a more ‘socially desirable’ response. In addition to recall issues, participants were required to categorise their activity as moderate or vigorous, which may not be accurately done. Accuracy of recall could vary between measurement periods for both groups. The administration of the survey by telephone at the two follow-ups allowed greater opportunity for prompting and clarification from the interviewer. These differences are likely to be non-differential between study groups. However, there is the possibility for differential measurement error between study groups, due to the potential for the step recording diary to improve the accuracy of recall in the intervention group.

In conclusion, a pedometer in conjunction with a step-recording diary was a useful tool to promote short term improvements in physical activity in people with type 2 diabetes and IGT, but did not lead to sustained improvements. While the intervention was inexpensive and relatively simple to implement, future studies need to examine whether a longer intervention, individualised physical activity counselling and support for achieving step goals could result in increasing physical activity over the long term.

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Table 1: Baseline characteristics of the study groups

Characteristics of participants	**Intervention (n=121)**	**Comparison (N=105)**	**P value**
Age: mean years (SD)	58.3 (12.6)	61.6 (12.3)	0.04
Gender			
Female	56 (46.3%)	51 (48.6%)	0.73
Diagnosis			
Type 2 Diabetes	68 (56.2%)	60 (57.1%)	0.89
IGT	53 (43.8%)	45 (42.9%)	
Health problems (eg arthritis or heart disease) that could prevent you from being physically active			
Yes	25 (22.3%)	25 (26.3%)	0.50

Table 2: Time spent walking at baseline, 2 and 20 week follow-up periods

	Intervention	**Comparison**	**Difference**
Walking	**Mean minutes per week (95% CI)**	**Mean minutes per week (95% CI)**	**Mean minutes per week (95% CI)**
Baseline	184.9 (149.9 to 219.9)	154.5 (119.2 to 189.8)	30.4 (-19.4 to 80.1)
2 weeks[a]	223.3 (192.3 to 254.4)	164.0 (131.7 to 192.3)	59.4 (14.6 to 104.2) [b]
20 weeks[a]	153.2 (121.5 to 184.8)	151.2 (118.1 to 184.4)	1.9 (-44.2 to 48.0)

(a) Adjusted for minutes walked per week at baseline and gender

(b) $p<0.05$

Table 3: Participants engaged in adequate levels of moderate-intensity and total physical activity at baseline, 2 and 20 week follow-up periods

	Total (n)	**Adequate n (%)**	**Univariate odds-ratio (95% CI)**	**Multivariate odds-ratio (95% CI)**
Moderate-intensity physical activity				
Baseline				
Intervention	111	54 (48.7)	1.1 (0.6-1.9)	1.1 (0.6-1.9)
Comparison	93	43(46.2)	1.0	1.0
2 weeks[a]				
Intervention	104	66 (63.5)	2.4 (1.4-4.3)	2.2 (1.1-4.2)[c]
Comparison	98	41 (41.8)	1.0	1.0
20 weeks[a]				
Intervention	89	36 (40.5)	1.1 (0.5-2.0)	0.8 (0.4-1.7)
Comparison	85	33 (38.8)	1.0	1.0

Total physical activity				
Baseline				
Intervention	105	59 (56.2)	1.3 (0.7-2.3)	1.3 (0.7-2.4)
Comparison	91	45 (49.5)	1.0	1.0
2 weeks[b]				
Intervention	103	71 (68.9)	2.4 (1.4-4.3)	2.1 (1.0-4.2)[c]
Comparison	98	47 (48.0)	1.0	1.0
20 weeks[b]				
Intervention	89	38 (42.7)	1.1 (0.6-1.9)	0.7 (0.4-1.5)
Comparison	85	35 (41.2)	1.0	1.0

Notes:

(a) Adjusted for gender and adequacy of moderate-intensity physical activity at baseline

(b) Adjusted for gender and adequacy of total physical activity at baseline

(c) $p<0.05$

Table 4: Acceptability of the pedometer and step recording diary

Acceptability measures at 2 week follow-up	**Percentage (number)**
Participants who used the pedometer for 14 days	65.5 (72/110)
Participants who would use a pedometer again	95.5 (105/110)
Participants who would recommend a pedometer to a friend or family member	88.2 (97/110)
Participants who found the diary useful	81.8 (90/110)
Acceptability measures at 20 week follow-up	
Participants who used a pedometer during the last 2 weeks (even though not required)	39.2 (38/97)
Participants who found the pedometer useful	90.0 (87/97)
Participants who would recommend a pedometer to a friend or family member	90.7 (88/97)