A population-based randomized controlled trial of the effect of combining a pedometer with an intervention toolkit on physical activity among individuals with low levels of physical activity or fitness

Christina Bjørk Petersen ⁎, Maria Severin, Andreas Wolff Hansen, Tine Curtis, Morten Grønbæk, Janne Schurmann Tolstrup

National Institute of Public Health, University of Southern Denmark, Øster Farimagsgade 5A, 2nd floor, 1353 Copenhagen, Denmark

Abstract

Available online 19 December 2011

Keywords:
Exercise
Walking
Intervention studies
Randomized controlled trial
Health promotion

Objectives. To examine if receiving a pedometer along with an intervention toolkit is associated with increased physical activity, aerobic fitness and better self-rated health among individuals with low levels of physical activity or fitness.

Methods. The intervention was nested in the Danish Health Examination Survey (DANHES) and carried out in 2008. Participants were randomly assigned to either a pedometer group (n = 326) or a control group (n = 329). Physical activity, aerobic fitness, and self-rated health were measured at baseline and at 3-month follow-up, and differences were tested by Wilcoxon signed rank tests and Chi-squared tests.

Results. At follow-up, no significant differences in physical activity, aerobic fitness and self-rated health were found between the groups. However, the oldest participants in the pedometer group reported significantly more walking time compared to the controls (controls = 368 min/week, pedometer group = 680 min/week, P = 0.05). Among participants who completed the intervention, a significant effect on total walking time was observed (median difference = 225 min/week, P = 0.04).

Conclusions. The results suggest that receiving a pedometer and along with an intervention toolkit can increase walking time in older individuals, but not in younger individuals. Thus, this type of intervention offers great potential for promoting physical activity in older individuals.

Trial registration number: NCT01071811

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Introduction

Regular physical activity is associated with a reduced risk of several chronic diseases as well as all-cause mortality (Bauman, 2004; Nocon et al., 2008; Paffenbarger and Lee, 1997). Despite an increased focus on the health benefits of physical activity during the past two decades, a large part of the Danish population is physically inactive (Petersen et al., 2010). Hence, knowledge of easily incorporable and cost-effective population-based interventions to increase physical activity is needed.

Walking is a popular and simple form of exercise. Pedometers are small inexpensive devices and the immediate feedback on the number of steps taken has been found to be a motivating tool for increasing physical activity (Bravata et al., 2007; Chan et al., 2004; Engel and Lindner, 2006; Kang et al., 2009; Tudor-Locke and Lutes, 2009). However, motivation most likely depends on individual goals (Bravata et al., 2007; Hultquist et al., 2005). Pedometer-based programs that aim at reaching a self-set individual goal are inexpensive and easy to manage. Thus, they have the potential of reaching a large part of the population, including those who may not wish to participate in organized sports and exercise.

Among chronically ill patients, pedometer-based goal-setting interventions seem to be efficacious in increasing the number of daily steps (Moreau et al., 2001; Talbot et al., 2003; Yamanouchi et al., 1995). Further, increased walking time may also have a positive effect on mood (Ekkekakis et al., 2000; Murphy et al., 2007). However, few have examined the effect of a combined pedometer and goal-setting intervention in the general population and results are inconsistent (Baker et al., 2008; Chan and Tudor-Locke, 2008; Hultquist et al., 2005; Rooney et al., 2005; Sidman et al., 2004; Sugita et al., 2002). Many of these studies lack a control group, implement numerous interventions simultaneously, include few participants and have large drop-out rates. The aim of this study was to investigate the effect of receiving a pedometer and an intervention toolkit including a self-guided step goal booklet and a logbook on physical activity, aerobic fitness and self-rated health in a population-based approach.

⁎ Corresponding author.

E-mail addresses: cbj@niph.dk (C.B. Petersen), maria@dansk-atletik.dk (M. Severin), awh@niph.dk (A.W. Hansen), tcinph.dk, tinecurtis@gmail.com (T. Curtis), mg@niph.dk (M. Grønbæk), jst@niph.dk (J.S. Tolstrup).

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Methods

Participants and recruitment

The intervention was nested in the Danish Health Examination Survey (DANHES), which has been described in detail elsewhere (Eriksen et al., 2011). The present study was carried out in three of the 13 municipalities (Silkeborg, Frederiksberg, and Varde) from August to October 2008. A random sample of 52,500 individuals was invited to participate in a health examination, of which 4979 individuals participated (9.5%). Prior to the recruitment, the participants underwent an extensive health examination. Individuals with a low aerobic fitness level (ml O$_2$ min$^{-1}$ kg$^{-1}$), or who were sedentary or had low levels of physical activity in leisure time, were enrolled in the study (n = 2767). The classification of aerobic fitness level was defined by comparison to the distribution in a Scandinavian reference-population (Åstrand, 1960). Individuals who participated in other interventions nested in DANHES and pregnant women were excluded (n = 1625). Of the 1142 eligible participants, 487 did not wish to participate. Thus, the final study population consisted of 655 individuals who were randomized to either a pedometer group (n = 326) or a control group (n = 329) (Fig. 1). All participants gave informed consent before randomization. Random allocation was performed by means of a sealed envelope prepared beforehand and sorted by the responsible staff member. Blinding was not feasible, either for staff or for participants. The study was approved by the National Committee on Biomedical Research Ethics in Denmark.

Intervention

The aim of the intervention was to increase physical activity and it was theoretically based on the Theory of Planned Behavior (Ajzen, 1991), by giving participants knowledge of the benefits and barriers to physical activity, increasing their self-efficacy, and helping them to translate their intentions into behavior changes. The participants in the pedometer group received a pedometer (Yamax Digi-Walker SW-200) (Crouter et al., 2003), a book with a pedometer-based goal-setting program (Petersen, 2007), a handout with a summary of the goal-setting program, and a logbook for registration of the number of steps taken daily. The book included information of the health benefits of physical activity, encouraging participants to incorporate walking in their everyday life. During the 3-month trial period, participants were asked to reset the pedometer every morning and to register the number of steps in the logbook every evening.

The participants were informed face-to-face that taking 10,000 steps per day has documented health benefits and, therefore, is a reasonable goal for healthy adults (Welk et al., 2000; Wilde et al., 2001). Before setting the goal, participants were asked to monitor and record their number of steps per day during a first week. The goal was set by the participants themselves. It could be set at 10,000 steps per day, or it could be less or more depending on the participant’s physical shape, health condition and individual ambition. The most important goal was the improvements from baseline values. In the goal-setting program, instructions were given to increase the number of steps by 20% each week until the goal was reached. However, the program also allowed for some stable weeks. When having reached the goal, participants should maintain this level and start focusing on increasing the intensity, e.g. by walking more briskly or running. The participants received three emails at a three-week interval to encourage them to keep using the pedometer and adhere to the program. Participants who were assigned to the control group received a leaflet from the National Board of Health in Denmark describing the benefits of physical activity and the national recommendations of a minimum of 30 min of physical activity per day. Other than this leaflet, the controls were not given any attention before follow-up.

![Consort flow diagram of the pedometer-based goal-setting intervention.](Denmark, 2008).
Assessments

The baseline assessment consisted of a self-administered questionnaire and a health examination. The questionnaire included information on demography, health, certain diseases, lifestyle, and health behavior. Participants’ age was categorized in three groups: 18–44 years, 45–64 years, and 65+ years. Educational level referred to the highest number of years of schooling obtained at the time of the baseline examination and categorized into three educational groups: ≥12 years, 13–14 years, and 15+ years.

The physical activity items included: (1) the long version of the International Physical Activity Questionnaire (IPAQ). It consists of 31 items that collect information on physical activity in four domains: work, transport, housework/gardening, and leisure time. In the present study, we focused on time spent walking in the four domains. Additionally, it included time spent sitting; (2) level of physical activity in leisure time during the last 12 months in one of four predefined categories: (a) vigorous physical activity (aerobic activity such as running or cycling at an intensity of ≥4 h a week); (b) moderate physical activity (work, transport, housework/gardening, and leisure time); (c) low physical activity (walking, bicycling, or other light activities for a minimum of 4 h a week); (d) sedentary activities (reading, TV-watching, or other sedentary activities). Although not validated, this question has shown the ability to predict cardiovascular morbidity and mortality (Andersen et al., 2000); (3) motivation for changing physical activity behavior was assessed by the question ‘Do you wish to be more physically active than you already are?’ (Yes, no or don’t know).

Aerobic fitness was tested using an ergometer and estimated from a watt-max (Andersen, 1995) or a sub-max test (Åstrand and Rodahl, 1986) on a bicycle. Ideally, the maximal exercise test was used as this test is considered more reliable than the submaximal test. However, in some participants such testing was contraindicated by medical or physical conditions. For this reason, we chose also to include the submaximal test, which has shown a reasonable correlation when compared to the max-test (Legge and Banister, 1986). The watt-max test started with a 5-minute warm-up at 75 W and 100 W for women and men, respectively. The workload was then increased by 35 W every 2 min until the participant reached exhaustion. Maximal oxygen consumption was estimated from the highest achieved workload. The sub-max test consisted of the 5 min warm-up on the bike, and maximal oxygen consumption was estimated from heart rate after 4½ min in relation to age and sex.

Self-rated health was assessed by questionnaire prior to the health examination with the following response categories: very good, good, fair, poor and very poor. We defined optimal self-rated health as very good or good. The 3-month assessment included questions identical to the baseline questionnaire as well as items relating to the effect and compliance of the intervention: (1) ‘During the last three months, did you change your physical activity level?’ (Yes or no); (2) ‘Did the pedometer and the goal-setting program help you to increase your physical activity level?’ (Yes or no); (3) ‘During the last month, how often did you wear the pedometer?’ (all days, ≥20 days, 10–19 days, ≤9 days, or no days); (4) ‘Did you follow the pedometer program during the last three months?’ (Mostly, some, a little, or not at all). For the controls, the follow-up questionnaire included: ‘During the last three months, did you use a pedometer?’ (Yes or no).

The 3-month health examination included measurement of aerobic fitness in which participants were re-tested in the same protocol as at baseline. The researchers who performed the examinations were blinded to group assignment.

Statistical analyses

Missing or unrealistic IPAQ values were excluded from the analysis on physical activity in specific domains, for instance if total walking time exceeded 8 h per day and total sitting time exceeded 12 h per day (n = 35 in the control group and n = 37 in the pedometer group at baseline). n = 18 in the control group and n = 44 in the pedometer group at follow-up).

Results were primarily analyzed on an intention-to-treat principle, where baseline data were carried forward to account for missing data at follow-up. Additionally, sub-analyses were performed including only participants who completed the 3-month follow-up health examination and/or the questionnaire. Also, analyses including only participants who participated at follow-up and who had been wearing the pedometer all or most days during the last month were carried out.

Differences within and between the study groups were evaluated using the Wilcoxon signed rank test for continuous variables (age, walking time, sitting time, and aerobic fitness), as these were non-normally distributed. The Chi-squared test was used for categorical variables. Subgroup analyses were used to investigate differential effects of the intervention by sex, age, educational level, and physical activity level (the 50% who reported most and least total walking time at baseline). In all tests, statistical significance was defined as p < 0.05. Analyses were carried out using STATA version 11.0.

Results

The study group consisted of 655 participants with low levels of physical activity in leisure time or fitness. There was a majority of women in the study (67%), and the median age was 52 years. Among the participants, 43% had more than 15 years of education. The participants walked for a median of 450 min/week (64 min/day). The median aerobic fitness level was 30 ml O2/min/kg. Almost half of the participants (47%) wished to become more physically active, and 80% had an optimal health. At baseline, no significant differences between the study groups were found in terms of age, education, physical activity, aerobic fitness and self-rated health (Table 1).

At 3-month follow-up, 198 (61%) participants in the pedometer group and 178 (54%) participants in the control group completed the health examination. A total of 192 (59%) and 173 (53%) participants filled in the follow-up questionnaire in the pedometer group and the control group, respectively (Fig. 1). Significantly more women in the pedometer group completed the 3-month health examination (61%) compared to the control group (49%). The participants who were lost to follow-up were slightly younger (median age = 47) compared to those who completed the follow-up examination (median age = 54) (P = 0.01).

Effect on physical activity, aerobic fitness and self-rated health

At 3-month follow-up, no significant differences were observed between the study groups in walking time, sitting time, physical activity in leisure time, aerobic fitness or self-rated health (Table 1). However, although statistically insignificant, the median walking time in the pedometer group was higher than among controls (controls = 460 min/week, pedometer group = 540 min/week, P = 0.30). When including only participants who completed the intervention, the median walking time was 630 min/week in the pedometer group and 405 min/week in the control group (P < 0.01) (Fig. 2). Table 1 shows that 28% in the pedometer group, compared to 17% in the control group, reported a level of physical activity that was higher than at baseline (P = 0.01). In line with this, a lower percentage in the pedometer group (42%) compared to the control group (50%) wished to increase their physical activity level (P = 0.03). Further, within subject analysis showed a significant increase in walking as transportation, in leisure time and in total walking time in the pedometer group whereas no significant changes were observed among the controls (Table 2).

No difference in the median aerobic fitness was found between the study groups (controls = 30.3, pedometer group = 29.6; P = 0.21). However, both groups had significantly improved aerobic fitness at follow-up compared to baseline (Table 2) and when including only completers in the analysis there was a tendency to a higher median aerobic fitness level in the pedometer group at 3-month follow-up compared to the controls (controls = 30.1, pedometer group = 31.8, P = 0.06).

At 3-month follow-up, no significant difference in self-rated health was observed. However, in both groups the proportion of participants who had an optimal self-rated health was lower at 3-month follow-up compared to baseline (Table 1).

Fig. 3 shows that the relative difference between the study groups in the median total walking time increased by age. Among the oldest
participants (65+ years) there was a significant difference of 312 min/week (P=0.05), whereas no difference in walking time was observed among younger participants. No relative differences in the effect of the intervention among men and women as well in subgroups of educational level and physical activity level were observed (data not shown).

Adherence

In the pedometer group, 49% reported that the intervention had helped them a lot or to some extent to increase their physical activity level, 26% found that it had helped them a little, while 21% did not find it helpful at all. Furthermore, 85% had been wearing the pedometer on all or most days during the last month of the trial period, 66% helped them a lot or to some extent to increase their physical activity (data not shown).

**Discussion**

Our results suggest that receiving a pedometer along with an intervention toolkit including guidance to a goal-setting training program may be an effective strategy to promote physical activity in middle-aged or older individuals. Further, the results show an effect on physical activity among those who completed the intervention. The intervention had no effect on aerobic fitness or self-rated health.

The finding of an effect among older individuals and not among younger ones may be due to the fact that walking is a popular way of exercise among the elderly, whereas younger people often prefer more intense activities, such as organized sport activities, weight training or jogging. Therefore, promoting physical activity through pedometer-based interventions may largely apply to the middle-aged or older part of the population.

Most pedometer-based interventions introduce instruments besides the pedometer such as organized training, telephone contact, face-to-face guidance, group sessions, and regular personal emails (Baker et al., 2008; Chan and Tudor-Locke, 2008; Hultquist et al., 2005; Rooney et al., 2005; Sidman et al., 2004; Sugiura et al., 2002). An intervention consisting of a pedometer along with an intervention toolkit including a self-guided step goal booklet, a logbook, and reminding emails such as the present intervention, is less resource demanding and can be carried out in a population-based setting. However, comparison with earlier findings is hampered due to differences in study designs (clinical/non-clinical setting, number of participants, sex of participants etc.).

In the present study, no increase in aerobic fitness was observed which may be due to a too short follow-up period when engaging in moderate physical activity. Furthermore, it may also be associated with short walking duration or with walking intensity (Murphy et al., 2007).

In this study, no effect of the intervention on self-rated health was observed. In contrast to this, Chan et al. found a significant difference...
In general health (SF-20) among participants who followed a pedometer-based intervention (Chan and Tudor-Locke, 2008). Further, other walking or training programs have also shown positive effects on self-reported health, well-being or quality of life (Murphy et al., 2007; Ogilvie et al., 2007). It does seem, however, that a minor decrease in the proportion of participants with an optimal health occurred in both groups from baseline to follow-up. This may be related to the assessment of self-rated health prior to the health examination at baseline.

In a public health perspective, it is of great relevance that a large proportion of the pedometer group adhered to the intervention and followed the goal-setting training program. Although, many participants may discontinue the behavior change after the 3-month follow-up, a recent review found a mean adherence of 85% in pedometer-based interventions. When taking the adherence and the cost-effectiveness aspect into account, a pedometer-based intervention such as the present has great potential as it is relatively easy to implement in a large population.

**Strengths and limitations**

In this study, we performed intention-to-treat analyses to preserve the validity of comparisons between the groups established by randomization. Thus, this type of analysis is an indication of the effect of the intervention under ideal conditions. However, completers’ analyses can be biased as those who drop out may differ from those who remain in the study (Ware, 2003). Nevertheless, due to randomization we expected no difference in health behavior between the groups. We chose to include individuals who were sedentary or had low levels of physical activity in leisure time or individuals who had low aerobic fitness levels because we wished to study the effect on aerobic fitness as well as on self-reported physical activity. Thus, participants could possibly be highly physically active in leisure time but with a low aerobic fitness level which might have attenuated the effect on self-reported physical activity.

The participants in the control group received written material recommending increased physical activity and they also underwent an extensive health examination similar to the pedometer group. This may have motivated the controls to increase their physical activity leading to an underestimation of the effect of the intervention.

Previous reports have shown that self-reported physical activity is a fairly accurate measure (Andersen et al., 2000; Hu et al., 2005). Nevertheless, participants in the pedometer group may have exaggerated their physical activity level or have a better recall of their activities as a result of intense information on the health benefits of physical activity.

The large number of participants enables us to study differences in the effect of the interventions by subgroups in the population. We found that the pedometer-based intervention was motivating older individuals to a larger extent than younger individuals although, among participants in the oldest age group, the activity level was higher at baseline in the pedometer group compared to controls despite the randomized design. However, in contrast to our results, previous findings have shown similar effects across all age groups (Kang et al., 2009). We found no differences in the effect when stratifying analysis by gender, educational level or physical activity level. Future studies should include analysis on subgroups of the population to target future interventions more appropriately.

**Conclusions**

In conclusion, this study showed that receiving a pedometer along with an intervention toolkit including a self-guided step goal booklet and a logbook may be effective in increasing physical activity among older individuals with low levels of physical activity or fitness. This study supports that combining pedometers with a self-guidance intervention toolkit is a simple method that offers a great potential for promoting physical activity.

**Conflict of interest statement**

The authors declare that there are no conflicts of interest.
Acknowledgments

The authors would like to acknowledge the participating municipalities. The study was financially supported by the Tryg Foundation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at doi:10.1016/j.ypmed.2011.12.012.

References