Feasibility of a portable pedal exercise machine for reducing sedentary time in the workplace

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ABSTRACT

Background Sedentary time is independently associated with an increased risk of metabolic disease. Worksite interventions designed to decrease sedentary time may serve to improve employee health.

Objective The purpose of this study is to test the feasibility and use of a pedal exercise machine for reducing workplace sedentary time.

Methods Eighteen full-time employees (mean age+SD 40.2+10.7 years; 88% female) working in sedentary occupations were recruited for participation. Demographic and anthropometric data were collected at baseline and 4 weeks. Participants were provided access to a pedal exercise machine for 4 weeks at work. Use of the device was measured objectively by exercise tracking software, which monitors pedal activity and provides the user real-time feedback (eg, speed, time, distance, calories). At 4 weeks, participants completed a feasibility questionnaire.

Results Participants reported sitting 83% of their working days. Participants used the pedal machines an average of 12.2+6.6 out of a possible 20 working days and pedalled an average of 23.4+20.4 min each day used. Feasibility data indicate that participants found the machines feasible for use at work. Participants also reported sedentary time at work decreased due to the machine.

Discussion Findings from this study suggest that this pedal machine may be a feasible tool for reducing sedentary time while at work. These findings hold public health significance due to the growing number of sedentary jobs in the USA and the potential of the device for use in large-scale worksite health programmes.

The health-related benefits of regular moderate and vigorous intensity physical activity have been well established.[1–3] Conversely, physical inactivity is a leading preventable cause of death and all-cause mortality,[4] and has been referred to as one of the most important public health problems of the 21st century.[5] Within the realm of physical inactivity, researchers of the past decade have explored more specifically the health implications and associated health mechanisms of 'sedentary behaviour'.[6] Recent reviews have defined sedentary behaviour as 'activities that do not increase energy expenditure substantially above resting levels' and include activities such as lying down, sitting and using screen-based technologies such as televisions and computers.[7 8] Interestingly, even short bouts of reduced energy expenditure have been associated with substantial detriments to metabolic health in animals models.[9–12] Emerging studies with humans seem to corroborate such findings, as time spent being sedentary has been demonstrated to be independently associated with an increased risk of metabolic diseases.[13] Furthermore, sedentary time in the form of sitting has been associated with an increased likelihood of being overweight/obese.[14] Conversely, evidence supports breaking up prolonged bouts of sedentary time as a means of improving metabolic risk factors such as body mass index (BMI), waist circumference, fasting glucose levels and triglyceride levels.[15]

The workplace has been identified as an ideal setting for reducing sedentary time as full-time employees working a 40 h work week spend over a third of their weekly wakeful hours at work. In addition, working days are associated with less standing time and more time sitting time compared with non-work days,[16] and evidence suggests occupational activity as a whole is on the decline with high physical activity occupations decreasing while low activity occupations have risen steadily over the past half century.[17 18]

Previous worksite programmes aimed at increasing employees' physical activity have demonstrated efficacy for increasing physical activity, with some demonstrating improvements in worksite-specific outcomes such as attendance and job stress.[19 20] Past worksite physical activity interventions have taken many approaches for promoting physical activity, including promoting stair use through point of decision prompts, promoting active transport and providing access to worksite fitness facilities.[21 22] It could be argued, however, that many of these approaches are somewhat limited with regard to their reach and impact in that they do not target the large portion of time in which the typical desk/computer-dependent employee is working and therefore sedentary. With the rise in screen-based technologies in the worksite, computer use, an identified barrier to physical activity,[23] has become a staple of the typical work day. Still, few worksite intervention approaches have focused specifically on reducing the sitting time of sedentary employees for improving health.[24] Furthermore, no worksite interventions to date have attempted to reduce sedentary time while adapting to the typical computer work environment in which sitting is necessary.

Thompson *et al*[25] recently tested the feasibility of a walking workstation designed to allow employees to continue their work while being active. Hospital employees in four different occupations were recruited for participation. While using the walking workstations, participants increased daily walking by an average of 2000

steps or an equivalent of 100 kcal/day.[26] Participants also reported that they could perform normal work tasks (ie, computer work, professional phone calls) while using the device and declines in productivity were not reported to be an issue. However, such devices do have limitations that might prohibit widespread use such as high cost, size requirements that may not be met in small offices, lack of portability and lack of use for special needs populations such as those with orthopaedic limitations or joint pain.

McAlpine *et al*[27] conducted a study testing the energy expenditure of an office stepping device that seemingly addressed several of the feasibility limitations of the walking workstation. The device used in their study was portable, cost feasible, nearly silent and when attached to a personal computer (PC) connected accelerometer allowed for self-monitoring. While the stepping device did result in significant increases in energy expenditure above sitting in a controlled laboratory setting, the study did not explore the feasibility of the device in a real-life setting.

Several portable pedal exercise machines that also address many of the limitations of the walking workstation have recently become commercially available. One machine in particular, the MagneTrainer mini exercise bike (3D Innovations, LLC, Greeley, CO) is a cost feasible, stable yet portable device that can be set up in front of most standard office chairs for use while sitting and also allows for objective self-monitoring (eg, time used, distance pedalled, average speed, caloric expenditure) through a PC connection. To our knowledge, no studies have explored the feasibility or use of a portable pedal machine for reducing time spent sedentary in an occupational setting. Therefore, the primary aims of this study are to test the feasibility, acceptability and use of a portable, pedal exercise machine for reducing sedentary time in a free-living, occupationally sedentary adult population. We hypothesise that participants will find the machines feasible and acceptable for use in the sedentary work environment, and that participants will decrease their sedentary time at work as a result of using the pedal machine.

METHODS

Subjects

A total of 18 healthy, adult, (age 40.2+10.7 years; BMI 26.7+5.0 kg/m^2; 88% female) full-time employees (self-report working a minimum of 35 h/week) working in sedentary (minimum of 75% of working day spent sitting), desk/computer-dependent occupations was recruited from the greater Providence, Rhode Island, region for participation by local internet advertisements. Assessments occurred between October 2009 and March 2010. Participants were devoid of ambulatory/exercise limitations, and free from overt cardiovascular, metabolic, respiratory or neurological diseases as assessed by medical history screening. Participants were compensated US$15 each time they attended two separate assessment sessions (total of US$30 possible). Experimental protocols were approved by the Lifespan Office of Research Administration in Providence, Rhode Island, and voluntary informed consent was obtained from each participant.

Experimental design

All testing assessments were conducted at a research laboratory located at the Miriam Hospital in Providence, Rhode Island, USA. Participants were asked to attend two testing sessions, one at baseline and a follow-up assessment 4 weeks later. Body mass was measured to the nearest 0.1 kg and height to the nearest 0.5 cm using a calibrated medical balance beam scale (Detecto, Webb City, Missouri, USA). BMI (kg/m^2) was calculated as weight (kg) divided by height (m) squared. Participants completed a modified version of the 7-day physical activity recall questionnaire,[28] which included supplementary questions targeting the total number of hours and minutes spent 'sitting', 'standing but not walking' and 'walking' while at work over the previous 4 weeks. Participants then completed a 6-min pedal test following the Astrand-Rhyming protocol[29] to become familiarised with the pedal machine.

Participants were then provided access to a MagneTrainer pedal exercise machine (3D Innovations) for use while at work for four continuous weeks (figure 1). The MagneTrainer pedal exercise machine was chosen due to its relatively low cost (US$150 for pedal machine and software), portability and compact size (18 in height, 20 in length) and its ability to monitor and record participant's daily and accumulated pedalling activity objectively through a PC connection (FitXF Exercise Tracking Software; 3D Innovations). The FitXF software also provides users with real-time feedback on pedal speed, time used, distance and calories, which is displayed on their computer monitor. The FitXF software also begins recording pedal activity the moment the user begins pedalling and stores daily and accumulated summary data for total time spent pedalling

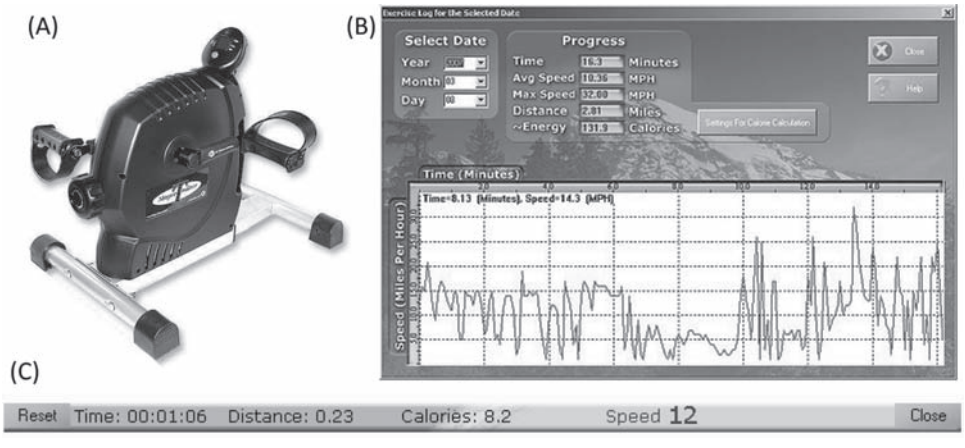

Figure 1 (A) The portable pedal exercise machine. (B) A screenshot of the exercise log, which provides feedback on pedal use activity per day. (C) A screenshot of the real-time monitor, which provides real-time feedback to the user.

(min/day), average speed (mph/day), distance pedalled (miles/day) and estimated caloric expenditure (kcal/day). A member of the research team delivered the pedal machine to the participant's worksite, downloaded the FitXF software to the participant's work computer and worked with the participant to identify the most feasible physical set up for using the machine (eg, under the desk, next to the desk). All participants were required to gain clearance from their immediate supervisor before enrolling in the study.

Following 4 weeks, pedalling activity data were downloaded from each participant's personal work computer with the authorisation of the participant's supervisor. Participants then returned to the testing facility to repeat all baseline tests and to complete a 23-item, five-point Likert scale (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree) feasibility/acceptability questionnaire designed to enquire about the user's opinions and experiences with the machine (see appendix 1) as well as the intensity at which they typically pedalled using the Borg 0–10 rating of perceived exertion (RPE) scale.[30] Participants were also asked to report any barriers to using the machine and/or suggested improvements for the machine while at work. Consistent with the purpose of testing the feasibility and acceptability of the pedal machine, participants were only provided access to the machine and were not provided any behavioural intervention materials for the purpose of reducing sedentary time (eg, goals, motivational resources, self-monitoring prompts) during the course of the study.

Statistical analyses

Minutes of pedallling activity and days of pedalling activity were recorded and downloaded from the pedal machine through the FitXF exercise tracking software. Means and SD of pedal use activity were calculated and are presented in table 1. Medians and quartiles of the feasibility/acceptability data were calculated and are presented in table 2. Means and SD of average pedal time per day used for each participant were calculated and are presented in figure 2. Average pedal time among all users on days 1–20 and compliance using the pedal machine (percentage participants that pedalled each day during days 1–20) was summarised and is presented in figure 3 Paired t tests were conducted to test whether participants' time spent sitting, standing and/or walking changed over time from the baseline to the 4-week assessment. Statistical significance was set a priori at $p<0.05$.

RESULTS

On average, participants were middle aged (mean 40.2±10.7 years), overweight (mean BMI 26.8±5.0 kg/m^2) and primarily female (88%). Participants self-reported working an average of 40.9±4.7 h/week. Participants reported sitting an average of 6.80±1.5 h (83%) of their total working day. Participants pedalled an average of 12.2±6.6 (range 2–20 days) out of a possible 20 working days in which they had access to the pedal machine (61% compliance) and pedalled an average of 23.4+20.4 min on days they used the machine (see table 1 and figure 2). The estimated averages provided by the FitXF software for distance pedalled per day and caloric expenditure per day per participant equalled 4.8±3.6 miles/day and 186.5±142.2 kcal/day, respectively. Participants self-reported pedalling at an average intensity of 4.4±1.6 or 'somewhat hard' on the Borg 0–10 RPE scale. Average pedal time was maintained over the duration of the study, whereas the number of participants who used the machines each day (compliance) declined progressively over the course of 4 weeks (figure 3). As presented in table 2, when asked to respond to several statements pertaining to their experience with the pedal machine using a 1–5 Likert scale (1, strongly disagree; 5, strongly agree), participants reported the pedal machine to be 'easy to use', and 'as an alternative activity during bad weather'. Participants overwhelmingly reported they would 'use the pedal machine regularly at work if offered one by their employer' and reported neither their 'work productivity' nor their 'quality of work' declined as a result of using the machine at work. Participants reported 'their sedentary time at work decreased as a result of using the machine'. However, no significant differences in self-reported time spent sitting ($p=0.11$), standing ($p=0.65$) and/or walking ($p=0.77$) were observed from baseline to 4 weeks.

DISCUSSION

Findings from this study suggest this portable pedal exercise machine is a feasible tool for reducing time spent sedentary while at work. Overall, participants reported positive experiences with the pedal machine and reported that they would use the machine at work if offered one by their employer. When provided access to the device, on average participants used the machines more than half of all working days although compliance did decrease over the course of the 4 weeks (see figure 3). This is not a surprising finding given the lack of any behavioural intervention provided to these previously sedentary participants during the course of the study. However, the average minutes pedalled per day was maintained throughout the 4 weeks and participants pedalled for an amount of time (23 min per day used) that could result in health benefits if performed on a regular basis and at an average intensity reported by participants (eg, 'somewhat hard' on the Borg 0–10 scale).[3] A logical next step would be to test the efficacy of combining the pedal machine with a behavioural intervention

Table 1 Accumulated and daily means±SD and ranges of pedal time, pedal speed, distance pedalled and caloric expenditure

	Mean+SD	Range
Average total pedal time (min)	358.0±401.7	4.0–1489.0
Average number days pedalled	12.2±6.6	2.0–20.0
Average pedal time/day used (min)	23.4±20.4	1.2–73.1
Average pedal speed (mph)	12.5±4.4	5.3–18.4
Average distance pedalled (miles)	69.0±62.6	0.5–214.0
Average distance pedalled/day used (miles)	4.8±3.6	0.3–13.4
Average total kcal expended (kcal)	2758.8±2699.7	18.0–8334.8
Average total kcal expended/day used (kcal)	186.5±142.2	9.0–501.9

Data were downloaded using the FitXF exercise tracking software.

Table 2 Quartile and median Likert scale responses (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree) to feasibility/acceptability questions following 4 weeks of access to the pedal machine

Do you agree or disagree with the following statement?	Q1	Median	Q3
If offered to me by my employer, I would use the machine while at work	4.3	5.0	5.0
My physical activity increased while at work as a result of the machine	3.0	4.0	5.0
My physical activity increased outside of work as a result of the machine	2.3	3.0	4.0
The pedal machine is easy to use	4.0	4.0	5.0
I would use the machine as an alternative activity in bad weather	4.0	5.0	5.0
I am comfortable using the machine in the presence of others	3.0	4.0	5.0
The time I spent sedentary at work decreased as a result of the machine	3.0	4.0	4.0
I would use the machine while at home	4.0	5.0	5.0
The machine is too noisy	1.0	1.0	2.0
My work-related productivity decreased while using the machine	1.0	1.0	2.8
The quality of my work decreased while using the machine	1.0	1.0	2.0
The machine interfered with my daily work-related tasks	1.0	1.0	2.0
I was more tired on days I used the machine	1.0	2.0	2.0
I had more back pain on days I used the machine	1.0	1.5	2.0
I had more joint pain on days I used the machine	1.0	1.0	2.0
I had more muscle aches on days I used the machine	1.0	1.5	2.0
I could conduct a professional telephone call while using the machine	2.0	3.0	5.0
I could conduct normal computer tasks while using the machine	2.0	3.0	4.0
I could read comfortably while using the machine	4.0	4.0	5.0
The real-time monitor increased my use of the machine	3.3	4.0	5.0

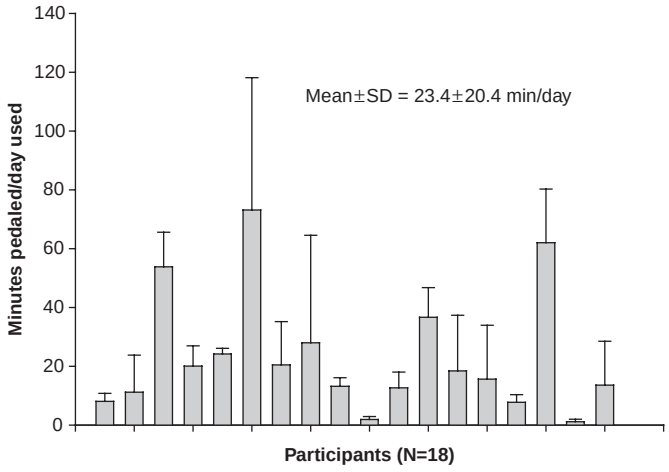

Figure 2 Average pedal time for days pedal machine was used per participant (N=18).

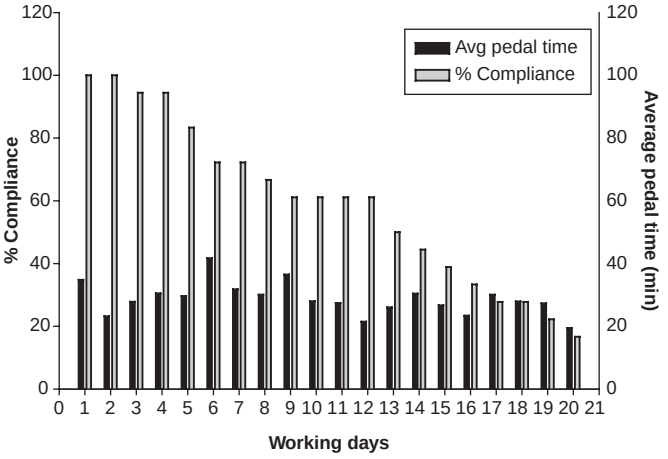

Figure 3 Average pedal time (minutes) and percentage of participants who pedaled each working day.

for reducing sedentary time at work and reducing the risk of chronic diseases.

When examining the pedal machine used from a human factors perspective, the MagneTrainer offers several features that make it a particularly attractive tool for future health promotion studies. Importantly, the device offers functions that are directly in line with three out of four features previously identified as necessary for technologies designed to promote physical activity and reduce sedentary time.[31] It is suggested that such technologies should: (1) give users proper credit for activities completed; (2) provide users personal awareness of his or her activity levels; (3) consider the practical constraints of users; and (4) support social influence.[31]

First, through the PC connection, the MagneTrainer pedal machine automatically and objectively monitors participants' pedalling activity (eg, credits user for activity completed). This function would be especially important from an assessment perspective in future research studies, and could potentially serve as a means to monitor employee participation in worksite wellness programmes that offer financial incentives for participation.

Second, the software enabled real-time feedback monitor and progress monitor, which summarises past activity by day and provides the user with a personal awareness of his or her current and past activity levels. The pedal machine provides users with real-time feedback of time spent pedalling (minutes), average speed (mph), maximum speed (mph), distance pedalled (miles) and estimated calories burned (kcal), which is displayed on a thin monitor that can be moved anywhere on the user's desktop. When asked to report how often they self-monitored their pedalling activity using the real-time feedback monitor (eg, time, distance, calories, speed) using a 1–4 Likert scale (1, never; 2, rarely; 3, occasionally; 4, frequently), participants reported frequently using the monitor (3.7+0.9). In addition, participants agreed the monitor increased their use of the machine (4.0+0.9 on 5-point Likert scale) suggesting that the monitor is a motivational tool.

What is already known on this topic

Evidence of the negative impact prolonged sedentary time has on metabolic health is growing. Many new devices with the potential to reduce prolonged sedentary time have recently become available on the commercial market. However, few studies have tested the feasibility and use of such devices among free-living populations in the work environment.

What this study adds

This study demonstrates a portable pedal exercise machine (MagneTrainer) to be feasible for use in the sedentary work environment. This study also found participants used the machines regularly without being provided a behavioural intervention. This study supports future interventions that test the efficacy of combining such devices with evidence-based behavioural approaches to reduce sedentary time at work.

Third, the portability, stability and near silent operation of the pedal machine allows this machine to be used in most typical office settings without interfering with daily operations. Importantly, portable pedal machines may serve as a tool to reduce sedentary time in the work environment without necessarily influencing the sitting time necessary for performing computer-related tasks. Participants reported the machine to be quiet, easy to use and usable in a typical office. Participants also reported that the pedal machine did not interfere with their quality of work or work productivity and did not result in any added pain to their joints or back. Participants agreed that they could read while using the pedal machine but not all users agreed they could complete computer tasks. Such practical considerations are important to consider for future worksite programmes that use the pedal machine.

Finally, while the pedal machine does not necessarily support social influence, previous worksite physical activity promotion studies using pedometers have utilised a social support component with great success.[32] Therefore, it stands to reason that the pedal machine could stimulate social support in the same light. In addition, our staff received 166 emails from interested participants in less than 72 h following an advertisement posted on the Lifespan hospital intranet website. The overwhelming response to this study is indicative of sedentary employees' desire to become more active while at work.

The results of this study should be interpreted with caution as this study is limited by a sample of primarily educated, Caucasian (94%) women (89%). It is possible that the pedal machine may not be viewed as favourably by men, racial and ethnic minority populations and/or individuals working in non-desk-dependent occupations. For example, individuals working in jobs that do not require a specific office space would probably not benefit from this machine. In addition, simply providing access to devices like the pedal machine is not enough to stimulate long-term use. The novelty of this device appeared to wear off over time, and may benefit from a combination of evidence-based behavioural techniques such as regular email prompts for sustained use. Future interventions testing the efficacy of combining behavioural content with the pedal machine are warranted. Finally, the pedal machine used in this study has certain limitations that deserve mention. For instance, the accuracy of the caloric expenditure output has yet to be confirmed.

Collectively, these findings hold public health significance due to the growing number of sedentary jobs in the USA, our growing understanding of the costs sedentary behaviour has on our health, and the potential of portable pedal machines (eg, portable, low cost, objective monitoring) for use in large-scale worksite health programmes. Future physical activity promotion interventions utilising portable and practical devices such as the pedal machine are warranted.

Contributors The contributing authors have made substantial contributions to the conception, design, analysis and interpretation of data, drafting of the article and have all given final approval of the current version and agree to its submission.

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Competing interests None.

Patient consent Obtained.

Ethics approval This study was conducted with the approval of the Miriam Hospital, Providence, Rhode Island, USA.

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Appendix 1 Feasibility questionnaire

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. The pedal machine is easy to use					
2. The pedal machine could be used in the typical office-style work environment					
3. The pedal machine is too noisy					
4. I would use the pedal machine as an alternative to be active on days that the weather is bad					
5. I felt comfortable using the pedal machine in the presence of others at my work					
6. My work-related productivity decreased while using the pedal machine					
7. The quality of my work decreased while using the pedal machine					
8. The pedal machine interfered with my daily work-related tasks					
9. I could conduct a normal, professional telephone conversation while using the pedal machine					
10. I could conduct normal computer-related tasks while using the pedal machine					
11. I could read comfortably while using the pedal machine					
12. I was more tired on days I used the pedal machine					
13. I had more back pain on days I used the pedal machine					
14. I had more joint pain on days I used the pedal machine					
15. I had more muscle aches on days I used the pedal machine					
16. My physical activity increased while at work as a result of the pedal machine					
17. The time I spent being sedentary decreased while at work as a result of the pedal machine					
18. My physical activity increased outside of work as a result of the pedal machine					
19. If I were offered a pedal machine by my employer, I would use it while at work					
20. I would use the pedal machine while at home					
21. The real-time monitor increased my use of the pedal machine					