



Enhancing physical activity promotion in midlife women with technology-based self-monitoring and social connectivity: A pilot study

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Abstract

This pilot study tested a novel program to promote adoption and maintenance of aerobic activity in midlife women. Lifestyle modification group sessions were held weekly for 3 months, followed by two booster sessions during the 3-month maintenance phase. During all 6 months of the program, participants used a physical activity sensor to automate self-monitoring and a web platform to facilitate social connectivity. Aerobic exercise increased from 63 to 132 minute/week from baseline to 3 months ($p < .01$), and activity was maintained at 6 months (135 minute/week). Technology enhancements have strong potential to promote maintenance of behavior change.

Keywords

exercise, Internet, intervention, lifestyle, social support

Risk for cardiovascular disease (CVD), the leading cause of death among women, escalates during and after the menopausal transition (“midlife”; Matthews et al., 2009). Physical inactivity is strongly associated with high CVD risk during this period (Seguin et al., 2014). Conversely, moderate-to-vigorous physical activity (MVPA) is associated with CVD-related health benefits, including weight control (Gebel et al., 2014), lower blood pressure and cholesterol levels (Barnett, 2009), and improved metabolic functioning (Hutchison et al., 2011; Kelley et al., 2011). Even modest increases in MVPA have led to meaningful improvements in cardiorespiratory fitness among sedentary midlife women (Church et al., 2007).

Unfortunately, most adult women do not engage in recommended levels of physical activity, and physical activity engagement steadily declines with age (Schoenborn et al., 2013). Supervised exercise programs and group-based lifestyle modification programs have positive short-term results, but participant engagement over the long-term is challenging, and poor maintenance of behavior change is

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common (Altman, 2009; Appel et al., 2011; Dishman, 1994). There is a critical need to develop physical activity promotion programs that are effective for maintaining behavior change and use intervention methods that are broadly disseminable.

Self-monitoring and social connectivity are two elements of lifestyle modification programs that appear especially powerful for initiating and maintaining behavior change (Greaves et al., 2011; Webb et al., 2010). Their joint effects are particularly promising. Greene et al. (2013) incorporated a combined accelerometer and social networking device to help participants implement healthy lifestyle choices. Participants who received this device achieved significantly greater weight losses and increases in leisure-time walking than those who did not receive the device. Technology also has the potential to facilitate self-monitoring and social connectivity in the absence of other intervention contact. Evaluating this potential use of these devices is critical, as maintaining frequent face-to-face contact over the long term is not feasible or cost-effective (Greene et al., 2013; Pellegrini et al., 2012; Peterson et al., 2014; Unick et al., 2012). Evaluating acceptability with particular populations who may have less technology experience, such as midlife women, is also necessary.

The current pilot study used a single-group design to test the feasibility, acceptability, and initial effectiveness of a 6 month, technology-enhanced lifestyle modification program intended to help midlife women achieve and maintain high levels of MVPA. Self-monitoring and social connectivity were facilitated by use of physical activity sensors that were synced to a web platform, where group members shared information. The primary aim of the study was to test the hypothesis that participants would significantly increase MVPA during the first 3 months of the program (Phase I) and maintain those changes during the following 3 months (Phase II), when intervention contact was decreased and physical activity would otherwise be expected to decline. Weight control was examined as a secondary outcome.

Method

Participants ($n=36$) were recruited from the community with postcards and radio advertisements offering a lifestyle modification program for women to improve their health. Women were eligible to enroll if they were between the age of 40 and 65, engaged in <150 minute/week of MVPA, and had the ability and willingness to access the Internet. The average participant was 54 years old (standard deviation (SD)=7.18) with a body mass index (BMI) of 32.69 kg/m^2 ($SD=7.32$). The sample was racially diverse (62% Caucasian).

Assessment

Assessments took place at baseline, end of Phase I (3 months), and end of Phase II (6 months). At each assessment, participants wore Actigraph GT3X+ accelerometers on their hips for 7 consecutive days (days were assigned by the research team) to measure physical activity. Accelerometers measure movements across several planes and recorded intensity, frequency, pattern, and duration of activity. They provide more accurate and comprehensive measures of physical activity than do pedometers and self-report questionnaires and have been demonstrated as the most valid and reliable method of measuring physical activity, with minimal reactivity (Corder et al., 2007). Standardized intensity cutpoints were used to define sedentary, light, moderate, and vigorous activity (Troiano et al., 2008). Participants were weighed in the research clinic, in light street clothing, at each assessment using a standardized Seca® scale calibrated to 0.01 kg. The Barriers to Being Active questionnaire assessed perceived barriers to physical activity in several domains, including lack of social support, lack of willpower, lack of skill (Centers for Disease Control and Prevention, 2013). Participants were asked to rate effectiveness and satisfaction with the program on a 5-point Likert-type scale, with higher ratings being more favorable. They were also asked to rate likelihood of recommending the program to another woman interested in

increasing physical activity and to rate their confidence in maintaining physical activity.

Intervention

Participants attended 12, 90-minute group meetings, with approximately 12 participants in each group. A total of 10 meetings were held during Phase I (initial behavior change stage, Months 1 through 3) and 2 additional meetings were held during Phase II (maintenance stage, Months 4 through 6). Intervention sessions were facilitated by group leaders with prior experience in lifestyle modification. Session material focused on using behavioral and cognitive skills to gradually increase MVPA. Healthy weight control was a secondary emphasis, and participants were encouraged to adopt a goal of preventing weight gain or achieving and maintaining modest weight loss. All content was tailored to address concerns of midlife women.

Sessions began with a structured check-in during which participants reported their progress in meeting behavioral goals, with a primary emphasis on minutes per week of MVPA. Other goals included specific changes to eating behavior (e.g. eating breakfast every day, increasing fruit and vegetable intake) and communication with group members outside of intervention sessions (detailed below). Group leaders provided feedback on progress and encouraged participants to offer each other suggestions. The remainder of each session was devoted to learning behavior modification skills, such as self-monitoring, goal-setting, problem solving, and communication skills.

To enhance self-monitoring, each participant was provided with a physical activity sensor (Fitbit® Flex™) to be worn on the wrist every day during Phases I and II. The Fitbit® Flex™ device, which has preliminary information establishing reliability and validity (Noah et al., 2013), captures detailed information about various types of physical activity, which was displayed on a web platform for each participant to view. (As reported above, all participants also wore research-grade Actigraph GT3X+accelerometers on their hips for 7 days at the point of each

assessment for purposes of outcomes evaluation. GT3X+ accelerometers were used for outcomes assessment because they have been established as the gold standard for measuring physical activity for research purposes. Data from the Fitbit® Flex™ were not used to evaluate the change in physical activity that occurred during the intervention.) The front page (or “dashboard”) of participants’ web profiles showed their physical activity intensity over the course of the current day, displayed in 15-minute increments, as measured by the Fitbit® Flex™. Participants were encouraged to personalize their dashboards to display information about step totals, minutes of sleep, water and calorie intake, and/or milestones such as reaching 10,000 steps in a day. Because participants also interacted with each other during face-to-face groups, their web profiles showed participants’ real names (first names only). Identities were shared in order to allow direct interaction with known others over the sensor’s social network. Each participant was able to add a photo or an avatar, as well as personal information she wished to share (e.g. behavioral goals). Weight and other individual health information was kept private. The web platform also displayed a “Leaderboard” on which participants viewed their physical activity progress (as measured by the physical activity sensor) relative to that of other group members. Monthly step totals for each participant were displayed in rank order (highest on top); rankings by minutes of MVPA were available by changing display options.

Each intervention group communicated via a private message board (“Community Board”) on the web platform, where participants were asked to post once per week. In their posts, participants were prompted to report on progress with that week’s goals or discuss their recent successes or challenges. Participants also were encouraged to start their own topics and to respond to the fellow group members’ posts. Group leaders monitored the Community Boards and replied to participants’ posts periodically, typically acknowledging participants’ efforts and providing encouragement. Group leaders also on occasion responded to

participants' reports of challenges and prompted them to use particular behavioral skills that were not already suggested by other group members. Instances of participants sharing incorrect information were rare; in these situations (both on the Community Board and during group meetings), group leaders provided direct responses.

Data analysis

The primary outcome of interest was change in MVPA, as measured by Actigraph GT3X+accelerometers. Secondary outcomes included light physical activity, sedentary time, and weight change. As a key aim of the present study was to examine maintenance of Phase I improvements during Phase II, paired *t*-tests evaluated accelerometer-assessed physical activity for (1) change from baseline to 3 months, (2) change from 3 months to 6 months, and (3) change from baseline to 6 months. Exploratory examinations of weight change and barriers to physical activity used a similar approach. Correlational tests investigated relations between change in physical activity barriers and change in MVPA and weight, as well as between indicators of social connectivity and MVPA/weight. Regression methods (general linear models) were used to test relations between social connectivity during Phase I and outcomes during Phase II. Information regarding participant retention, use of the physical activity sensor (Fitbit® Flex™) and Community Board, and self-reported response to the intervention were examined to determine the feasibility and acceptability of the Next Steps program.

Results

Of the 36 women who initiated the program, 4 participants withdrew due to scheduling conflicts and 4 were lost to follow-up. Two participants completed the 6-month assessment but provided invalid accelerometer data. Thus, the cohort of intervention completers had 28 women, 26 of whom provided valid accelerometer data at all three time points.

Physical activity change

MVPA increased from 63 minute/week at baseline to 132 minute/week at 3 months ($t(28)=4.45$, $p<.01$). Increases were maintained at 6 months ($M=135$ minute/week), and overall change from baseline to 6 months was significant ($p=.01$; see Table 1 for full descriptive statistics). Table 1 also shows similar patterns of change and maintenance for the number of MVPA bouts per week and overall percent time spent in MVPA. Light activity showed non-significant change from baseline to 6 months ($t(25)=1.35$, $p=.18$) and during each phase ($ps>.35$). Sedentary time decreased from baseline to 6 months ($p<.05$); between-phase decreases did not reach significance ($ps>.28$).

Weight change

Participants demonstrated significant weight loss from baseline to 6 months ($t(28)=2.69$, $p=.01$). Participants lost 0.78 kg during Phase I and an additional 1.86 kg during Phase II, with a trend toward greater weight loss in Phase II ($t(25)=1.99$, $p=.06$; see Table 1). Average BMI decreased from 31.8 kg/m² to 30.9 kg/m² at 6 months ($t(28)=2.59$, $p=.02$).

Treatment acceptability

Perceived barriers to physical activity decreased from baseline to 6 months, including lack of skills ($t(20)=2.38$, $p=.03$) and lack of willpower/motivation ($t(20)=2.60$, $p=.02$). Perceived lack of skills decreased during Phase I ($t(20)=1.23$, $p=.06$) and did not show meaningful change during Phase II ($t(20)=.08$, $p=.77$). Identification of willpower/motivation as a barrier showed moderate decreases during Phase I ($t(20)=1.68$, $p=.11$), whereas decreases during Phase II were noticeably larger ($t(20)=3.29$, $p<.01$). Perceived lack of social support for physical activity showed non-significant decreases from baseline to 6 months ($t(20)=1.48$, $p=.16$), and change during Phase I was minimal ($t(20)=0.12$, $p=.91$). However, participants endorsed significant decreases during Phase II

Table 1. Change in physical activity levels and weight during Phase I (baseline to 3 months) and Phase II (4 months–6 months).

	Baseline, M (SD)	3 months, M (SD)	6 months, M (SD)	Overall change, baseline to 6 months, <i>t</i>	Change Phase I, baseline to 3 months, <i>t</i>	Change Phase II, 3 months– 6 months, <i>t</i>
Minutes per week in MVPA bouts	62.71 (60.16)	131.60 (99.92)	134.59 (125.05)	2.77*	4.45**	0.41
Bouts of MVPA per week	1.75 (2.30)	4.13 (3.70)	3.69 (3.98)	2.22*	4.13**	1.03
Percent of time in MVPA per day	3.65 (1.65)	4.92 (2.45)	4.83 (2.63)	1.81 [†]	3.52**	0.83
Minutes per week in light activity	1029.0 (323.42)	1080.35 (329.15)	1204.81 (669.41)	1.35	0.44	0.87
Minutes per week in overall activity	1207.33 (381.32)	1335.42 (398.50)	1486.42 (773.76)	1.84 [†]	1.30	0.75
Percent of time sedentary per day	75.6 (5.72)	74.3 (5.71)	73.2 (5.81)	2.10*	1.08	0.28
Weight (kg)	84.62 (18.88)	83.78 (18.41)	81.92 (17.82)	2.69*	0.32	1.78 [†]
BMI	31.83 (6.23)	31.58 (6.08)	30.88 (5.88)	2.59*	1.78 [†]	3.70**

MVPA: moderate to vigorous physical activity; BMI: body mass index.

Physical activity was assessed with Actigraph GT3X accelerometers.

[†] $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

($t(20)=3.81$, $p<.001$), indicating improved social support. The extent to which participants experienced improvement in social support during Phase I was associated with increases in MVPA during Phase II ($F(1, 20)=2.15$, $p=.05$), and showed a trend toward an association with weight loss during Phase II ($F(1, 20)=1.73$, $p=.10$).

Participants frequently viewed their group's Community Board (87% of participants in a 24-hour period, on average) and Leaderboard (71% of participants in a 24-hour period, on average). Posts to each group's Community Board demonstrated compliance with program recommendations to contribute each week during Phase I ($M=1.18$ per week, $SD=0.72$). Posting decreased slightly during Phase II ($M=0.83$ per week, $SD=0.69$). However, more than half of participants (58%) continued to post at least once per week during Phase II, in the absence of weekly prompts from group leaders. The number of times a participant

posted to the Community Board was positively associated with change in MVPA during Phase I, such that participants who posted more frequently also showed greater increases in MVPA ($r=.46$, $p=.02$).

Participants showed high compliance with recommendations to wear their physical activity sensors every day. Overall compliance was 86% of days during the program, with no meaningful change in compliance rate from Phase I to Phase II (87% vs. 84%; $t(41)=0.32$, $p=.75$). The most common reasons for non-wear were forgetting the wristband at home and running out of battery charge. At 6 months, 77% of participants reported that they had already purchased (or intended to purchase) a device of their own to keep.

The majority of participants rated the program effective for increasing physical activity (89%). Participants reported moderate to high satisfaction with the program's approach to increasing physical activity ($M=4.11$ out of 5,

$SD=1.14$), and with the schedule of group meetings ($M=4.00$ out of 5, $SD=0.94$). At 6 months, 88% of participants endorsed confidence in their ability to maintain a high level of physical activity over the next 3 months; 88 percent also agreed that they would recommend the program to other women. Accountability to the group, interacting with other group members in-person and online, and the physical activity sensor were most commonly cited as the “best” aspects of the program. Specific recommendations for program improvement included adding time for participants to get to know each other better (either in group or on the Community Board).

Discussion

This pilot study was designed to test the effectiveness and feasibility of a novel lifestyle modification program, which used technological enhancements in self-monitoring and social connectivity to promote and maintain changes in MVPA. The program demonstrated a high level of effectiveness. Participants approximately doubled their amount of MVPA during the 3-month Phase I period (to 132 minute/week), and this increase was maintained during Phase II, the 3-month period during which groups met only two times. This increase is large enough to confer important health benefits (Church et al., 2007). These results compare favorably to other physical activity promotion programs, which have typically either failed to achieve maintenance of physical activity or achieved increases of 30–60 minutes per week of activity with much more intensive intervention contact (Greaves et al., 2011; Kuller et al., 2006; Stoddard et al., 2004). As expected, no change in light activity was observed. It is encouraging that participants were able to adhere to program recommendations regarding intensity of exercise, and it is reassuring that no compensatory decrease in light activity was observed.

Participants also were successful in their weight control efforts: average BMI decreased by approximately one unit at 6 months. Of note,

weight loss was significant during Phase II, when weekly intervention groups had discontinued, a period during which many intervention programs find that participants gain weight (Butryn et al., 2011). These results demonstrate the potential for a technology-enhanced intervention to support maintenance of behavior change in a disseminable format that does not require a high number of ongoing face-to-face meetings.

In addition, participant retention was good and participants reported a high level of satisfaction with the program. Participants had excellent compliance with physical activity sensor wear, and the frequency of sensor use did not differ between Phase I and Phase II, suggesting good maintenance of this key self-monitoring tool. Participants had frequent use of Community Board and other features of the physical activity sensor's web platform. Participants also demonstrated good compliance with the recommendation to post on the Community Board once per week, although compliance appeared superior in Phase I versus Phase II.

Challenges to intervention delivery using technology and social connectivity support were minimal. Of note, a small number of participants had initial difficulty installing sensor software and syncing devices with their web profiles. Additional instruction and/or support may be necessary for participants who have limited experience or comfort with technology. As social connectivity features are limited on the sensor's mobile platform, future programs may include the use of alternative communication methods. Group leaders had little difficulty facilitating Community Board discussions, and cited the ability to monitor participants' progress outside of face-to-face sessions as a unique benefit of the intervention.

These findings demonstrate the promise of automated physical activity sensors and associated social connectivity components for increasing physical activity among sedentary women. Of course, because this pilot study used a single group design, it is not possible to draw conclusions about the unique influence of the social

connectivity and self-monitoring components. In this sample, a self-selection bias also may have occurred, in which participants were already motivated to increase physical activity. A randomized, controlled study with a larger sample size is warranted to further examine the effectiveness of this program and to establish mediators of change in behavior. A factorial design is needed to determine the unique contributions of particular program components, that is, lifestyle modification meetings, enhanced self-monitoring, and enhanced social connectivity. Such research would identify how much value the technology is adding, over and above standard intervention components. In addition, future research should include a longer follow-up period to examine sustained use of the physical activity sensor and the web platform and long-term maintenance of physical activity and weight. It also is unknown to what extent this technology can promote maintenance when other intervention contact is terminated completely.

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