Promoting physical activity among women using wearable technology and online social connectivity: a feasibility study

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Wearable physical activity (PA) tracking technology, which has the capacity to connect users’ PA data to online social networks, could address the need for cost-effective, scalable PA programs for women. It is not yet clear how to use wearable devices to maximize the effectiveness of evidence-based PA promotion techniques. There also is need to examine time-sensitive, within-person relationships between aspects of social networking and PA progress. The present study tested the feasibility, acceptability, and effectiveness of an online PA program that employed wearable technology, an associated social network, and the assignment of program partners. Sedentary women (n = 20, M_Age = 50, M_BMI = 30.9 kg/m²) used wearable devices and attended one face-to-face session that introduced evidence-based PA promotion skills (e.g. goal setting). The remainder of the six-week program emphasized online communication with PA partners and other group members. Participants completed online surveys about their social contact at the end of every week. The recruitment target (set at 20) was reached after three weeks, and retention over six weeks was 100%. Objectively verified daily device wear was high (97%) and participant program ratings were favorable (e.g. M = 3.85 of 5, SD = 1.04 for “effectiveness”). Participants showed large increases in daily steps (from 3796 [SE = 478] to 8190 [SE = 516]) and daily minutes of moderate-to-vigorous PA (from 12.68 [SE = 3.15] to 24.05 [SE = 3.48]). Multilevel models revealed meaningful within-person relationships between PA and social contact (ps < .02); PA was highest at times when social contact was higher than a participant’s average level. Findings support the feasibility, acceptability, and effectiveness of incorporating wearable technology and online social networking into an online PA program for women, and provide time-sensitive evidence that social networking is beneficial for PA. Consequently, larger, randomized trials of this approach are warranted.

**Keywords:** wearable technology; physical activity; eHealth; women’s health; social support

1. Introduction

Despite increasing knowledge about the risks of physical inactivity, most adults in the USA fall far short of the physical activity (PA) levels that are recommended for maintaining health and

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preventing chronic disease (American College of Sports Medicine, 2013; Barnes & Schoenborn, 2012). Physical inactivity is a particular problem among women; considerable evidence demonstrates that women engage in less overall PA than men (both self-reported and objectively assessed), and that fewer women achieve the recommended levels of PA, relative to men (Centers for Disease Control and Prevention, 2015; Hagströmer, Oja, & Sjöström, 2007; Troiano et al., 2008). This problem persists in the face of programs specifically designed to promote PA among women (Gary & Lee, 2007; Roussel et al., 2009; Rovniak, Hovell, Wojcik, Winett, & Martinez-Donate, 2005).

As such, there is a critical need for PA programs that better address the unique needs of women. For example, although most adults cite lack of time and lack of motivation as key barriers to PA (Booth, Owen, Bauman, Clavisi, & Leslie, 2000), women are more likely to cite lack of social support and other social influences (e.g. embarrassment) as obstacles to PA engagement (Cannioto, 2010; Reichert, Barros, Domingues, & Hallal, 2007). Group- and team-based programs are thought to facilitate beneficial social processes such as support and accountability (Wing, Tate, Gorin, Raynor, & Fava, 2006), but few (if any), interventions specifically focus on these processes as drivers of PA motivation and engagement. Ideally, new and/or improved programs for women will combine evidence-based behavioral approaches to promoting PA (e.g. self-monitoring, progressive goal setting, planning/time management; Greaves et al., 2011) with innovative methods of delivery and intervention, and will carefully consider ways to use social processes relevant to women’s PA.

Commercially available, wearable PA tracking technology (FitBit®, Jawbone®), which can connect users’ PA data to online social networks, has the potential to address the need for innovative methods of social facilitation for women (Arigo, Schumacher, Pinkasavage, & Butryn, 2015; Butryn, Arigo, Raggio, Colasanti, & Forman, in press). Yet this technology rarely has been tested as a core component of PA promotion programs, and it is not clear how to use wearable devices to maximize the effectiveness of evidence-based PA promotion techniques.

For instance, PA self-monitoring – which is the primary function of a wearable sensor – increases an individual’s awareness of her current PA level, and allows for realistic goal setting and recognition of goal achievement (Burke, Wang, & Sevick, 2011; Consolvo, Everitt, Smith, & Landay, 2006). Existing technology, such as pedometers, are cost-effective and easy to use for monitoring purposes, but have noteworthy limitations (e.g. recording only overall number of steps; Corder, Brage, & Ekelund, 2007; Valanou, Bamia, & Trichopoulou, 2006). Wearable sensors communicate PA intensity and timing, as well as total PA. Such features help users to identify times of the day when PA is most needed and plan for those times effectively. Data are summarized on the device itself, and are presented in interactive and visually appealing formats via web and mobile platforms (Ledger, 2014; Lewis, Lyons, Jarvis, & Baillargeon, 2015).

1.1. Social connectivity: PA-based contact between participants

Existing web platforms for managing the PA self-monitoring data collected with wearable technology often provide unique opportunities for social connectivity (i.e. facilitating social contact and a sense of connectedness among users). As noted, several wearable device platforms have built-in social networks that incorporate multiple social processes. First, public and private message boards allow users to communicate with each other directly, in order to share beneficial information, support and encouragement (Bunde, Suls, Martin, & Barnett, 2006; Nakhasi, Shen, Passarella, Appel, & Anderson, 2014). Second, these social networks allow users to share their objective PA data (as assessed by the device), ranked against that of other users. Sharing objective PA progress and rankings may facilitate communication and a sense of connection to others.
(Ledbetter et al., 2010), as well as increase accountability and positive pressure for behavior change (Consolvo et al., 2006; Munson, Krupka, Richardson, & Resnick, 2015; Nyer & Dellande, 2010).

PA data sharing – particularly sharing ranked PA progress from highest to lowest – also presents opportunities for social comparison, or evaluating oneself relative to others (Arigo, Suls, & Smyth, 2014; Festinger, 1954; Taylor, Vlaev, Maltby, Brown, & Wood, 2015). Comparisons to others who achieve greater PA success than the self (i.e. upward comparisons) may be perceived as motivating and inspiring, as these others can serve as role models for positive change (Arigo, Smyth, & Suls, 2015). Existing evidence suggests that such comparisons are particularly useful between women (Lockwood, 2006), and women with stronger interest in upward comparisons show greater increases in moderate-to-vigorous PA (MVPA) over four weeks (Arigo, Schumacher, Pinkasavage, & Butryn, 2015). Conversely, comparisons to others whose PA progress is less than one’s own (i.e. downward comparisons) may produce satisfaction with one’s own PA, and motivate the comparer to continue with PA efforts (Wills, 1981). Both upward and downward comparisons also may decrease motivation; however, comparing upward could highlight one’s inferior status, whereas comparing downward could indicate one’s own likely decline (Arigo, Schumacher et al., 2015; Arigo, Smyth, & Suls, 2015; Buunk & Ybema, 1997). At present, it is unclear specifically for whom and under what circumstances comparison may increase (vs. decrease) motivation for PA in the context of a partner-based intervention.

The benefits of these social processes are supported by evidence showing that more (vs. less) frequent interaction with online social networks is associated with better outcomes in the context of weight loss programs (Greene, Sacks, Piniewski, Kil, & Hahn, 2012; Turner-McGrievy & Tate, 2011). To date, however, this evidence is limited to the total number of initiated contacts (i.e. posts to a message board) and overall weight or PA change. These findings indicate a between-person effect – that participants who interact more overall do better. However, such findings do not indicate whether this relationship is due to pre-existing individual differences or to intervention effects. Demonstrating a time-sensitive relationship between PA-based-based social contact and objectively-assessed PA over time would provide stronger evidence for a within-person process – that participants do better when they have more frequent social interaction (Curran & Bauer, 2011). Such evidence would further support the notion that social contact is a uniquely beneficial component of PA promotion programs.

1.1.1. Assigning PA partners to maximize engagement

Although social accountability often is a primary motivator for enrollment in a formal PA program, engagement in both face-to-face interventions and health-based social networking shows dramatic decreases over time (Greene et al., 2012; Maher et al., 2014; Moroshko, Brennan, & O’Brien, 2011). Time constraints may prevent participants from receiving direct feedback or feelings of connectedness from clinical staff, and their sense of accountability may wane as a result. Creating dyads or “partnerships” between participants, and facilitating consistent communication and feedback between partners, could provide an added layer of accountability, engagement, and support (Arigo, Schumacher et al., 2015; Prestwich et al., 2012). Partnerships may be particularly useful when partners can view each others’ PA progress via online social networks that are connected to wearable technology. Progress is communicated directly (without relying on self-initiated disclosure), which could result in faster and more effective feedback (Munson et al., 2015). However, wearable device users can view their PA data without using the device’s social network, and there has been little systematic investigation of social networks that are connected to wearable device data. The lack of information about the benefits of
device-connected social networks has been identified as a key gap in the evidence base relevant to wearable devices (Lewis et al., 2015).

Combining the benefits of evidence-based PA-focused behavior change methods with the self-monitoring and social connectivity opportunities of social network-enabled wearable technology may produce greater effects than any of these components alone, and the development of such programs is a high priority (Butryn et al., in press). A small number of studies has pilot-tested this combination among women, using online and hybrid face-to-face/online delivery formats (Arigo, Schumacher et al., 2015; Butryn et al., in press), with noteworthy effects. However, it is not yet clear how best to incorporate wearable technology and its social connectivity components with evidence-based PA promotion techniques, and there is particular need to examine the within-person dynamics of components such as social connectivity (Hyde, Conroy, Pincus, & Ram, 2011).

1.2. Aims of the present study

The goals of the present study were to determine the feasibility, acceptability, and preliminary effectiveness of an online PA program. Novel features of this program were (1) the use of wearable technology with an associated online social network, and (2) the assignment of PA partners for added support and accountability. Weekly electronic assessments afforded the opportunity to explore time-varying associations between social connectivity and PA, which were of particular interest. Outcomes were the ability to meet our recruitment target in northeast Pennsylvania (USA), participant retention, compliance with daily device (sensor) wear, weekly survey completion, acceptability ratings, and measures of program effectiveness (i.e. changes in PA, percent of days meeting PA levels recommended by the American College of Sports Medicine (2013), and change in proposed process measures).

2. Method

2.1. Participants

Women aged 25 or older were recruited for a partner-based PA program via print and online advertisement. Women interested in increasing their PA were eligible if they were fluent in English; free from medical contraindications for PA (assessed via interview and using the Physical Activity Readiness Questionnaire (PAR-Q); Thomas, Reading, & Shephard, 1992); currently engaging in less than 30 minutes of MVPA per week and low lifestyle PA (self-reported via telephone in minutes per week and low/moderate/high, respectively); not currently enrolled in a separate weight loss or PA program and not currently using a wearable PA sensor; and able and willing to use the internet to track PA and communicate with other participants. Participants were informed that their commitment to the program involved reading and posting to a group message board at least once per week, and communicating with a partner (frequency to be determined by each partner dyad).

As access to the full sensor-connected online social network is available only on the web platform, screening involved confirming that participants’ internet access was not limited to their smartphones. Participants were invited to use the web platform at work, at home, or both, depending on their preference. Two potential participants expressed interest in also using the mobile platform to track their PA; these participants agreed to use the web platform for group communication and were provided with a brief overview of the sensor’s mobile application.

The target for recruitment was set at 20 participants. A total of 42 women responded to study advertisements over three weeks. Eleven of these women were excluded for engagement in MVPA that exceeded 30 minutes per week. Four additional women expressed interest but did
not respond to return phone calls; two scheduled initial assessments but did not attend; and three declined to participate after receiving a thorough overview of the study. One participant enrolled but withdrew before the formal start of the program, due to injury. The final sample was primarily Caucasian (95%), reflecting the demographic profile of the local area (U.S. Census Bureau, 2015). Eighteen of the 20 participants (90%) were affiliated with the sponsoring institution (e.g., faculty, staff). The average participant was 50 years old (SD = 7.2) with a BMI of 30.9 kg/m² (SD = 8.9). Half of the participants were married (50%), and the majority had a bachelor’s degree or higher (70%). Two participants had previously used a pedometer to track steps per day; one of these women continued to use her pedometer (in addition to the wrist-worn sensor) as required by her health insurance. Two additional participants reported existing blood pressure concerns, though both acknowledged that their physicians had encouraged them to engage in light to moderate exercise.

2.2. **Treatment components**

2.2.1. **Skills session**

As described below, participants received and practiced with FitBit® Flex™ device prior to the program start date. The program began with a 90-minute, face-to-face group meeting, held on the campus of the supporting institution at a specified day and time (n attended = 14). All partner dyads attended this session at the same time; for those dyads who could not make the scheduled session, an alternative small group session was scheduled for the following day (n attended = 6). This session was designed to introduce behavioral and cognitive skills for increasing PA. Behavioral skills included progressive goal setting and time management (Brownell, 2000); cognitive skills included challenging negative self-talk, as well as acceptance-based techniques such as values clarity and willingness (Butryn, Forman, Hoffman, Shaw, & Juarascio, 2011).

During this session, participants set daily step and/or weekly MVPA goals for the first two weeks of the program. Goals were based on their starting PA levels (to prevent increasing too quickly) and overall goal (suggested as 10,000 steps per day). An example progression can be found in Figure 1; participants received feedback from their partner and the program director in order to ensure that goals were challenging but reasonable. Participants were encouraged to

| Week | Steps per Day | Minutes of Moderate-to-Vigorous PA |
|------|--------------|----------------------------------|
| 1    | < 2,000      | 10 per day 2 days                |
| 2    | 2,000        | 10 per day 3 days                |
| 3    | 4,000        | 15 per day 3 days                |
| 4    | 6,000        | 15 per day 3 days                |
| 5    | 8,000        | 20 per day 3 days                |
| 6    | 10,000       | 20 per day 4 days                |

Figure 1. Example exercise progression over six weeks (provided to participants).
schedule time each weekend to review their progress for the week and set their goal(s) for the following week, according to SMART criteria (Locke, 1999). The remainder of the session was devoted to facilitating communication between partners. Participants were introduced to effective communication techniques (Linehan, 1993) and were guided to set appointment times and methods (e.g. text message, email) for checking in with their partners. (Additional information about this session can be found in Arigo, Schumacher et al., 2015.)

2.2.2. Online social networking

Program staff created a private group on the FitBit® system, which allowed users with permission to join a closed online forum. This forum, called the Community Board, included two key features of social connectivity. First was a message board for communicating with the group. At the start of each week in the current program, topic threads were posted by the program director, encouraging participants to describe their use of skills, share their PA accomplishments, and plan for the following week. Participants were asked to respond at least once per week, and additional posts were encouraged; participants also were encouraged to read the board as needed for support, reinforcement, or inspiration. The number of posts per participant (per week) was recorded by research staff, who also monitored responses to verify a positive and welcoming tone. The number of views was assessed via self-report in weekly surveys.

Second, a Leaderboard displayed each member’s PA progress (based on FitBit® data), ranked from highest to lowest. All program participants and the program director were able to view other participants’ progress. No other FitBit® users were able to access this group or the Leaderboard, and participants were asked to limit their FitBit®-based social networking to only other program participants for the duration of the study. Participants were introduced to this feature during their initial interview, and were provided with guidance for using this information (and associated social comparisons) to their benefit.

2.2.3. PA partner

Partner assignment by research staff maximized similarity between partners by accounting for: (1) starting level of PA (as assessed by the FitBit® Flex™ device), (2) age, and (3) affiliation with the supporting institution (faculty, staff, or no affiliation). These characteristics were selected based on existing evidence to suggest their importance for enhancing aspects of social connectivity (Buunk & Ybema, 1997; Darr & Kurtzberg, 2000; McPherson, Smith-Lovin, & Cook, 2001), as well as participant feedback from a previous version of the program (Arigo, Schumacher et al., 2015). Starting levels of PA were viewed electronically on the FitBit® website; participants were ranked by the site according to average number of steps per day and minutes of MVPA during the baseline period. Those who were most similar in average PA levels were then compared on the aforementioned demographic indicators; participants who were most similar in each of these domains were paired as partners.

Partner dyads were introduced at the start of the initial skills session; 16/20 participants knew at least one other participant (e.g. from campus events), most participants had minimal familiarity with their partner. (Four participants worked for the same campus division and thus had greater familiarity with one another.) During the session, participants were guided through practicing effective communication skills and establishing a schedule of regular contact. Participants were encouraged to contact their partners at least twice per week, in order to communicate goals at the start of the week and check on progress later in the week. The majority of dyads (8/10) scheduled communication to occur twice per week; one dyad scheduled contact on three days per week, and the final dyad agreed on one scheduled communication per week. All participants indicated
that they would initiate additional contact as needed (e.g. if they felt unmotivated for PA or wanted suggestions for new PA options). Dyads also established their method(s) of contact based on mutual preferences. Exercising together (e.g. brisk walking during lunch breaks) was suggested as a potential method of support and contact, though several dyads anticipated difficulty with coordinating their schedules.

2.3. **Self-report measures**

2.3.1. **PA acceptance (baseline and end-of-treatment)**

The PA Acceptance Questionnaire (Butryn et al., 2015) is a 10-item scale that assesses respondents’ ability to tolerate negative thoughts and feelings associated with exercise. Items such as “Even if I have the desire to stop while I am exercising, I can still follow my exercise plan” are rated on a scale of 1 (never true) to 7 (always true). This measure previously has demonstrated high internal consistency (0.89) and one-week test–retest reliability (0.83), and has shown both concurrent and predictive validity for objectively assessed PA. In the present study, Cronbach’s alpha was equal to 0.86.

2.3.2. **Barriers to PA – social support (baseline and EOT)**

The Barriers to Being Active questionnaire includes three items that assess lack of social support for PA (e.g. “None of my family members or friends like to do anything active, so I don’t have a chance to exercise;” Centers for Disease Control and Prevention, 2011). Items on this scale are rated from 0 (very unlikely) to 3 (very likely), with higher scores indicating that lack of social support is perceived as a greater barrier to PA. Cronbach’s alpha in the present study was 0.82.

2.3.3. **Social comparison orientation (baseline and EOT)**

The Iowa-Netherlands Comparison Orientation Measure (INCOM) uses a 23-item scale to quantify the respondent’s tendency to compare herself to others. Items are rated on a scale of 1 (strongly disagree) to 5 (strongly agree), and include “I always pay a lot of attention to how I do things compared with how others do things.” This measure has shown adequate internal consistency and validity across various samples; the observed test–retest reliability of 0.60–0.70 allows the INCOM to capture change in comparison orientation over time (Gibbons & Buunk, 1999), Cronbach’s alpha in the present sample was 0.78 for overall comparison orientation (11 items), 0.92 for upward orientation (6 items), and 0.71 for downward orientation (6 items).

2.3.4. **PA goals and program-based communication (weekly)**

Participants completed an electronic survey at the end of each week. These surveys were implemented to assess PA progress and social contact as they unfolded over the course of the program, which limited problems with retrospective recall (Smyth & Stone, 2003), and allowed program staff to address any communication problems (e.g. participants not responding to contact from their partner, which happened only twice). Participants reported their goal for the previous week (in steps and/or minutes of MVPA) and the number of times that they viewed the Community Board that week; they also reported number of times they communicated with their partner and topics they may have discussed. Topics were rated on a three-point scale from not at all helpful to very helpful; participants also had the option of selecting “not applicable” if a certain topic was not discussed that week. Topics discussed included sharing ideas
about how to build in extra PA, encouraging/motivating each other to be active, and supporting each other during a lapse in PA. Participants also noted other features of their communication and whether they exercised together that week, and how helpful they found these activities. This measure included 10 items.

2.3.5. **Treatment acceptability (EOT)**

Participants rated the program in terms of its effectiveness, as well as their level of satisfaction and confidence in their ability to maintain PA gains (from 1/not at all to 5/very much; Arigo, Schumacher et al., 2015). Additional items assessed features of FitBit® used during the program, whether partner communication met their expectations, participants’ perceived “best aspects” of the program, and recommendations for program improvements. This measure included six items.

2.4. **PA tracking**

PA was assessed throughout the day using the FitBit® Flex™, worn on the wrist. This device measures several aspects of PA, including steps per day, time spent sedentary, and the intensity of PA (light, moderate, or vigorous). Participants were asked to wear the devices during all waking hours, other than showering, swimming, or other activities that would involve submerging the device in water. Participants were notified that the device could be used to track their sleep, and were invited to use this feature if they had interest. As sleep outcomes were not a priority for the present study, participants did not receive instruction in the use of this feature.

Data are transmitted to the user’s web and mobile profiles, and PA data can be exported from the web platform as Excel files. The FitBit® system has demonstrated reliability and validity in comparison to other PA assessment methods (Adam Noah, Spierer, Gu, & Bronner, 2013; Gusmer, Bosch, Watkins, Ostrem, & Dengel, 2014; Montgomery-Downs, Insana, & Bond, 2012; Vooijs et al., 2014). Daily wear (determined by an objective record of >100 steps in a day; see Bassett, Wyatt, Thompson, Peters, & Hill, 2010), step counts, and minutes of MVPA were of interest in the present study. MVPA was calculated by summing minutes of moderate and vigorous. Of note, FitBit®’s method for calculating MVPA changed just before the start of the program, counting only MVPA that occurred in bouts of at least 10 minutes. Therefore, in comparison to previous studies that used FitBit® to record MVPA (Arigo, Schumacher et al., 2015), the threshold for achieving MVPA was higher in this study.2

2.5. **Procedures**

All procedures were approved by the Institutional Review Board at a small university in northeast Pennsylvania (USA). Interested individuals were instructed to contact the research center to complete a screening interview by telephone. Those who were eligible were scheduled for an individual, face-to-face interview with the program director, which began with written consent procedures. Weight and height were assessed with a Health o Meter® balance-beam scale and stadiometer.

The remainder of the meeting focused on providing additional details about the program and training in the use of the FitBit® Flex™ device, web platform, and Community Board. Participants were introduced to the FitBit® Dashboard as a method for checking their daily PA totals, and were encouraged to sync their devices and check progress at least twice per day: once in the afternoon (to determine the number of steps or MVPA minutes left to reach their goals), and once before bed (to assess goal attainment). The FitBit® weekly email notifications feature was turned off in order to encourage more active engagement with the platform during the short program period. As
noted, two participants expressed interest in the mobile application and used this at their discretion, in addition to the web platform. All participants then engaged in a baseline period of FitBit® wear, with an average length of 8.2 days (SD = 6.3), and these data were used to match partners based on starting PA level.

Participants then attended the face-to-face skills session with their partner and other group members to review behavioral and cognitive skills for increasing PA. At the end of each week, participants received emailed instructions to complete the weekly survey. In the week following the sixth week of the program, participants completed a longer survey (including questions about treatment acceptability) and engaged in a face-to-face exit interview. Participants received a $10 Starbucks gift card as compensation for their time.

2.6. Data analysis

Descriptive statistics (i.e. frequencies, percentages, and average ratings) were used to determine recruitment and retention outcomes, daily sensor wear, weekly survey completion, and treatment acceptability. Effectiveness was determined in two ways. For PA outcomes, a multilevel modeling (MLM) approach was used to calculate change in steps and minutes of MVPA per day. This technique is designed for the analysis of longitudinal data with repeated measurements, and is superior to ordinary least-squares methods in its treatment of nested data structures and missing data (Hox, 2010; Quené & Van den Bergh, 2004).

As participants were encouraged to set weekly goals at the start of each week of the program (and as no other variables were assessed at the day level), models estimated PA at the week level; these models produce more accurate PA estimates than simply averaging daily PA within a given week (Jones, Riley, Williamson, & Whitehead, 2009). Analyses for the present study employed SAS PROC MIXED (SAS Institute, 2014) with restricted maximum likelihood estimation to summarize daily PA assessments (M = 54 per participant), nested within program weeks, nested within participants. MLM also was used to determine time-varying relations between program-related social contact and PA at the week level; these predictors were person-mean centered for ease of interpretation. Given that MLM maximizes the power of within-person assessment, significance level for these tests was set at p < .05. In contrast, cognitive and social processes related to PA and program participation were assessed only at baseline and end-of-treatment (EOT), and paired t-tests were used to assess change in these processes during the program. Finally, relationships between baseline social experiences and overall social contact during the program were evaluated with bivariate Pearson correlations. Effect sizes, rather than p-values, were of interest for both t-tests and correlations.

3. Results

3.1. Feasibility

3.1.1. Recruitment, retention, and FitBit® wear

A total of 42 women responded to study advertisements over three weeks. Eleven of these women were excluded for reporting high engagement in PA. Five additional women expressed interest but did not respond to return phone calls; two scheduled initial assessments but did not attend; and three declined to participate after receiving a thorough overview of the study. One participant enrolled but withdrew before the formal start of the program, due to injury. Recruitment thus met the pre-identified target of 20 women, and participant retention over six weeks was 100%. FitBit® adherence was high, with participants wearing their trackers on 97% of days, on average (range 80–100%).
3.1.2. Survey completion and social contact

Approximately 50% of the sample completed each survey within 24 hours of email notification; an additional 40% completed within 48 hours, and the remaining 10% completed within 72 hours (after email reminders from research staff). Of the 120 weekly surveys sent (20 participants × 6 weeks), only two were missed (i.e. not completed within 72 hours of initial notification), for an overall completion rate of 98%. Responses to these surveys indicated that self-reported viewing of the Community Board and partner communication occurred approximately twice per week ($M = 2.48$ and $M = 2.09$, respectively). Between-participant frequencies ranged from 0 to 10 views and from 0 to 10 partner contacts per week. Across weeks, two participants reported 0 Community Board views (in different weeks), and two participants reported 0 partner contacts (one dyad failed to make contact in a single week). Participants indicated that email was their most frequent method of partner communication (8/20), followed by instant message (6/20), phone calls (4/20), and in-person conversations (4/20).

Records of posts to the group Community Board showed that posting occurred approximately once per week ($M = 1.03$). Of note, 3/20 participants did not post on the Community Board at all, and 5/20 posted <50% of program weeks (as assessed by research staff). Frequency of Community Board viewing and posting were modestly related to social comparison orientation at baseline, such that stronger interest in comparisons predicted more frequent viewing ($r = 0.24$), but less frequent posting ($r = -0.21$; $p = .31$). Baseline ratings of lack of social support as a barrier to PA also were modestly associated with more frequent viewing ($r = 0.21$; $p = .39$), but were unrelated to posting frequency ($r = -0.05$; $p = .83$).

Participants’ weekly survey responses also showed that the nature of partner communication occurred as intended. In weekly surveys, motivating each other to increase PA was the most frequent feature of partner communication (reported in 73% of surveys), followed by sharing ideas for increasing PA and supporting each other through a lapse in PA (both in 56% of surveys). Exercising together (in person) was reported in 40% of surveys. Motivating each other was most frequently cited as “very helpful” (vs. “somewhat” or “not at all” helpful; 47% of surveys). Overall, ratings of any of these features as “not at all helpful” occurred in 39% of surveys. At EOT, half of the participants (10/20) listed social aspects of the program, including the Community Board and/or partner pairing, as key benefits.

3.2. Acceptability

As shown in Table 1, treatment acceptability was rated as high. Participants rated the program as effective ($M = 3.85$ of 5, $SD = 1.04$), and reported both satisfaction with the program’s approach ($M = 3.79$ of 5, $SD = 1.18$) and confidence in their ability to maintain PA gains ($M = 3.85$ of 5, $SD = 0.75$). Of note, the number of participants who selected “not at all” in response to these items was 0. All participants also indicated that they would recommend the program to other women ($M = 3.5$ of 4, $SD = 0.76$). Five participants stated that they liked the program as delivered and had no suggestions for change. Among the other participants, suggestions for improvements primarily focused on increasing the amount of program-related social contact—either face-to-face, on the Community Board, or between partners (total = 13/20). Eleven participants indicated that partner communication occurred less frequently than they wanted, whereas the remaining nine indicated that the frequency was “just right”. Those who consistently posted on the Community Board (i.e. 12/20) expressed a specific desire to see more members post, as well as more interactive discussion.

In addition, 11 of the 20 participants named the awareness and/or accountability provided by the FitBit® device as a key benefit of the program. Three participants had purchased FitBit® devices (the Flex™ or Charge™) by the time of their EOT interviews, and 10 additional
participants stated an intention to do so (total = 13/20). A small subset of participants had purchased or intended to purchase a different type of activity tracker (e.g. the Misfit Flash; 5/20); only two participants stated that they had no interest in continuing to use an activity tracker. During exit interviews, 16/20 participants mentioned the hectic nature of an academic schedule (and the timing of the program, during the last six weeks of a semester) as challenging for maintaining PA gains. Many of these participants indicated that their partner (15/20), the group (10/20), and the FitBit® (7/20) helped them stay on track.

3.3. Preliminary effectiveness

Participants showed a large increase in steps per day, from 3796 (SE = 478) during their baseline period to 8190 (SE = 516) during the last week of the program (week six). MVPA also increased from 12.68 (SE = 3.15) minutes per day at baseline to 24.05 (SE = 3.48) per day during the final week. Across participants, the average number of days that steps reached the recommended 10,000 was 17 (range 0–39, of 45 study days), and the number of days that MVPA minutes reached 30 was 16 (range 2–43; American College of Sports Medicine, 2013). Weekly averages for daily steps and MVPA can be found in Table 1. With respect to social connectivity, the frequency of reported partner communication and viewing of the Community Board, as well as staff-recorded number of posts per week, showed no between-person relationships with steps per day and minutes of MVPA (ps > .10). Thus, participants who engaged in a higher total number of contacts with other program members did not show higher PA overall.

However, controlling for individuals’ between-person (i.e. average) frequency of social contact, there were specific, positive relationships between weekly within-person variability in social contact and PA. Steps per day were higher than average during weeks when Community Board viewing and posting both were higher than a participant’s average (ps < .03; see Table 2). B-values for these tests indicated that viewing and posting to the Community Board one extra time per week was associated with 283 and 669 additional steps per day, respectively. MVPA also was higher during weeks when partner communication and Community Board viewing were more frequent than a participant’s average (ps < .04); increases in partner communication and viewing by one time per week were associated with 2.17 and 2.14 additional minutes of MVPA per day, respectively. Thus, Community Board viewing was associated with increases

| Steps per day | Minutes of MVPA |
|--------------|-----------------|
| Estimate (SE) | Estimate (SE)   |
| Baseline     | 3797 (478)      | 12.68 (3.15)   |
| Week 1       | 5533 (518)      | 17.47 (3.47)   |
| Week 2       | 7941 (518)      | 18.89 (3.40)   |
| Week 3       | 8878 (517)      | 25.39 (3.45)   |
| Week 4       | 8731 (520)      | 24.18 (3.48)   |
| Week 5       | 7822 (519)      | 22.89 (3.47)   |
| Week 6       | 8190 (516)      | 24.05 (3.48)   |

Notes: MVPA, moderate-to-vigorous PA; SE, standard error.
in both steps and minutes of MVPA per day; Community Board posting was associated with increases in steps per day (but not MVPA; \( p = .90 \)), and partner communication was associated with increases in MVPA (but not steps per day; \( p = .13 \)).

As expected, participants’ PA-related cognitive and social experiences also improved during the program. From baseline to EOT, participants showed both a meaningful increase in PA acceptance (\( t[19] = 2.74, d = 0.63 \)) and a meaningful decrease in lack of skills as a barrier to PA (\( t[19] = -2.85, d = 0.67; \) \( ps = .01 \)). Importantly, perceived lack of social support as a barrier to PA decreased during the program (\( t[19] = -3.58, d = 0.87, p = .003 \)). Overall tendency to compare oneself with others (\( t[19] = -2.85, d = 0.64; \) \( p = .01 \)) also decreased, though specific interest in upward and downward social comparisons did not change (\( ds = 0.07 \) and \( 0.08, ps > .75 \)).

4. Discussion

The combination of evidence-based behavior change skills and wearable PA tracking technology may be able to address the existing need for cost-effective, disseminable, and scalable PA
promotion programs for women. To date, however, limited evidence exists to indicate how best to present and deliver these components to the target audience (Arigo, Schumacher et al., 2015; Butryn et al., in press; Maher et al., 2014). Results from the present study further support the feasibility and desirability of a program that combines these components using one face-to-face meeting and regular online communication. We were able to meet our recruitment target in three weeks and retain all participants for the following seven weeks (including one-week post-intervention), with very high device wear compliance and the expected level of partner communication. A large proportion of participants had purchased or intended to purchase a wearable device for personal use after returning the program device (80%); this interest highlights the potential for longer term behavior change via introducing wearable technology to novice users.

Findings also demonstrate the high acceptability of this approach, and suggest the unique potential of partner pairings. Disengagement with intervention programs, technology use, and online social networking is common (Greene et al., 2012; Moroshko et al., 2011); as such, an open online forum might not maximize accountability, as no one is “responsible” for each others’ progress. Assigning partners creates an additional mechanism for accountability, as well as for support and direct feedback. Indeed, participants rated these features of partner assignment as occurring frequently and as particularly beneficial, and this study is one of the first to show positive, within-person relations between program-based social interaction and PA. An additional social contact was associated with 300–700 more steps per day and with 2.15 extra minutes of MVPA per day, or an additional 5–7% of recommended daily PA levels (American College of Sports Medicine, 2013). Additional research is needed to determine the optimal timing and nature of social contact.

It is noteworthy that only viewing the Community Board was associated with increases in both steps and minutes of MVPA per day. In contrast, partner communication was associated only with minutes of MVPA, and posting to the Community Board was associated only with steps. Viewing the Community Board offered opportunities for reading others’ descriptions of successes and struggles (on the message board) as well as observing Leaderboard progress, facilitating a variety of social processes (e.g. support, comparison). It is possible that the social opportunities of viewing had broad impact, whereas sharing one’s individual PA experiences and barriers (with partners or the group) has salutary effects for one type of activity versus another. For example, partner communication may have helped participants to schedule future MVPA sessions (e.g. a gym visit or brisk walk), but scheduling steps may have been more difficult. Participants also were not asked to report on their specific social comparisons in weekly surveys, thus limiting conclusions about this aspect of social contact, and it is critical to note that the social-PA associations observed in this study do not indicate causal relationships. Clarifying relations between unique social processes and PA parameters, as well as the temporal sequencing of these experiences, are primary goals for future work in this area.

With respect to effectiveness, participants began the present study at a low level of lifestyle PA and MVPA, and increased to just below American College of Sports Medicine recommendations in six weeks (American College of Sports Medicine, 2013). Interestingly, participants’ average levels of PA seemed to peak during the third week, and were fairly stable (with slight decline in the fifth week) thereafter. Given that participants were sedentary at baseline and participated for only six weeks, PA variability and lapses were expected (Brownell, 2000), and it is noteworthy that PA increased again by the final week of the program. As described above, the timing of the program may have further contributed to inconsistency.3

A key strength of this study is the employment of MLM techniques to maximize the power of daily PA assessment, rather than averaging daily observations to create weekly estimates. Although such aggregation is a common approach to summarizing PA data, this approach results in losing a great deal of information about variability and change. MLM also addresses
the inherent correlations between repeated assessments and flexibly addresses missing data, generating more accurate estimates of PA change (vs. aggregation techniques; Jones et al., 2009). Change in relevant cognitive and social processes from baseline to EOT also suggests that the program affected proposed mechanisms of action. A necessary next step is to test formal mediation of effects on PA via cognitive and social processes, using similar multilevel techniques.

4.1. Limitations and additional future directions
As are many feasibility studies, this study was limited by a small sample size, a single-group design, and a short intervention/follow-up period. Although FitBit® shows convergent validity with other PA assessment methods, this and other wristworn sensors do not represent the gold standard of PA assessment, and there currently is no accepted standard for determining device “wear time”. In future work that uses daily or weekly PA variability, an optimal approach may be to verify FitBit® assessments with waistband accelerometers at the start of the study (using the accepted accelerometer wear time standard of >10 hours per day; Tudor-Locke, Johnson, & Katzmarzyk, 2011). There also was considerable variability between participants in the length of baseline PA observation, which may have affected partner pairings. The present findings thus provide only preliminary indication that the selected approach is effective; additional work using larger samples, randomized designs, and long-term follow-up is needed to determine whether this approach outperforms existing intervention packages. A larger sample size also would allow for the examination of partnership effects (e.g. whether certain dyads did better than others, whether partners became more similar to one another over time). The observed effects do, however, suggest that such work is warranted.

In addition, this study did not focus on differentiating the effects of wearing the FitBit® device (i.e. wireless self-monitoring) from connecting with other FitBit® users (i.e. social connectivity); rather, the device was presented as a tool for both purposes, with emphasis on the latter. Quantifying the independent contributions of these features (using additive or factorial designs), especially over the long-term, will inform the design and improvement of PA promotion programs. Further, this study focused on a limited range of wearable device features and social connectivity mechanisms. The FitBit® and other sensor systems offer myriad functions not tested in this study, including sleep tracking, food logging, weight monitoring, public discussion forums, and competitive “challenges” between users. Given that users have differing preferences and needs, the optimal combination of device functions likely differs across users (e.g. based on specific health concerns and/or communication styles; Heron & Smyth, 2010). Indeed, a key advantage of technological advances in health monitoring is the adaptability of the device to individuals’ needs (Newman, Przeworski, Consoli, & Taylor, 2014). Large randomized, controlled trials provide strong evidence to support efficacy of a treatment package. Yet the ability to individually tailor treatment using wearable devices points to the need for innovative research designs that test these devices (and specific device features) for individual benefit (Heron & Smyth, 2010; Lewis et al., 2015).

Importantly, participants in the present study were overwhelmingly Caucasian and well educated. Although this demographic profile is representative of the local area, there is need to replicate these findings in other groups. In particular, determining feasibility, acceptability, and effectiveness in groups at unique risk for chronic illness (e.g. those who belong to particular ethnic groups, who show premorbid illness profiles, and/or who are underserved based on socioeconomic status). The current study relied on local campus and community advertising during a short recruitment window. Reaching groups at risk for illness, and engaging them in long-term behavior change, would require a wider variety of recruitment and support methods. For instance, recruiting from healthcare clinics or community services (e.g. YMCA), and involving clinicians
familiar with the target population(s) throughout the process. Adjusting the current program to enable greater social contact via mobile platforms also may increase the potential reach of this approach.

As social support and norms for other social processes related to PA differ by culture (Biddle & Mutrie, 2007; Kriska, 2000), it is possible that matching participants based on cultural background may enhance the benefit of partnerships and group support. The role of cultural background will need to be tested as the intervention is evaluated in larger, more diverse samples. Although the partner assignment process was guided by social psychology theory and evidence, it is unclear whether the method and particular considerations of partner assignment are optimal for such a purpose. It is possible that other demographic or personal characteristics (such as cultural background) are equally or more important than those selected; future research in this area should focus on developing a standardized partner assignment process based on accumulating evidence to support the use of partners.

An additional possibility is allowing participants to sign up as partners or choose their own partners during the initial skills session. Because many overweight women cite embarrassment as a barrier to PA (Cannioto, 2010), and because lack of social support itself is a key obstacle for women, partner assignment is likely to be an attractive feature of this approach (vs. other available options). As this treatment was designed for women, it is yet unknown whether a similar approach may benefit men. In addition, this study focused on a limited number of psychological processes that were expected to relate to PA improvements. Several other relevant processes, such as self-efficacy for PA and outcome expectancies, should be assessed in future work.

The current study extends previous findings that show positive relations between social contact and health outcomes (Butryn et al., in press; Turner-McGrievy & Tate, 2011), and highlights a key opportunity for program improvement. More than half of the participants wanted more frequent partner contact and Community Board interaction, and a subset of participants in the present study offered little (if any) information on the Community Board. These findings are consistent with previous work that has attempted to facilitate PA-based online social contact (Arigo, Schumacher et al., 2015; Butryn et al., in press). In each case, participants desired more contact but seemed to have difficulty initiating. Thus, promoting partner and group communication is a consistent challenge for digital interventions, and remains an important area of emphasis for maximizing the potential of this approach (Greene et al., 2012; Lewis et al., 2015). One alternative technique is to rotate responsibility for post topics/initiation, which could increase engagement and accountability to the group and/or partners.

4.2. Conclusion

In summary, findings from the present study support the combination of evidence-based cognitive-behavioral skills, wearable technology, and online social networking for increasing PA among women. In particular, this study demonstrates that PA is highest during weeks when various aspects of social contact are most frequent, extending previous findings in this area. It is likely that the optimal implementation of the treatment package (in terms of frequency and nature of social contact) depends on the delivery setting and participants’ existing level of familiarity with one another. The ongoing examination of these factors will help to refine and optimize the use of wearable technology and social connectivity in PA promotion programs for women.

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Notes
1. During the initial interview, participants were asked whether they had ideas about the type of partner who might be helpful to them. This discussion was designed to introduce the importance of identifying and clearly communicating one’s goals and desired type(s) of support, rather than to inform pairings. Of note, six university-affiliated participants expressed desire for a partner who could appreciate time limitations as a key barrier to PA, given that the program was offered at the busiest time of the semester (i.e. the last six weeks of Spring 2015). As this was the case for all university-affiliated participants (and most noted time as a barrier in other areas of the discussion), it was considered addressed by matching on university affiliation.

2. PA was assessed using the wearable sensor (only) for several reasons. Given the study’s emphasis on weekly PA variability and within-week relations between PA and social contact, participants would have had to wear an additional device during all days of the study, which did not seem feasible. Also, compliance with the FitBit® was of interest, adding a device might have interfered with compliance. Finally, accumulating evidence suggests that FitBit® shows similar PA records to those of accelerometers and other devices; as the FitBit® is more clinically useful (i.e. FitBit® provides immediate feedback, whereas accelerometers do not), we chose to limit to this device, similar to methods for pedometer-based studies (cf. Chan, Ryan, & Tudor-Locke, 2004).

3. The timing of the program was intentional, and designed to provide PA assistance when participants would be most in need (vs. at times when they experienced fewer challenges).

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