A theory-driven intervention delivered by email to promote physical activity in women who are overweight or obese: Participants’ perspectives on acceptability and usability within the context of a three-arm parallel group randomized controlled trial

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Research Article

Keywords: behavior change, motivation, overweight, obese, physical activity, women, digital, randomized trial

Posted Date: October 20th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2139135/v1

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Title: A theory-driven intervention delivered by email to promote physical activity in women who are overweight or obese: Participants’ perspectives on acceptability and usability within the context of a three-arm parallel group randomized controlled trial

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Background: Insufficient physical activity and excess weight increase illness risk for women. Email-delivered interventions may be a solution for offering accessible, cost-effective, brief support to women to increase their engagement in physical activity. This study explored participants’ perspectives of the acceptability and usability of a theory-driven, email-delivered intervention coupled with a wearable activity monitor designed to promote physical activity in women who were insufficiently active and overweight/obese. Methods: In this three-arm parallel group randomized controlled trial (unblinded), participants allocated to the main intervention arm received a fully automated intervention consisting of: (a) six weekly emails, (b) a Polar A300 activity monitor (with access to the Polar website and companion smartphone application), and (c) a copy of the Canadian physical activity guidelines for adults (18-64 years). Email content, informed by self-determination theory, was designed to enhance autonomous motivation for physical activity through fostering perceptions of competence, autonomy, and relatedness by sharing motivational and behaviour change techniques to promote needs satisfaction. Post-intervention, participants completed an acceptability survey containing open- and closed-ended questions online. Descriptive and content analyses were performed for responses to closed- and open-ended questions, respectively. Results: Data from 14 women (age range=18-63 years, mean body mass index=31.3±5.8 kg/m²) who received the main intervention and completed the post-intervention survey were analyzed. Qualitative data indicated most were satisfied with the intervention and appreciated that emails prompted self-reflection, kept them on track and accountable, provided informational support, and were non-pressuring. Further, it suggested the monitor was “enjoyable” and “helpful;” quantitative data corroborated this as 71.4% said the monitor was “very valuable/absolutely valuable,” 71.7% would “very
probably/definitely” still use one, and 85.7% wore it ≥5 days/week for ≥8 hours/day and checked it “occasionally/frequently/very frequently.” However, potential threats to acceptability were noted, including “long” and “text-heavy” emails, lack of personal contact, and cumbersome, non-aesthetic monitors. **Conclusions:** Results suggest this self-determination theory-driven email-delivered intervention may be an acceptable low-contact approach to help promote physical activity in women who are overweight or obese and insufficiently active, although improvements are warranted and studies ascertaining its effectiveness are needed. Nonetheless, results may inform the development or refinement of similar interventions in other contexts. **Trial Registration:** This trial was registered at ClinicalTrials.gov (ID: NCT03601663, Date: July 26, 2018; [http://clinicaltrials.gov/ct2/show/NCT03601663](http://clinicaltrials.gov/ct2/show/NCT03601663)). **Keywords:** behavior change, motivation, overweight, obese, physical activity, women, digital, randomized trial
BACKGROUND

Regular participation in physical activity (PA), an important cornerstone of disease prevention, is considered beneficial for both physical and psychological health (1). The Canadian PA guidelines for adults aged 18-64 years (2) recommend engaging in at least 150 minutes of moderate-to-vigorous intensity PA (MVPA) per week. Despite the well-documented health benefits of PA (3, 4), general adherence to PA guidelines is modest (5). Indeed, the most recent Canadian Health Measures Survey (N=2,372; age range=18-79 years) revealed that less than 40% of adults were meeting the Canadian PA guidelines based on objectively-measured PA. Also, research in Canada (5) and around the world (6) indicates that women, especially those who are overweight or obese (i.e., body mass index (7) >25 kg/m$^2$), are less likely to adhere to PA guidelines than men (8), posing a significant threat to women’s long-term health. Whilst increasing women’s awareness of PA guidelines is important so they have a PA target in mind (i.e., the primary behavioural outcome), it is critical to provide women strategies to increase compliance because the existence of PA guidelines alone is insufficient to change PA behaviour (9). Indeed, helping women increase their PA behaviour requires consideration of key modifiable determining factors and selection of intervention strategies that will affect a change in the determinants.

Health behaviours determinants are articulated and explained in numerous individual-level theories and models (e.g., Health Belief Model (10), Theory of Planned Behaviour (11), Social Cognitive Theory (12), Transtheoretical Model (13)); in turn, they have been used to guide the development and evaluation of interventions intended to increase PA (and its determinants). Current research suggests that theory-informed (i.e., those vaguely describing theory use) and theory-driven (i.e., those integrating theory throughout intervention planning,
design, and evaluation; (14) interventions (henceforth collectively referred to as ‘theory-based) may be more effective at increasing PA than those that are not theory-based (15). Among existing theories and models, Self-Determination Theory (SDT; (16)) has been applied often in recent years, SDT-based interventions have shown superiority in increasing PA as compared to usual care (17, 18). SDT now has broad support for producing meaningful behaviour change in a variety of health settings, including improving weight management behaviours in women who are overweight or obese (19). Consistent with SDT, research shows motivation to engage in PA varies to the degree to which it is experienced as autonomous (or self-determined), with greater autonomous motivation associated with greater PA (20). Accordingly, the primary goal of SDT-informed or -driven interventions should be to foster autonomous motivation to promote behaviour change consistent with one’s personal values (20). Additionally, interventions should embed strategies to help enhance individuals’ perceptions of competence, autonomy, and relatedness to increase autonomous motivation while decreasing controlling sources of motivation.

Although evidence suggests PA behaviour change interventions (SDT-based) offered to women are effective in increasing PA levels (19, 21-23), developing and implementing such interventions requires an understanding of potential challenges that women face with respect to intervention participation. For instance, women have reported multiple and complex role demands and stressors (24) as well as barriers to PA (e.g., lack of time, motivation, family support, caregiving responsibilities, climate, and safety concerns (25, 26)) that can impair their ability to access and engage in behaviour change interventions (27). Thus, these barriers should be carefully considered and practical ways of promoting PA that are effective, efficient, and sustainable should be utilized. During the past decade, improvements in infrastructure have
allowed a greater number of adults to access to the Internet, providing a formidable solution to the barriers that women face and garnering growing interest in low-cost technology-based interventions to encourage PA (28, 29).

Technology-based approaches to promoting PA have included the use of mobile applications, wearable devices, computer software, social media, game-based methods (e.g., exergames, virtual reality games, active video games), e-mails, and websites to help end-users address or change PA behaviours, cognitions, and/or psychosocial states (28-30). Technology-based interventions have shown promising results for increasing PA in women who are overweight or obese (22, 31, 32) and may have the potential to transform healthcare delivery; however, the use of technology as an interventional tool can also present new challenges. For instance, participants (especially those who are less technologically-literate) may struggle to adjust to the applications/tools provided, infrastructure issues (e.g., unstable internet connectivity) may hinder participation, and limited/lack of in-person interaction may affect engagement in such interventions. Thus, there is a need to investigate the acceptability of technology-based interventions developed to increase PA; that is, researchers should evaluate the extent to which those receiving the intervention consider it to be appropriate, based on anticipated or experiential cognitive and emotional responses to the intervention (33). This is important because interventions that are unacceptable will either not be adopted, or, if adopted, they will not be implemented with fidelity and likely be ineffective. Indeed, guidelines for the design of interventions stipulate the need to consider the acceptability of interventions acceptability from the outset and suggest pretesting of the intervention in context prior to full-scale implementation (34). As well, recent frameworks for developing and evaluating complex
health interventions emphasize a need to focus on their initial development to ensure they attain desired change in real-world contexts (35).

The key to developing effective behaviour change interventions requires confirmation that target end-users consider it acceptable. Thus, this study evaluated participants’ perspectives of the acceptability and usability of a technology-based intervention driven by SDT that utilized wearable devices and emails to promote PA in women who were overweight or obese (i.e., Body Mass Index (BMI) $\geq 25 \text{ kg/m}^2$) and insufficiently active (i.e., not currently meeting Canadian PA guidelines for adults aged 18-64 years (2). Specifically, it aimed to understand participants’ perspectives regarding the wearable device and the weekly behaviour support emails, as well as their usage patterns for both. Participants in this study were a group of women who were part of a larger randomized controlled trial (RCT) addressing a different objective (i.e., to determine if adding behavioural support emails to a wearable activity tracker intervention can further increase PA levels in women who are overweight or obese in comparison to a wearable activity tracker–only intervention and a control condition) (7). Results corresponding to the effect of the SDT-driven, email-delivered intervention (i.e., the main intervention of interest) on the primary outcome measure of PA are reported elsewhere (7).

On the basis of evidence that self-monitoring (often conducted using technology) is correlated with PA behaviour change (36), participants randomized to the main intervention of interest received and were encouraged to use a wearable activity tracker to self-monitor the frequency and intensity of their PA behaviours towards daily or longer-term goals (e.g., walking a certain distance over time). In addition, participants received a paper copy and verbal explanation of the Canadian PA guidelines for adults to establish a target for their behaviour change. Finally, previous research has shown links between SDT constructs and behaviour
change (20, 37) and several motivational and behaviour change techniques (38). Thus, participants received weekly non-tailored emails (i.e., the same content was provided to all participants, though emails were addressed to participants and participants could tailor the content (2)). Designed to target SDT constructs (as described below), the goal was to promote perceptions of competence, autonomy, and relatedness (i.e., the basic psychological needs) and to place emphasis on developing autonomous motivation for PA. Motivational and behaviour change techniques, selected on the basis of previous research and their relation to SDT (39-42), were shared with participants to: (a) share information (e.g., basic information about the multiple health benefits of regular PA on physical and mental health and to reduce the risk of chronic disease; guidelines for PA), (b) offer feedback/advice (e.g., practical advice for starting and maintaining a regular PA schedule with daily walking suggested as an activity; suggestions for how to best form PA habits and restructure the environment to aid), (c) encourage self-monitoring by teaching ways to track PA behaviour and experiences (e.g., journal activities, reflections, monitoring with wearable activity tracker), (d) promote goal setting (e.g., support to develop personally meaningful and important goals for PA that are specific, measurable, achievable, relevant, and time bound; encouragement to form action plans and coping plans), (e) foster social support (e.g., self-identify sources of support and elicit support from such sources), (f) support self-reward (e.g., self-identify recompenses to obtain upon reaching their goals for PA), and (g) enhance enjoyment (e.g., self-reflect on experiences, increase awareness of how thoughts and feelings can lead to inactivity, and thus consider enjoyable activities).

**METHODS**

**Study Design**
This study explored the acceptability of a theory-driven, email-delivered intervention within the context of a larger, single centre, unblinded, three-arm parallel group RCT; the effects of the intervention were compared to a very low-contact intervention (i.e., wearable activity tracker only) and a control condition to promote PA in women who were overweight or obese and insufficiently active (see Table 1 for an overview of the three arms, and (7) for further description). Specifically, the objectives of the larger trial were to: (a) assess changes in PA within each group and determine if there were significant differences in changes in PA between groups, and (b) explore changes in PA-related basic psychological needs satisfaction and motivational regulations within and between groups to gain more insight into any observed changes (or lack thereof) in PA. As reported by Black and Brunet (7), women randomized to the main intervention reported a significant increase in walking and in perceptions of competence and relatedness, though not in moderate-to-vigorous intensity PA, nor in perceptions of autonomy and motivation. Participants’ responses could have been influenced by their subjective perceptions of the intervention, as well as their measurable sustained engagement with the intervention. Thus, to gain insights into which aspects were preferred by participants and which may have limited their motivation to engage with it, participants’ acceptability of the intervention and usability of its components were assessed retrospectively (i.e., after they engaged with it) to determine if the intervention content and/or mode of delivered require refinement(s) and/or revision(s). The results reported herein are presented in accordance with the Consolidated Standards of Reporting Trials (CONSORT) 2010 statement (43) and the CONSORT guidelines for e-health interventions (44).

Table 1. Overview of study arms.

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Features</th>
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<tbody>
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</table>
Weekly behavioural support emails  | Wearable activity tracker with access to Polar website and companion smartphone application | Basic education on the Canadian PA guidelines
---|---|---
**Arm 1: Main intervention**  | Yes  | Yes  | Yes
**Arm 2: Low-contact intervention**  | No  | Yes  | Yes
**Arm 3: Control condition**  | No  | No  | Yes

*Note. See (7) for further description of each arm.*

### Sampling and Recruitment

As previously outlined (7), the sample size for the trial was determined a priori based on the primary objective (i.e., to determine whether there were significant within-group changes in PA and significant between-group differences in change in PA). As the objective of the current study was to explore participants’ acceptability of a theory-driven, email-delivered intervention, only those assigned to the main intervention arm were included herein.

Participants were recruited for the larger trial via convenience sampling online using social media (i.e., Facebook) and online boards (i.e., Kijiji, Craigslist, local classifieds), and offline using posters in publicly accessible areas (i.e., community centers, physician’s offices).

The inclusion criteria were: (a) self-identify as female, (b) age between 18 and 65 years, (c) BMI \( \geq 25 \text{ kg/m}^2 \), (d) able to read and write in English, (e) report engaging in <150 minutes of MVPA and strength or resistance training (e.g., free weights, weight machines, resistance bands, exercises using body weight) <2 times per week, (f) have access to the Internet and an active email account, and (g) living <50 km of the University of Ottawa. Of note, computer/Internet literacy was assumed (and training was provided on Polar website and companion smartphone application by MB at baseline). Exclusion criteria were: (a) be pregnant or lactating, (b) answer ‘yes’ to the question, “*do you have any health concerns that could prevent you from safely engaging in physical activity?*”, and (c) currently use or have used a wearable activity tracking device in the past 12 months.

### Procedures
Black and Brunet (45) described the protocol for the larger trial in detail. In short, a rolling recruitment strategy was used wherein each person who contacted MB began their flow through the trial procedures. MB first provided study information and assessed interested persons for eligibility. Once eligibility criteria were confirmed, persons were sent an email that included a link to access an online survey platform (i.e., SurveyMonkey). Upon accessing the platform, persons were required to read a consent form and digitally sign it, after which they were redirected to complete self-reported measures. Participants then attended a meeting with MB at a convenient location (e.g., participants’ homes, university premises) to complete objective measures (i.e., anthropometrics). Once baseline (i.e., pre-randomization assessment; week 0) self-report and objective measures were completed, participants were randomized to one of three arms. Those randomized to the main intervention arm received the first weekly email one day following their baseline meeting with MB. Subsequent emails were sent to them at one-week intervals following the first weekly email. Of note, MB encouraged participants to read the emails in sequence over the six-week intervention period; however, all emails remained accessible (i.e., emails became a resource that participants could return to at any time), which was a key design feature to enhance accessibility of the intervention. Beyond the unidirectional provision of weekly emails, there was no contact between participants and the researchers during the six-week intervention period. One day after the last email was sent to participants, they received an email with a link to an online platform to complete self-report measures and were invited to schedule a second in-person meeting with MB to complete objective measures (i.e., post-intervention assessment; week 7). Participants, including dropouts, were advised that their data were still valuable regardless of their level of actual PA participation to promote retention and data collection completeness. Twenty-one weeks after their baseline meeting with MB,
participants received a final email with a link to an online platform to complete self-report measures (i.e., follow-up assessment; week 21). Post-intervention and at follow-up, two email reminders were sent to non-responders at one and two weeks after the initial request.

Participants were allocated using permuted blocks of three and six via a web-based randomization software program (Sealed Envelope Ltd., 2017). Randomization was carried out by an independent researcher who was not involved in the trial, and arm allocation was subsequently conveyed to participants by MB via email. Due to the nature of the arms and the researchers’ active role in delivering the intervention, respectively, participants and the researchers were aware of the allocated arm (i.e., unblinded); neither were blinded after assignment to arms. To minimize bias, self-reported measures were administered online.

**Intervention Materials**

The intervention was developed by MB (i.e., a graduate student in the School of Human Kinetics at the University of Ottawa) and her supervisor, JB (i.e., an Associate Professor in the School of Human Kinetics at the University of Ottawa). It was designed to be self-guided so that women could access resources at any time and in any location. It was comprised of three components: (a) a paper copy and brief verbal explanation of the Canadian PA guidelines for adults 18–64 years, (b) a Polar A300 activity monitor with a charging cable and access to the Polar Flow website (46) and companion smartphone application, and (c) six weekly behavioural support emails designed to enhance autonomous motivation for PA. Components 1 and 2 were provided to participants during their baseline meeting with MB. Regarding the wearable activity tracker, participants were instructed to wear the device on their wrist daily during waking hours for the six-week intervention period, except when swimming or bathing. MB provided instructions on how to navigate the device and assisted participants in syncing the device to their
computer and/or smartphone so they could review their PA data in greater detail on either the
Polar website and/or its smartphone applications. Participants maintained access to the device,
Polar website and companion smartphone application for the duration of the six-week intervention and had continued access to the Polar website and companion smartphone application after returning the device to MB during the post-intervention meeting.

Component 3 featured six standardized weekly behaviour support emails. This modality was chosen as emails are inexpensive, easy to administer, can offer continuous or brief support, and are commonplace in real-world settings. The frequency of emails was set to one email per week for six weeks to strike a balance between providing sufficient encouragement without becoming bothersome. The email content, which featured textual information and worksheets that participants could download and/or print, was developed by drawing on SDT principles (i.e., (a) providing autonomy support, structure, and interpersonal involvement, (b) enhancing perceptions of autonomy, competence, and relatedness, and (c) increasing autonomous motivation) and empirically-supported motivational and behaviour change techniques (47-49).

Accordingly, emails were written using autonomy-supportive phrasing; that is, non-controlling language to enhance participants’ perceptions of autonomy (i.e., perceived control over one’s actions), competence (i.e., perceived mastery of tasks and skills), and relatedness (i.e., perceived belonging and connection to others), as well as their autonomous motivation for PA (50, 51). Key motivational and behaviour change techniques included goal setting, action planning, contingency planning, and self-monitoring. Other recurring themes throughout the emails included learning from trial and error, focusing on making small changes, choosing enjoyable activities, and aligning plans with personal beliefs and values. A detailed overview of content and techniques included in the emails have been previously published (45).
Measures

A complete description the primary (i.e., PA behaviour) and secondary outcome measures (i.e., PA-related basic psychological needs satisfaction and motivational regulations), including how and when they were used, is available in Black and Brunet (45). Results of analyses performed for primary and secondary outcomes are reported elsewhere (7). Pertinent to the current study, participants self-reported sociodemographic and health information (e.g., age, marital status, ethnicity, education, work status, smoking status) at baseline within an online survey using the platform SurveyMonkey. Their height (m), body mass (kg), body composition (body fat percentage) and waist circumference (cm) were measured by MB during their in-person meeting at baseline and again at post-intervention. These data were used to describe the sample.

Post-intervention (week 7), acceptability and usage patterns data were collected online using the platform SurveyMonkey. As outlined in Table 2, three open-ended questions were used. Specifically, participants were asked what they liked and disliked about the intervention and were invited to comment on points of improvement. Participants were also asked to rate their likelihood of using the wearable activity tracker in the future and to assess its value using a 5-point Likert scale. Finally, participants were presented with five questions that asked them to indicate how often they used the wearable activity tracker and checked their data on their computer and smartphone; they were asked to select the appropriate response from a list of possible responses.

Table 2. Acceptability measures.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Questions</th>
<th>Response Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptability of the intervention overall</td>
<td>1)  <em>What did you like about this intervention?</em></td>
<td>Open-ended/free-text response</td>
</tr>
<tr>
<td></td>
<td>2)  <em>What did you dislike about this intervention?</em></td>
<td>Open-ended/free-text response</td>
</tr>
</tbody>
</table>
### Acceptability of the wearable activity tracker

1. **How likely are you to use a wearable activity tracker in the future?**
   - Definitely not, possibly, probably, very probably, definitely

2. **How valuable was having a wearable activity tracker for you?**
   - Not valuable at all, of little value, of average value, very valuable, absolutely valuable

### Device usage patterns

1. **On average, how many days per week did you wear your wearable activity tracker?**
   - 7 days/week, 6 days/week, 5 days/week, 4 days/week, 3 days/week, 2 days/week, 1 days/week, 0 days/week

2. **On days that you wore your wearable activity tracker, how many hours did you wear it?**
   - >10 hours/day, 10 hours/day, 9 hours/day, 8 hours/day, 7 hours/day, 6 hours/day, <6 hours/day, I did not wear my wearable activity tracker

3. **On days that you wore your wearable activity tracker, how often did you check your physical activity data on your device?**
   - Very frequently, frequently, occasionally, rarely, very rarely, I did not wear my wearable activity tracker

4. **On days that you wore your wearable activity tracker, how often did you check your physical activity data on your smartphone?**
   - Very frequently, frequently, occasionally, rarely, very rarely, I did not use the smartphone application

5. **On days that you wore your wearable activity tracker, how often did you check your physical activity data on your computer?**
   - Very frequently, frequently, occasionally, rarely, very rarely, I did not use the online application

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**Notes.** *Italics* = Exact questions asked for acceptability measures.

**Statistical analysis**

All data were de-identified prior to analysis. Statistical methods pertaining to primary and secondary outcomes are described elsewhere (7). Descriptive statistics were used to summarize the sample characteristics and responses to the acceptability questions with fixed-response options; Statistical Package for Social Sciences (SPSS) (version 26; IBM Corporation, Armonk, NY, USA) was used to conduct these analyses. Content analysis using a deductive approach (52) was carried out by SS and JP to generate themes derived from participants’ free-text responses to the open-ended acceptability questions. First, JP and SS (i.e., two graduate students familiar with the trial but not otherwise involved in its development or execution) read through all the textual data to obtain a general understanding. Next, they created a preliminary generation of codes based on the acceptability questions and searched for themes independently. Discrepancies were
then discussed, and JB became involved; she reviewed each theme and all open-ended responses
to the survey, and discussions took place until a consensus was reached. Microsoft Word was
used to store, code, and analyses open-ended responses to the survey.

RESULTS

Sociodemographic and health characteristics

Recruitment started in September 2018 and ended in March 2019 when the target sample
size was reached, and follow-up assessments took place until August 2019; a flow diagram
including the number of participants who were randomly assigned, who received the
intervention, and who were analyzed is presented elsewhere (7), as are the reasons for exclusions
and losses. Fifteen participants were randomized to the main intervention arm; of these, 14
(93.3%) provided acceptability data post-intervention (see Table 3 for characteristics;
characteristics for all participants are presented elsewhere (45)). Due to efforts to ensure
anonymity and data protection, it was not possible to ascertain the reason(s) for dropout). The
analyzed sample of women were between 18-63 years of age and most (74.3%, n=11/15) self-
identified as White. There were no reports of adverse events or unanticipated effects during the
duration of the trial.

Table 3. Sociodemographic and health profile of participants at baseline who provided
acceptability data post-intervention (n=14).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ranges</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, M years, (SD)</td>
<td>18–63</td>
<td>32.6 (7.8)</td>
</tr>
<tr>
<td>BMI, M kg/m², (SD)</td>
<td>23.6–45.7</td>
<td>31.3 (5.8)</td>
</tr>
<tr>
<td>Body composition, n (%)</td>
<td>24.2–55.0</td>
<td>41.1 (5.8)</td>
</tr>
<tr>
<td>Waist circumference, M cm (SD)</td>
<td>71–141</td>
<td>97.4 (13.1)</td>
</tr>
<tr>
<td>Self-rated health, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>1 (6.7)</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>5 (33.3)</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>9 (60.0)</td>
<td></td>
</tr>
<tr>
<td>Very good</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Smoking status, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never smoked</td>
<td>13 (86.7)</td>
<td></td>
</tr>
</tbody>
</table>
Previously smoked 1 (6.7)
Currently smokes 1 (6.7)

Education, n (%)  
High school 0 (0)
Some college or university 1 (6.7)
College or university 13 (86.7)
Graduate degree 1 (6.7)

Employment status, n (%)  
Unemployed 2 (13.3)
Student 3 (20.0)
Part-time worker 3 (20.0)
Full-time worker 7 (46.7)

Annual household income (CAD), n (%)  
≤49,999 6 (46.2)
50,000–99,999 3 (23.1)
≥100,000 4 (30.7)

Race, n (%)  
White 11 (74.3)
Other 4 (26.7)

Notes. M = mean. SD = standard deviation. BMI = body mass index. $CAD = Canadian dollars.

Summary of quantitative data on perceived value and usability patterns.

Figure 1 displays data on perceived value and usage of the wearable activity tracker, as well as the likelihood of future usage of the wearable activity tracker. Scores were generally positive for the value of having a wearable activity tracker; most reported that the tracker was “very valuable” or “absolutely valuable” for them (71.5%, n=10/14) and that they would “very probably” or “definitely” wear it in the future (71.5%, n=10/14). Additionally, 72% (n=10/14) reported wearing the tracker 6–7 days/week and 100% (n=14/14) wore it for ≥8 hours/day, with the majority (85.7%; n=12/14) wearing it for ≥12 hours/day. In terms of checking their PA data, 50% (n=7/14) of participants checked it on the device, whereas the remaining 50% (n=7/14) checked it on the device “very rarely” or “occasionally”. Similarly, most did not check their PA data on their computer (50%, n=7/14) or did so “very rarely” (14.3%, n=2/14), “rarely” (21.4%, n=3/14), or “occasionally” (14.3%, n=2/14); none did so “frequently” or “very frequently.” Also, 28.6% (n=4/14) did not use their smartphone to check their PA data or did so “very rarely” (7.1%, n=1/14), “rarely” (7.1%, n=1/14), or “occasionally” (42.9%, n=1/14); only 14.2% (n=2/14) did so “frequently” or “very frequently.”
Figure 1. Proportion of participants valuing the wearable activity tracker (A), their usage of it during the intervention (B-C), and their intended usage (D).

Summary of qualitative content analysis

The 14 women who completed the post-intervention survey provided a total of 41 responses to three open-ended acceptability questions (see Table 2). The final themes comprise their expressed likes and dislikes pertaining to the intervention, as well as recommendations for future implementation; these are presented below, along with quotations from free-text responses to illustrate key ideas. To protect confidentiality, participants were assigned pseudonyms, which are included next to each quotation.
Overall likes with the intervention and its components

Participants’ responses suggested they were mostly enthusiastic about the email-delivered intervention. Overall, the intervention was considered useful because it helped keep them ‘on track and accountable’ (Anna) and offered a sense of accountability in a non-pressuring manner. Participants expressed positive regard for the emails and felt they were an important element of the intervention. Specifically, they mentioned that the emails provided useful and helpful informational support, offered new ideas and activities they could try to meet their PA goals, and helped them learn how to develop feasible and/or alternative PA goals. Moreover, participants appreciated that the emails contained relevant information as they were ‘based around health for women’ (Jackie). They also relayed that the information delivered within the emails helped increase their awareness of their PA behaviour by prompting self-reflection; as Michelle highlighted, ‘It got me to think about my actions and where there were problems.’ Beyond the content, participants said the frequency of delivery of emails (i.e., once per week) was appropriate; weekly emails helped keep them engaged and served as ‘good reminders to reflect on making change’ (Peyton). Further, the design and layout of the activity sheets embedded within the emails were appreciated. Last, participants’ responses demonstrated that they positively perceived the wearable activity tracker as it offered them an objective measure of their PA; these data were meaningful because it increased participants’ awareness of their current PA levels and helped identify discrepancies between their current and desired levels. The device also served as a visual reminder to participants that their PA levels were being tracked, and thus encouraged them to be more active.
**Overall dislikes with the intervention and its components**

Although participants largely appreciated the intervention, they also reported dislikes that may have interfered with the acceptability of the invention and limited their motivation for participation. Their dislikes were related to the style of messaging within the emails (i.e., non-tailored content), design and delivery of the emails (i.e., textual presentation, spacing, timing, automated), intervention delivery schedule, and device factors. In terms of the style of messaging, participants said that receiving non-tailored content was suboptimal because the information provided was not specific to their individual PA needs and preferences; this, in turn, reduced their perceived value and utility. A key issue undermining the potential value and utility of the emails was that they only offered ‘passive guidance’ (Maya), and consequently did not serve to increase participants’ willingness and capability to successfully engage in PA in their daily lives.

In terms of the design and delivery of the emails, there were three specific issues. First, while they could be informative, emails were automated and therefore did not allow for two-way communication between participants and MB. Participants cited two-way communication as important for ensuring they engaged with the intervention and felt that having to submit their completed activity sheets would have increased their motivation to complete them. Indeed, the lack of accountability due to the one-way emailing design did little to enhance Priya’s motivation to change her PA behaviour as it was ‘hard only being accountable to myself.’ Relatedly, participants disliked that the one-way emailing did not afford them opportunities to share difficulties/challenges/failures with MB and receive tailored messaging in return; their responses suggested that this would have been beneficial to prevent negative feelings about not achieving their PA goals. Second, participants felt the emails lacked examples to visually help them
produce their own PA programs, which left them feeling overwhelmed and unsure how to proceed. Maya explained that ‘choosing the best activity to make the most noticeable improvement is difficult as there are so many choices of forms of exercise’ and expressed disappointment that the emails ‘did not lay out example exercise schedules to follow.’ Third, some expressed dissatisfaction related to the design (i.e., length and density) and delivery (i.e., spacing and timing) of the emails. For instance, Leah and Sam described the emails as ‘long’ and ‘text-heavy,’ respectively, whereas Julie explained that she ‘had trouble completing the weekly self-assessments’ because there was not enough time to do so in-between emails. The time of the week that emails were sent was also raised as an issue; Jackie suggested that she would have been more inclined to read them had they arrived towards the end of week, as opposed to mid-week.

Moreover, the rolling-recruitment strategy adopted in this study presented challenges for some recruited during Winter months. Kristen gave specific reasons for difficulty engaging in PA (e.g., below-freezing temperatures, icy sidewalks, winter blues), and noted that the timing of the intervention was suboptimal because she had ‘a really hard time starting new active things outside in the winter.’ Finally, participants expressed dissatisfaction with both the physical appearance and accuracy of the Polar A300 activity monitor. That is, they found the monitor to be ‘cumbersome’ and ‘aesthetically unappealing,’ and they worried that it did not register some of their activities, leading to an underestimation of their PA levels.

Elements of the intervention that warrant reconsideration

The open-ended responses to the survey questions were also valuable in understanding what may help enhance participants’ acceptability of future iterations of the intervention, and thus, perhaps their motivation, uptake, engagement, and adherence. While some indicated there
was nothing they would change about the intervention, others made recommendations relating to its specific components (i.e., emails, device). As a means of improving the emails, participants suggested they be shorter, less text-heavy, and embedded activity sheets revised to contain more background information. They also suggested emails be personalized to provide tailored content for each individual and be delivered when desired by participants. Further, participants suggested adding multimedia components to the emails (e.g., video/audio content, graphical illustrations), including ‘incorporate some videos’ (Anna) and ‘provide exercise schedules to use either at home or at a gym’ (Peyton). Moreover, in reference to the wearable activity tracker, participants suggested that it be swapped for a device that is more aesthetic and capable of accurately monitoring PA (i.e., by including a built-in heart rate monitor).

Other recommendations based on participants’ responses related to the overall intervention approach/methods. These included: (a) offering a booklet (either digital or print) that collates all emails and supporting materials to increase accessibility, and (b) requiring greater participant involvement by requesting that activity sheets be returned for review. Indeed, one participant indicated that ‘reviewing each week’s assignment with a person who could provide advice/support would help.’ As well, participants desired two-way communication and suggested the intervention provides both automated (prescheduled) emails and opportunities to interact with someone to receive further support as needed. For the latter, proposed adaptations to the intervention included introducing ‘a meeting halfway’ (Maya), back-and-forth emailing, and/or phone calls. Others suggested combining the email-delivered intervention with ‘group or one-on-one fitness classes/walks’ (Priya), although participants did not offer opinions on desired context of such sessions (e.g., who should lead them, where they should occur, how frequently they should be offered).
DISCUSSION

This study explored participants’ perspectives of the acceptability and usability of a theory-driven intervention delivered by email—a familiar and ubiquitous communication method—that was designed to promote PA in women who were overweight or obese and insufficiently active. Overall, participants provided positive feedback after completing the intervention. Both quantitative and qualitative data helped understand which aspects of the intervention participants were satisfied with, and which warrant reconsideration to enhance perceived interest, benefit, enjoyment, utility, and engagement amongst future participants. This work is an important step in the development and delivery of interventions delivered by email that target women.

Collectively, the findings reinforce the critical need of formative research in the development and delivery of such interventions and can guide future research and practice decisions for those who are considering investing in and/or delivering similar interventions.

The quantitative data suggested good overall acceptability and usability for the wearable activity tracker as it was rated as being valuable and likely to be used by most. Correspondingly, participants’ responses to open-ended questions suggested they valued the objective PA data the tracker provided because it helped them better understand their current PA levels (or lack thereof) and encouraged them to make changes. However, certain design factors (e.g., size, lack of aesthetic appeal) did affect the acceptability of the device and participants’ motivation to wear it. The quantitative data on the usage patterns of the Polar website and companion smartphone application showed variability amongst participants; some used these tools more frequently, whereas others used them a limited number of times or not at all. The latter is surprising because the emails included statements that could have prompted more frequent use of the Polar website and companion smartphone application (e.g., they encouraged self-monitor and proposed the
website and application as means to do so). Potential reasons for the variation in participant engagement with these technology-based tools were not queried, but may be: (a) differing preferences for how to monitor PA (e.g., a preference for printed PA logs), (b) limited opportunities to interact with the tools, (c) feelings of disappointment triggered by results (e.g., failing to reach step count goal), (d) low perceived utility, (e) increased perceived burden from manual tracking, (f) lack of understanding or trust in the data, making it seem pointless to review its data, and (g) concerns about privacy. As well, perceived usability or ease of use could have influenced usage patterns (53). That is, previous experience (or lack thereof) using digital applications in general, design flaws, and/or technical issues could also account for variability in participants’ engagement with the device itself and with the Polar website and companion smartphone application. Unfortunately, there was no interviewer to intervene and ask follow-up questions (unlike in interviews), which could have given insight into the reasons and offer suggestions to increase usage. To fill this knowledge gap, synchronous, in-depth interviewing (by telephone, online, or face-to-face) could be used to delve deeper into the reasons. Regardless of the reason(s) behind (non)usage patterns, it would be helpful to address low device and applications usage issues in future iterations of this intervention as it is reasonable to expect it may undermine effectiveness.

Participants’ responses to the open-ended questions suggest that an email-based intervention has potential to be well-received by women who are overweight or obese and insufficiently active because of what they can offer. Specifically, the women in this study felt the emails: (a) provided useful and helpful informational support, (b) offered new ideas/strategies to meet PA goals, (c) taught them how to develop feasible and/or alternative PA goals, and most importantly, and (d) prompted self-reflection on their PA behaviour, thus motivating them make
the changes necessary to progress towards their personal PA goals. Nevertheless, participants’ responses also shed light on potential threats to acceptability and point towards what could be improved. Primarily, participants raised concerns about the content, format, and style/design of the emails, as well as the predetermined, researcher-set delivery schedule. This suggests emails should be tailored and personalized to the individual (both in terms of their content and delivery protocol [i.e., timing, spacing]), and that some text should be replaced or emphasized with multimedia (e.g., videos, graphics) to foster better content engagement. Considering the extent of the suggested revision, it will be important to conduct an efficacy trial to test the effects of the revised emails (and delivery protocol) on PA behaviour.

Finally, issues were raised concerning the fully-automated nature of the intervention. Although participants were provided with a description of the intervention, their responses suggest that rather than being passive recipients of information via one-way emailing, they would have preferred the opportunity to actively participate through interactions with MB (e.g., via two-way emailing, phone calls, meetings) or with other women (e.g., via PA classes). This finding is not surprising given women’s desires for support by credible health experts (54) and engage with other participants during PA interventions (55). With these desires in mind, developing tailored interventions that allow women’s needs, wants, and preferences to dictate the level of human involvement (i.e., the type of support offered, the timing and frequency of the support, how it is initiated, and the medium by which the support is delivered) may be necessary to promote experiential cognitive and emotional responses that facilitate PA during and after the intervention. Accordingly, a stepped care model (56) may be a solution; that is, a fully-automated intervention could be initiated first, followed by increased human involvement as needed (e.g., stepping up the level of provider involvement to more intensive coaching or other
forms of support as needed). Future work is needed to determine if the introduction of this model renders this intervention more effective, and to explore the potential ramifications of featuring additional components (e.g., costs) and ensure it could be implemented outside of a research setting. Arguably, fully-automated interventions are beneficial as they can be delivered by administrative personnel or automatically through pre-programmed email-based software, thus incurring fewer costs. In contrast, increasing provider involvement or carrying out PA classes may have higher implementation costs as they may require more time to educate providers and participants, facilitate engagement, and support users. Thus, the decision to increase support, while perhaps more acceptable and possibly more impactful, should be considered in light of available resources. These are important issues to explore in future studies via cost metrics to gauge potential sustainability.

Although there has been a proliferation of email-delivered interventions, few studies have explored how to construct emails designed to promote PA using a participatory approach. The use of a qualitative approach in this study, and the use of an online platform to collect data which assured anonymity, revealed that overall, emails were an acceptable way of providing support to women, but they were suboptimal in certain regards and require further development and evaluation. Participant-driven recommendations included: reducing the length and density of the emails, varying how information is presented within the emails (e.g., adding video/audio content and graphical illustrations to text), providing more information on how to engage in PA (e.g., through sample programs), and compiling email content into a single booklet that can be printed (if desired). Although these data are informative, it remains necessary to directly ask women specific questions about their preferred email content; doing so will help identify the most facilitative versus gratuitous elements and utilize that information to determine what (if any)
content could be cut to reduce the length of emails. Further, as the design of the emails also requires careful consideration, it would be valuable to consult with health marketing and communications experts on the most effective ways to present information (e.g., multimedia, layout, font, colours). For example, to increase user engagement, some text could be replaced with multimedia (e.g., illustrations/graphics, audio/videos such as recorded content from researchers, health professionals, or past users, or animated information), testimonials, or personal stories. Importantly, all materials presented should be inclusive for diverse women (e.g., videos should feature women of varying shapes and sizes). To this end, using a participatory approach (i.e., involving end-users in intervention design, testing, and evaluation) may yield a series of emails that women consider more relevant, appealing, comprehensive, appropriate, meaningful, and practical when it comes to PA promotion. In turn, the co-created emails could be introduced in future interventions as a tool purposely designed with the input and voices of women, which may increase women’s willingness to participate, as well as intervention effectiveness.

Additionally, the data collected herein suggest that wearable tracker usage could be improved by providing women with a lightweight, stylish, and unobtrusive device that has documented validity and reliability. Accordingly, it could help to involve end-users at an early stage of intervention development to decide which wearable activity tracker would be best for them to monitor their PA. It will be important to explore factors that may limit engagement with the device itself and its associated website and smartphone application to ensure optimal usage because the effectiveness of the intervention is likely to depend on full engagement. Whilst not investigated in this study, such factors may be related to psychosocial, behavioural, or
Furthermore, results suggest that the level of human support needs to be increased, at least for some. Instead, in line with participants’ recommendations, weekly emails could be complemented by a mid-intervention touchpoint (via videoconferencing, telephone, instant messaging) and/or back-and-forth email communication to provide more personalized instructions, recommendations, feedback, and support. Yet, some may require even more human support, and so as suggested above, it may be best to provide a continuum of level of human support that encompasses completely human-delivered interventions, partially-guided interventions, and fully-automated interventions, and consider allowing participants to self-enroll into their preferred intervention. Regardless of which changes are made to the intervention or delivery protocol, a larger trial with adequate power to detect statistical significance is warranted; this will help determine whether the revised intervention and/or delivery protocol produces a meaningful, observable effects on primary outcomes (i.e., PA behaviour) and process outcomes (i.e., PA-related psychological needs satisfaction and motivational regulations).

Last, a critical, yet unresolved issue in this study is how well participants felt the intervention and its components helped foster their PA-related psychological needs satisfaction and autonomous motivation. The latter also warrants further investigation as it serves as one indicator of implementation success. Arguably, enhancing participants’ psychological needs satisfaction and autonomous motivation for PA is a necessary precondition for attaining subsequent desired change in PA behaviour. Adopting qualitative methods to conduct an in-depth investigation into how the intervention promoted or thwarted process outcomes will help
to advance knowledge on how these key constructs can be fostered in future iterations of this intervention.

This study has limitations that could be address in future work. First, convenience sampling was used and participants were self-selected, which may have resulted in selection bias. Specifically, participants may have been more interested in changing their PA behaviour (and thus more motivated to fulfill intervention requirements) and/or more competent with technology than women in the general population; both these factors could have influenced their responses and limit the applicability of the results. Second, no procedures were put in place to recruit a heterogenous sample based on sociodemographics, limiting the generalizability of the results. Future studies could use a purposive sampling method to recruit women with specific sociodemographics. Third, the exploratory nature of this study and sample characteristics did not allow for investigation of sociodemographic factors that may influence how the intervention would be received and acted upon. Fourth, important/relevant evidence regarding acceptability may not have been fully captured as usability and acceptability data were collected retrospectively using a brief questionnaire. Acceptability is dynamic and can be assessed prospectively, concurrently, and/or retrospectively. As well, it is a multifaceted concept that includes the following constructs: affective attitude (i.e., how an individual feels about the intervention), burden (i.e., perceived amount of effort that is required to participate in the intervention), ethically (i.e., goodness of fit between intervention and individual values), coherence (i.e., participant understanding of intervention and how it works), opportunity costs (i.e., extent to which benefits, profits, or values must be given up to engage in the intervention), perceived effectiveness (i.e., extent to which intervention is perceived as likely to achieve its purpose), and self-efficacy (i.e., confidence to perform required behaviours). Depending on when
acceptability is assessed and what constructs are assessed, evidence of acceptability may be different. In future studies, acceptability evaluations necessitate careful assessment of these different constructs over time. Relatedly, usability and acceptability data were collected from an online survey, which limited probing and follow-up question to gain more in-depth exploration of themes. Finally, device usability patterns were assessed via self-report, which can be prone to response bias, and no verification of whether participants read the emails and completed the activity sheets that were sent to them was carried out.

CONCLUSIONS

In-person interventions promoting PA often have considerable implementation costs and may be unappealing for women with barriers such as travel, scheduling, and fear of weight-based stigma. Therefore, the development and evaluation of low-cost technology-based interventions that can provide women with evidence-based information for increasing and sustaining PA deserves more investigation. Recent frameworks for developing and evaluating complex health interventions emphasize a need to focus on their initial development as many fail to demonstrate effectiveness in real-world contexts (35). Prior to conducting larger trials assessing the effectiveness of the intervention, this study was conducted to explore participants’ perspectives of the acceptability and usability of an email-delivered intervention designed to promote PA in women who were overweight or obese and insufficiently active. Indeed, the results provide preliminary support for the intervention’s acceptability and usability; however, issues were reported that could potentially undermine both. Participants noted preferences for two-way emailing, individualized delivery schedules, and tailoring of content. Designing appealing emails (including multimedia) and selecting stylish devices was also noted as important. As researchers continue to investigate the effectiveness of technology-based interventions that integrate
wearables to help increase PA in women who are overweight or obese and insufficiently active, more work is needed to implement these changes and engage end-users from various sociodemographic backgrounds to realize their full potential. One implicit assumption is that making such changes will improve several implementation outcomes (e.g., acceptability, adoption, appropriateness, feasibility, fidelity). Although probably true, analyzing such outcomes following the revised intervention is an important area of further research as there may be additional ‘costs of time’ for participants that cause them to drop out. However, such costs of time are theoretical and deserve further research as they may instead increase participants motivation and engagement and thus have greater effects on primary (i.e., PA behaviour) and secondary outcomes (e.g., mechanisms of change such as PA-related basic psychological needs satisfaction and motivational regulations). Future work should also collect fidelity data (e.g., via email management systems that allow tracking of email delivery and open rates) to ensure participants are receiving the intervention as intended and that it produces successful outcomes. Finally, work aimed at testing the associations between each intervention component, implementation outcomes, and PA outcomes is needed.

**Abbreviations**

PA: Physical Activity; MVPA: Moderate-to-Vigorous Intensity Physical Activity; SDT: Self-Determination Theory; BMI: Body Mass Index; RCT: Randomized Controlled Trial; CONSORT: Consolidated Standards of Reporting Trials; SPSS: Statistical Package for Social Sciences.

**DECLARATIONS**

**Consent for publication**

Consent for publication of raw data not obtained from participants.
Availability of Data and Materials

The corresponding and last authors have access to the data in a SPSS file. The data cannot be shared as participants were assured that their data would be kept private and confidential to the extent permitted by law and that only the research team would have access to the data.

Ethics approval and consent to participate

The trial protocol was approved by the Institutional Review Board at the University of Ottawa (H-06-18-437) before recruitment and data collection began. Participation was voluntary. All participants gave informed consent digitally in agreement with the Declaration of Helsinki, and participants were able to withdraw from the study at any time. Participants received no financial compensations for taking part in this study.

Competing interests

All authors declare that they have no competing interests.

Funding

The authors have no specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors to declare.

Role of Funders

Not applicable.

Acknowledgements

The authors would like to thank the individuals who participated in the trial. JB held a Canada Research Chair Tier II in Physical Activity Promotion for Cancer Prevention and Survivorship, and JP and SS were supported by SSHRC Canada Graduate Scholarships during the preparation of this manuscript.

Authors’ contributions
JB conceived the idea for this study. JB and MB co-developed the intervention. MB recruited participants, was responsible for data collection, and oversaw all technical aspects of the delivery of the intervention. JB, SS, and JP contributed to the data analysis and results interpretation. JB wrote the first draft of the manuscript and revised it with input from all authors. SS, JP, and MB contributed to refining the content of the manuscript and revised it critically for important intellectual content. All authors read and approved the final version.
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