Exploring the Effect of an eHealth Intervention on Women's Physical Activity Behaviour: A Randomized Trial

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Thesis submitted to the Faculty of Graduate and Postdoctoral Studies in partial fulfillment of the requirements for the Master of Arts degree in Human Kinetics

Abstract

The rising number of women who are overweight or obese living in Canada is concerning because an excess weight can lead to serious health problems. Nearly 65% of women living in Canada are considered overweight or obese. Regular physical activity (PA) participation is beneficial and can help women manage their weight. Considering women who are overweight or obese are generally physically inactive, interventions drawing on theory are warranted to promote PA. This thesis reports on the protocol and results of a randomized controlled trial that was conducted to assess the effect of a self-determination theory-based eHealth intervention on PA among women who were overweight or obese with low levels of PA. The full protocol for this study is described in Chapter 3: Protocol Manuscript and the results of the primary objective are presented in Chapter 4: Results Manuscript. Reflections on the lessons I have learned while implementing a clinical trial are presented in Chapter 5: Lessons Learned. Briefly, the self-determination theory-based eHealth intervention provided (A) six weekly behavioural support emails, (B) a wearable activity tracker, and (C) a copy of the Canadian PA guidelines. The primary objective of this study was to determine if participants who received the combined intervention (A+B+C) increased their PA levels from baseline to post-intervention. The secondary objective was to assess if this combined intervention leads to greater change in PA than those who received an intervention including (B+C) or only (C). It was hypothesized that participants in the combined intervention would increase their PA from baseline to post-intervention, and that this increase would be greater than the increase observed among those who received an intervention including (B+C) or only (C). In addition, measures of constructs embedded in self-determination theory (i.e., basic psychological need satisfaction and thwarting, motivational regulations) and wellbeing (i.e., affect, vitality, wellbeing) were included to address

tertiary objectives of examining if there are differences in changes in these constructs between groups. Participants were recruited between September 2018 and March 2019. Data were collected using self-report and direct measures three times: at baseline (week 0), post-intervention (week 7), and at follow-up (week 21). Data from forty-six women (M_{age}=37.72±11.87 years, M_{BMI}=31.55±5.96 kg/m^2) were analyzed. Mean PA at baseline across all participants was 1148.12±1091.03 metabolic equivalent minutes (MET-minutes) per week. In relation to the primary study objective, PA increased from baseline to post-intervention (F=17.95, p<.001, η^2=.295). Contrary to our hypothesis regarding the secondary objective, differences in PA between groups (p>.05) and the interaction between group and time (p>.05) were not significant. In summary, participants in this study showed a large and significant increase in PA, but the three different interventions did not have a differential impact on change in PA. Discussion of the findings regarding the primary and secondary objectives, and the potential implications of the tertiary objective, will provide insight into which combination of intervention components may be more effective at promoting PA among insufficiently active women who are overweight or obese, and thus inform the design of future interventions aiming to promote PA.

Statement of Contribution

I, Melissa Black, was responsible for conceptualization, study design, intervention design, data collection, data analysis, and writing, under the supervision of Dr. Jennifer Brunet. Dr. Jennifer Brunet provided substantial contributions to conceptualization, study design, intervention design, and editing. Ms. Emily Wolfe Phillips assisted in reviewing the content of the intervention and coding it according to the CALO-RE taxonomy of behaviour change techniques.

Acknowledgements

I am eternally grateful to the many people who have helped me to complete this Masters' degree. The proverb "it takes a village to raise a child" expresses my feelings of gratitude towards the many people who have supported me leading into and throughout this degree.

To my supervisor, Dr. Jennifer Brunet, thank you for taking me on as a student and pushing me to be the best that I could be. The support that you have provided has helped shape me for the better into the person I am today, and for that I am eternally grateful.

To my committee members, Dr. Bradley Young, Dr. Denis Prud'homme, and Dr. Jennifer Reed, thank you for helping to shape this research project and my final thesis. The discussions that took place during both my proposal defence and my thesis defence helped to elevate the quality of this study and contributed to my learning experience.

To the women who participated in this research project, thank you for welcoming me into your homes or making the trip out to the University of Ottawa, and for taking the time to complete the surveys. This research project would not have been possible without you.

To my lab-mates, Amanda, Emily, Jenson, Meagan, and Deeksha, thank you. Our chats, coffee dates, and car rides have been instrumental in working through this degree.

Finally, to Fred, Simone, and Stephanie, and to all of my friends, thank you for your patience and for giving me the freedom to study these past few years... And for reminding me to just get things done. Onwards!

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List of Abbreviations

BMI = Body mass index

BREQ-3 = Behavioural Regulation in Exercise Questionnaire (3rd version)

CONSORT = Consolidated Standards of Reporting Trials

CSEP = Canadian Society for Exercise Physiology

I-PANAS-SF = Positive and Negative Affect Schedule – Short Form

IPAQ-S = International Physical Activity Questionnaire – Short Form

MET = Metabolic equivalent

MVPA = Moderate to vigorous intensity aerobic physical activity

ORBIT = Obesity Related Behavioural Intervention Trials

PA = Physical activity

PASSES = Perceived Autonomy Support Scale for Exercise Settings

PHQ-9 = Patient Health Questionnaire (9 items)

PNSE = Psychological Need Satisfaction in Exercise Scale

PNTS = Psychological Need Thwarting Scale

SF-36 = RAND 36-item Short Form Health Survey

SPIRIT = Standard Protocol Items: Recommendations for Intervention Trials

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Chapter 1: Introduction

Physical activity (PA) is recognized for its numerous health benefits, including its notable role in reducing the risk of chronic diseases (Warburton & Bredin, 2017). For this reason, the Canadian Society for Exercise Physiology (CSEP) has developed guidelines that encourage adults to regularly engage in PA (Tremblay et al., 2011). Specifically, adults between the ages of 18 and 64 years are advised to accumulate at least 150 minutes of moderate-to-vigorous intensity aerobic PA (MVPA) and participate in at least two muscle and bone strengthening activities per week (Tremblay et al., 2011). However, low PA engagement remains a health epidemic as less than 32% of young and middle-aged adults living in Canada meet current MVPA guidelines (Statistics Canada, 2015). Moreover, women who are overweight or obese are significantly less likely than men and those who are normal weight to maintain a lifestyle that includes sufficient PA, regardless of their age or sociodemographic background (Colley et al., 2011; Tudor-Locke, Brashear, Johnson, & Katzmarzyk, 2010). Thus, women who are overweight or obese could benefit from a tailored intervention to promote PA.

Low PA engagement is, in part, the result of experienced barriers which could be addressed through an intervention. For instance, previous studies have found that lack of motivation, fatigue, excessive stress, and time constraints are common reasons for insufficient PA among adult women (Dugan et al., 2016; Eyler et al., 2002; Im, Lee, Chee, & Stuifbergen, 2011). Women who are overweight or obese may experience additional barriers to PA such as concerns about perceptions of excess weight or lack of interest (Cannioto, 2010; Leone & Ward, 2013; Yoke, 2017). Individually targeted interventions can help to address many of these barriers by teaching people skills and strategies for managing their behaviour.

Of the reported barriers to PA in the literature that could be addressed, low motivation makes an excellent intervention target as it is a malleable psychological construct and has been inversely associated with PA among women. Researchers have shown through a series of experimental studies that autonomous (or self-determined) motivation for PA can be increased by creating an autonomy-supportive environment (Edmunds, Ntoumanis, & Duda, 2008; Silva et al., 2008; Teixeira, Carraca, Markland, Silva, & Ryan, 2012). Autonomy-support is a concept derived from self-determination theory, a prominent macro-theory of human motivation and behaviour (Deci & Ryan, 1985; Ryan & Deci, 2000), which involves providing participants with rationale for the importance of PA, choice and positive feedback while using empathetic communication strategies (Kayser, Cossette, & Alderson, 2014; Patrick & Williams, 2012). By doing so, the basic psychological needs of autonomy, competence, and relatedness can be satisfied, self-determined motivation can be enhanced, and PA behaviour can be increased (Hagger, Chatzisarantis, & Harris, 2006; Ryan, Williams, Patrick, & Deci, 2009; Teixeira et al., 2012; Wasserkampf & Kleinert, 2015). To this end, developing interventions to increase PA behaviour using autonomy-supportive strategies may be particularly effective.

Despite the established efficacy of self-determination theory-based interventions among women who are overweight or obese (Silva et al., 2008; Silva, Vieira, et al., 2010; Teixeira et al., 2012), improvements can be made in efficiency. Given that women who are overweight or obese face substantial time pressures from long hours at work or school and family commitments (Welch, McNaughton, Hunter, Hume, & Crawford, 2009), there is a need to deliver interventions in a way that allows women to participate at their convenience. Wearable activity trackers may be a promising tool for PA interventions as they help women to self-monitor their PA levels and make changes accordingly. A systematic review of existing studies led to the conclusion that

these devices can positively impact PA behaviour (Z. Lewis, Lyons, Jarvis, & Baillargeon, 2015). These findings suggest that wearable activity trackers may be a valuable tool to improve PA in women, perhaps even more so when paired with an autonomy-support to address motivation.

To date, few researchers have examined the impact of wearable activity tracker use on motivation for PA, which is critically important because motivation is a significant and robust predictor of PA behaviour (Ryan et al., 2009; Teixeira et al., 2012). Moreover, understanding the changes in motivation associated with device use could provide researchers with a platform to explain why their intervention is, or is not, successful. Of two studies that have examined the links between wearable activity tracker use and motivation, one found that providing people with this type of device can increase introjected motivation (Mendoza et al., 2017), namely a controlled (or non-self-determined) form of motivation which occurs when people behave to avoid feelings of guilt or enhance feelings of pride (Ryan & Deci, 2000). The other study found that providing people with a wearable activity tracker can decrease basic psychological need satisfaction and self-determined motivation (Kerner & Goodyear, 2017). Findings from these two studies suggest that wearable activity trackers alone may not support self-determined motivation for PA.

Drawing on theoretical perspectives (Deci & Ryan, 1985; Ryan & Deci, 2000) and empirical research (Attig & Franke, 2018; Kerner & Goodyear, 2017; Mendoza et al., 2017), we reasoned that women's PA behaviour would be more likely to increase if women received an autonomy-supportive intervention to increase basic psychological need satisfaction and self-determined motivation in addition to receiving a wearable activity tracker to facilitate self-monitoring. We therefore developed a 6-week three-armed randomized trial to test this

hypothesis. Women assigned to the combined intervention (Group 1) received (A) six weekly autonomy-supportive weekly emails, (B) a wearable activity tracker to facilitate self-monitoring, and (C) a paper copy of the Canadian PA guidelines. Two comparison arms were used: one (Group 2) in which women received (B) and (C), and the other (Group 3) where women only received (C).

The primary objective of this study was to determine if participants in Group 1 increased their PA from baseline to post-intervention. The secondary objective was to assess if this combined intervention leads to greater change in PA than Group 2 or Group 3. It was hypothesized that participants in Group 1 would increase their PA from baseline to post-intervention, and that this increase would be greater than the increase observed in Group 2 or Group 3. In addition, measures of basic psychological need satisfaction and thwarting, motivational regulations, and wellbeing were included for the tertiary objective of this study, which was to examine if there are differences in change in self-determination theory constructs (i.e., motivational regulations, basic psychological need satisfaction and thwarting) and indicators of wellbeing (i.e., affect, vitality, depression) between groups. The protocol for the full study is described in Chapter 3: Protocol Manuscript. The results for the primary and secondary objectives are addressed in Chapter 4: Results Manuscript. Descriptive statistics on data collected for the tertiary objective are presented in Appendix A; however, complete analysis of such data is outside the scope of this Master's thesis.

Chapter 2: Literature Review

Regular PA engagement has numerous health benefits (Warburton & Bredin, 2017); it reduces the risk of cardiovascular disease, diabetes, cancer, obesity, bone/joint diseases, and depression (Warburton, Nicol, & Bredin, 2006). For this reason, CSEP has developed the Canadian PA Guidelines for Adults, which encourage people to engage in regular PA to reduce their risk of chronic diseases and to promote fitness, strength, and mental health (Tremblay et al., 2011). Adults between the ages of 18 and 64 years are advised to accumulate at least 150 minutes of MVPA and participate in at least two muscle and bone strengthening activities per week (Tremblay et al., 2011). Regrettably, low PA engagement remains a health epidemic. Congruent with other developed countries (Bauman et al., 2012), only 32% of adults living in Canada who are between the ages of 18 and 39 years, and 18% of those between the ages of 40 and 59 years meet current MVPA guidelines (Statistics Canada, 2015). There is a critical need to promote PA behaviour among the millions of men and women living in Canada who could see reduced disease risk from even a small increase in PA behaviour (Warburton & Bredin, 2017).

Moreover, women who are overweight or obese are less likely than men and those who are normal weight to maintain a lifestyle that includes sufficient PA (Colley et al., 2011; Tudor-Locke et al., 2010). A plausible explanation for the discrepancy is that women take on more unpaid work than men (Miranda, 2011), resulting in large set of competing demands from their personal and professional lives. Miller and Brown (2005) suggested that given those demands, many women feel a lack of entitlement to leisure time and that other areas of their lives are more worthy of their time, ergo self-care behaviours are neglected leading to a sedentary lifestyle. In support of this contention, previous studies have found that lack of motivation, fatigue, excessive stress, and time constraints are common reasons for insufficient PA among adult women (Dugan

et al., 2016; Eyler et al., 2002; Im et al., 2011; Welch et al., 2009). Further, significant life changes such as getting married, giving birth, returning to work or study, or changing employment are significant predictors of low PA engagement among women (Brown & Trost, 2003). Women who are overweight or obese may experience additional barriers to PA such as concerns about perceptions of excess weight or lack of interest (Cannioto, 2010; Leone & Ward, 2013; Yoke, 2017), and could benefit from a tailored intervention to increase PA behaviour in order to improve their health and reduce their risk of developing chronic diseases.

Interventions for Physical Activity Behaviour Change

In general, interventions designed to promote PA have been shown to improve PA behaviour modestly (Dunn, Andersen, & Jakicic, 1998; Fjeldsoe, Neuhaus, Winkler, & Eakin, 2011; Kahn et al., 2002). Furthermore, multiple systematic reviews have highlighted that interventions which provide a sound theoretical backing for their methods are more effective than those which are not grounded in behaviour change theories (Glanz & Bishop, 2010; Gourlan et al., 2016; Michie, Whittington, Abraham, McAteer, & Gupta, 2009). Theories provide researchers with a platform to explain why their intervention is or is not successful, which is important so that their contributions can be used to inform future intervention designs and research (Michie & Abraham, 2004). Although multiple theories of human behaviour exist, self-determination theory (Deci & Ryan, 1985) is particularly well-situated to provide the foundation to an intervention for women targeting PA behaviour change. Self-determination theory is a macro-theory of human motivation, which is relevant as researchers have shown that lack of motivation is a common barrier to PA among working-aged women (Dugan et al., 2016; Eyler et al., 2002), and is inversely associated with PA behaviour in this population (Hagger et al., 2006; Silva et al., 2011).

Self-Determination Theory

Self-determination theory encompasses six mini-theories that collectively explain how individual psychological processes and environmental factors coalesce to influence motivation and behaviour (Deci & Ryan, 1985; Ryan & Deci, 2000). Deci and Ryan (1985) conceptualized that motivation exists along a continuum from amotivation (i.e., a complete lack of motivation for a given behaviour), through non-self-determined (or controlled) motivation (i.e., engagement in a behaviour for external reasons), to self-determined (or autonomous) motivation (i.e., engagement in a behaviour for its own sake). Within organismic integration theory, Deci and Ryan (1985) elaborate on the more controlled forms of motivation by defining four distinct types of motivational regulations: *external* (i.e., to satisfy an external demand or achieve a reward), *introjected* (i.e., to avoid feelings of guilt or enhance feelings of pride), *identified* (i.e., because a person consciously values that behaviour), and *integrated* (i.e., because that behaviour is part of a person's identity). The most autonomous motivational regulation, which occurs when a person engages in a behaviour strictly for its own sake or for enjoyment, is called *intrinsic motivation*. More autonomous forms of motivation are more predictive of sustained behaviour (Deci & Ryan, 1985; Ryan & Deci, 2000; Teixeira et al., 2012). For this reason, to increase a behaviour a person must internalize their motivation to progress along that continuum by having all three basic psychological needs (i.e., *autonomy*, *competence*, *relatedness*) satisfied, as outlined in basic psychological needs theory, whilst avoiding inhibition (i.e., frustration or thwarting) of these needs (Ryan & Deci, 2000). When taken together, the mini-theories of self-determination theory create a useful framework to explain the motives of human behaviour.

A substantial body of observational research has applied self-determination theory to explain PA behaviour. Satisfaction of all three basic psychological needs have been found to be

predictive of PA engagement (Hagger et al., 2006; Teixeira et al., 2012). Further, researchers have shown that psychological need satisfaction is positively associated with more autonomous motivational regulations (Edmunds et al., 2008; Markland & Tobin, 2010; Wilson & Rogers, 2008), which in turn is positively associated of PA behaviour (Silva et al., 2011; Teixeira et al., 2012). Also, some researchers have found that controlled motivational regulations are negatively correlated with PA behaviour (Ingledew & Markland, 2008; M. Lewis & Sutton, 2011; Wilson, Rodgers, & Fraser, 2002), while most have found no significant correlations (Teixeira et al., 2012). It is possible that thwarting of the basic psychological needs may be an independent and more robust independent predictor of controlled regulations and ill-being than basic psychological need satisfaction (Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011; Van den Broeck, Ferris, Chang, & Rosen, 2016). Moreover, researchers that have examined self-determination theory and PA behaviour exclusively in women generally support these findings (Markland, 2009; Milne, Wallerman, Guilfoyle, Gordon, & Courneya, 2008; Silva et al., 2011; Silva, Markland, et al., 2010), suggesting that self-determination theory is relevant for examining

PA Behaviour in Women

Given the utility of self-determination theory for explaining PA behaviour, several interventions have drawn on the theory to increase PA behaviour with success (Edmunds, Ntoumanis, & Duda, 2006; Ng et al., 2012). Often, implementation of a self-determination theory-based intervention aims to increase the basic psychological need satisfaction of participants by creating an autonomy-supportive environment, leading to more autonomous motivation and ultimately increased PA behaviour (Ryan, Patrick, Deci, & Williams, 2008). Autonomy-supportive environments are those which provide people with rationale for the importance of PA, choices, and positive feedback through empathetic communication strategies

(Kayser et al., 2014; Patrick & Williams, 2012). Researchers who have implemented interventions to increase PA among women by fostering an autonomy-supportive environment have found promising results such that women's PA behaviour increased significantly (Edmunds et al., 2008; Moustaka, Vlachopoulos, Kabitsis, & Theodorakis, 2012; Silva, Markland, et al., 2010; Silva, Vieira, et al., 2010), thereby providing evidence to support the utility of self-determination theory in this context.

Self-Regulation

When designing an intervention to promote PA among women who are overweight or obese, it is important to optimize intervention delivery to increase effectiveness while maintaining efficacy, as substantial time pressures from long hours at work or school and family commitments may be a barrier to PA for 73% of women (Welch et al., 2009). Providing participants with tools and strategies to foster self-regulation of PA may lead to greater and longer lasting changes in PA. Indeed, Knittle, De Gucht, Hurkmans, Vlieland, and Maes (2016) identified that PA behaviour following an intervention was predicted both by more autonomous motivation and by the greater use of self-regulation skills. Their findings are consistent with research which reports that self-regulation strategies are positively associated with PA behaviour (Anderson, Wojcik, Winett, & Williams, 2006). Further, one recent study found that using self-regulation techniques mediated the relationship between autonomous motivation and PA behaviour (Nurmi, Hagger, Haukkala, Araujo-Soares, & Hankonen, 2016), whereas another found that autonomous motivation mediated the relationship between PA and self-regulation for other health behaviours (Mata et al., 2009). It is reasonable to posit that self-regulation, when paired with autonomy-support to address motivation, may be a useful technique to teach within an intervention to increase PA in women.

Although many definitions have been used in the literature, self-regulation generally refers to the process of generating thoughts, feelings, and actions, and adapting them as necessary to achieve personal goals (Zimmerman, 2000). Self-regulation of human behaviour has roots in control theory (Wiener, 1948), which is a more general theory of self-regulating systems. The central idea of control theory is that systems self-regulate through a series of negative feedback loops (Wiener, 1948). A negative feedback loop is a cyclical process that detects the current state, compares it to a reference value, and produces an output behaviour to reduce any discrepancies (Wiener, 1948). Applied to the self-regulation of PA behaviour, a person would assess their current PA level, compare it to their goal or a standard, and then adjust their behaviour accordingly (Carver & Scheier, 1982). However, it is important to acknowledge negative feedback loops do not exist in isolation because humans are incredibly complex systems which often have conflicting objectives (Carver & Scheier, 1982). For this reason, behaviour change interventions need to highlight the relative importance of PA, as well as provide assistance in identifying, executing on and evaluating progress towards appropriate goals (Abraham & Michie, 2008; Michie et al., 2011). Given that the complexity in women's lives is substantial (Miller & Brown, 2005), an intervention to help shape self-regulation processes to promote PA behaviour could be beneficial.

Overall, behaviour change interventions that facilitate self-regulation skills for health behaviours, including PA, have been found to be effective (Dombrowski et al., 2012; Michie et al., 2009; Murray et al., 2017; Sniehotta et al., 2005). Whereas most research have recruited both men and women (Murray et al., 2017), a few randomized control trials focused on women have reported significant increases in PA behaviour (Keyserling et al., 2002; Marcus et al., 2015; Opdenacker, Boen, Vanden Auweele, & De Bourdeaudhuij, 2008; Stadler, Oettingen, &

Gollwitzer, 2009). Given this evidence coupled with studies linking self-regulation to PA behaviour (Anderson et al., 2006; Michie et al., 2009), it is important to consider self-regulation processes when addressing PA behaviour change.

Self-monitoring

Although various self-regulation strategies (e.g., goal setting, self-evaluation, intention formation, action planning) positively predict PA engagement, researchers have noted that self-monitoring is particularly important (Dombrowski et al., 2012; Michie et al., 2009; Murray et al., 2017). Self-monitoring is the process of directing attention towards a behaviour (e.g., step count, minutes of PA) or behavioural outcome (e.g., weight, heart rate, physical fitness, health) and keeping a record of it (Michie et al., 2011). Upon reviewing those records, informed adjustments in behaviour can be made to achieve the desired outcome. It is important to support self-monitoring of PA behaviour to ensure that women are equipped accurate information to take an active role in their health.

Providing women with a device (e.g., pedometer, accelerometer) that directly measures their PA behaviour may be particularly effective for facilitating self-monitoring of PA behaviour. Although direct measures of PA have limitations (e.g., they lack the ability to capture more complex movements and activities), they are more consistent than self-observation since they are not susceptible to recall bias (Colley, Butler, Garriguet, Prince, & Roberts, 2018). Devices that use accelerometry to measure PA, such as wearable activity trackers, are able to capture the frequency, duration, and intensity of a broader range of movements when compared to pedometers (Corder, Brage, & Ekelund, 2007) and may be well-suited to help women track their PA behaviour within behaviour change interventions.

Given the recent rise in popularity of wearable activity tracking devices (e.g., Fitbit, Apple Watch, Polar, Jawbone) in consumer markets (International Data Corporation, 2017), and the popular assertion that they may increase motivation for PA (Apple, 2017; Fitbit, 2018), it is pertinent to study their impact on PA behaviour and related psychological constructs. A systematic review of experimental studies that included the use of a wearable activity trackers found that device use was associated with increased PA behaviour (Z. Lewis et al., 2015). Since then, one study has used wearable activity trackers to increase PA behaviour among women, and found an increase of 62 minutes of MVPA per week among those who were given a Fitbit, and no change in PA among those who were given a pedometer (Cadmus-Bertram, Marcus, Patterson, Parker, & Morey, 2015). Although the associations between device use and PA behaviour are promising, several limitations remain and researchers have called for examination through higher-quality randomized controlled trials (Z. Lewis et al., 2015; Mendoza et al., 2017). For instance, most interventions using a wearable activity tracker to increase PA behaviour are multi-component, meaning they pair device use with additional behaviour change techniques in a single intervention group, yet few studies have isolated the device component to determine its specific effects on PA behaviour (B. Lewis, Napolitano, Buman, Williams, & Nigg, 2017; Ridgers, McNarry, & Mackintosh, 2016). Moreover, few studies to date have examined the impact of wearable activity tracker use on motivation for PA. Understanding the association between intervention components and motivation is critically important given that motivation is a significant positive predictor of PA behaviour (Ryan et al., 2009; Teixeira et al., 2012). Of notable exceptions, studies have found and increase in controlled motivation (Kerner, Burrows, & McGrane, 2019; Mendoza et al., 2017), a decrease in autonomous motivation (Kerner et al., 2019; Kerner & Goodyear, 2017), and a decrease in basic psychological need satisfaction

(Kerner & Goodyear, 2017). Although no studies have examined the impact of wearable activity tracker use on motivation for PA among women who are overweight or obese, it is plausible that wearable activity trackers in isolation may not support self-determined motivation for PA in this population.

Based on theoretical perspectives (Deci & Ryan, 1985; Ryan & Deci, 2000) and previous research (Kerner et al., 2019; Kerner & Goodyear, 2017; Mendoza et al., 2017; Teixeira et al., 2012), we reasoned that women's PA behaviour would be more likely to increase if women received an autonomy-supportive intervention to promote internalization of motivation in addition to a wearable activity tracker to facilitate self-regulation. We therefore developed a three-armed randomized control trial to determine if an intervention consisting of providing (A) six weekly behavioural support emails developed using tenets of self-determination theory, (B) a wearable activity tracker, and (C) a paper copy of the Canadian PA guidelines can increase PA among women who are overweight or obese. The secondary objective was to assess if this combined intervention leads to greater change in PA than providing (B) and (C) or only (C). The tertiary objective of this study was to examine if there are differences in change in self-determination theory constructs (i.e., motivational regulations, basic psychological need satisfaction and thwarting) between groups.

Chapter 3: Protocol Manuscript

Target journal: Contemporary Clinical Trials

Exploring the effect of an eHealth intervention on women's physical activity: Design and rationale for a randomized control trial

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Funding: The research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest: The authors declare that they have no conflict of interest.

Abstract

The rising prevalence of obesity among women living in Canada is concerning as it can lead to serious health problems. Nearly 65% of women living in Canada are considered overweight or obese. Regular physical activity (PA) participation is beneficial and can help women manage their weight. Considering women who are overweight or obese are generally physically inactive, interventions drawing on theory are warranted to promote PA. This manuscript reports on the protocol for a randomized controlled trial to assess the effect a self-determination theory-based eHealth intervention on PA among insufficiently active women who are overweight or obese. The intervention provides (A) six weekly behavioural support emails, (B) a wearable activity tracker, and (C) a copy of the Canadian PA guidelines. The effect of the intervention was compared to an intervention that provides (B+C) and another that provides (C). Participants were recruited between September 2018 and March 2019. Data were collected using self-report and direct measures three times: at baseline (week 0), post-intervention (week 7), and at follow-up (week 21). The primary outcome is total metabolic equivalent minutes of PA per week (MET-m/week); exploratory outcomes include number of days of strength training per week, self-determination theory constructs (i.e., motivational regulations, basic psychological need satisfaction and thwarting), and wellbeing indicators (i.e., affect, vitality, depression). Findings will provide insight into which combination of intervention components may be more effective at promoting PA among insufficiently active women who are overweight or obese, and thus inform the design of future interventions designs and research aiming to promote PA.

Keywords: intervention; motivation; obesity; physical activity; women.

Introduction

Promoting regular physical activity (PA) participation is important because it could confer health benefits and aid in weight management (King, Hopkins, Caudwell, Stubbs, & Blundell, 2009; Warburton, Nicol, & Bredin, 2006). Globally, 23% of adults are not meeting current guidelines of 150 minutes of moderate-to-vigorous intensity aerobic activity (MVPA) per week (Sallis et al., 2016), with lower rates being observed for women who are overweight or obese (Colley et al., 2011). It is critical to develop, evaluate, and implement tailored interventions to promote PA participation in this largely inactive segment of the population.

Perceptions of excess weight, low enjoyment of PA, insufficient time, and lack of interest in PA are barriers to PA participation for women who are overweight or obese (Cannioto, 2010; Leone & Ward, 2013; Yoke, 2017). As such, researchers must consider these barriers when developing intervention to promote PA participation in order to increase effectiveness while maintaining efficacy. Technology-mediated interventions, including those that provide participants with a wearable activity tracker to self-monitor their PA, are a promising strategy to promote PA in this population as they would allow women to enroll in and access the intervention at their convenience. Specifically, providing women with a wearable activity tracker may be particularly useful for promoting PA behaviour change because using a tracker can facilitate self-monitoring, which is an effective behaviour change technique (Michie, Whittington, Abraham, McAteer, & Gupta, 2009). Indeed, a recent systematic review found that five out of nine reviewed interventions that provided participants with a wearable activity tracker led to statistically significant increases in PA participation (Z. Lewis, Lyons, Jarvis, & Baillargeon, 2015). However, most interventions in which participants are provided with a wearable activity tracker also implement other intervention components such as PA counselling,

text messages, email-based behavioural support, and/or structured exercise programs (B. Lewis, Napolitano, Buman, Williams, & Nigg, 2017). It remains unclear whether the use of other intervention components influences the effect of providing a wearable activity tracker on PA participation.

There is reason to believe that pairing the provision of a wearable activity tracker with a brief intervention grounded in self-determination theory – a prominent macro-theory of human behaviour (Deci & Ryan, 1985) – may be a better approach when seeking to increase PA participation than only providing a wearable activity tracker. Preliminary evidence shows that providing participants with a tracker may thwart motivation (Mendoza et al., 2017) and hinder basic psychological need satisfaction (Kerner & Goodyear, 2017). Whist these observations have yet to be confirmed with a sample of women who are overweight or obese, there is evidence that theory-based interventions can lead to greater increases in PA participation (Gourlan et al., 2016), and that interventions based in self-determination theory specifically show promise for increasing PA participation among women who are overweight or obese (Silva et al., 2011; Silva et al., 2010). It is possible that targeting motivation and basic psychological need satisfaction by providing participants with autonomy-support (Ryan, Patrick, Deci, & Williams, 2008), in combination with providing a wearable activity tracker, may lead to greater increases in PA participation.

Therefore, the main objective of the study described in this manuscript is to determine if an intervention providing (A) six weekly behavioural support emails developed using tenets of self-determination theory, (B) a wearable activity tracker, and (C) a paper copy of the Canadian PA guidelines can increase PA participation among women who are overweight or obese. The secondary objective is to assess if this combined intervention leads to greater change in PA

participation than providing (B) and (C) or only (C). The tertiary objective of the study is to examine if there are differences in change in self-determination theory constructs (i.e., motivational regulations, basic psychological need satisfaction and thwarting) between groups.

Methods

Study Design

The study is a three-armed parallel randomized trial aiming to test if a 6-week self-determination theory-based eHealth intervention can lead to change in PA participation among women who are overweight or obese. This manuscript describing the study protocol was prepared in accordance with the Standard Protocol Items: Recommendations for Intervention Trials statement (Chan et al., 2013), and the manuscript reporting the study results will be prepared in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomized trials (Schulz, Altman, Moher, & CONSORT Group, 2010). An overview of the flow of participants through the study is available in Figure 1. The study is registered in the ClinicalTrials.gov database (NCT03601663) and it was approved by the University of Ottawa Research Ethics Board (H-06-18-437).

Participants

Women were eligible to participate in the study if they: (1) identified as female, (2) were between the ages of 18 and 65 years, (3) had a body mass index (BMI) greater than 25 kg/m^2, (4) could understand, read, and speak in English, (5) reported being able to safely engage in PA, (6) were not pregnant or lactating, (7) engaged in less than 150 minutes of MVPA per week and less than two muscle/bone strengthening training sessions per week, (8) had access to internet and email, (9) had not used a wearable activity tracking device within the previous 12 months, and (10) lived within 50 km of the University of Ottawa.

Recruitment

Participants were recruited between September 2018 and March 2019 using advertisements on social media or online volunteer boards, posters placed in publicly accessible areas, and by word of mouth. A rolling recruitment strategy was used whereby participants were assessed for eligibility upon contacting the first author, and those who were eligible and willing to participate were scheduled to have their first assessment completed within 14 days of initial contact.

Assessments

Participants completed assessments three times: at baseline (week 0), post-intervention (week 7), and at follow-up (week 21). PA participation, self-determination theory constructs (i.e., basic psychological need satisfaction and thwarting, motivational regulations), and wellbeing indicators (i.e., affect, vitality, depression) data were collected using an online survey administered at all three time points. Sociodemographic and health data were also collected using an online survey administered at baseline. Anthropometric measures (i.e., height, body mass, body composition) were collected in-person at baseline and post-intervention. Participants receiving a wearable activity tracker and/or weekly emails completed additional questions regarding these aspects in the online survey administered post-intervention. The assessment schedule is detailed in Table 1.

Randomization and Blinding

Participants were randomized into one of the three groups following the completion of the baseline assessment. The randomization sequence was generated by an independent researcher using permuted blocks of three and six using a web-based randomization software program (Sealed Envelope Ltd., 2017). The authors were blinded to participants' group

assignments until the baseline assessment was completed, at which point the trial was open label to allow the first author to deliver the intervention.

Intervention

The three arms of this trial are outlined in Table 2. The combined intervention (Group 1) provided participants with (A) six weekly behavioural support emails developed based on the tenets of self-determination theory, (B) a wearable activity tracker, and (C) a paper copy and verbal explanation of the Canadian PA guidelines. The first comparison arm (Group 2) provided participants with (B) and (C). The second comparison arm (Group 3) provided participants with (C) only.

Theoretical Framework

Self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000) is a macro-theory of human motivation encompassing six mini-theories, which collectively provide a framework for explaining PA behaviour and behaviour change. Within self-determination theory, motivation exists along a continuum from amotivation (i.e., a complete lack of motivation for a given behaviour), through controlled motivation (i.e., engagement in a behaviour for external reasons), to autonomous motivation (i.e., engagement in a behaviour for its own sake). There are four distinct types of controlled motivational regulations: external (i.e., to satisfy an external demand or achieve a reward), introjected (i.e., to avoid feelings of guilt or enhance feelings of pride), identified (i.e., because a person consciously values that behaviour), and integrated (i.e., because that behaviour is part of a person's identity). The most autonomous motivational regulation, which occurs when a person engages in a behaviour strictly for its own sake or for enjoyment, is called intrinsic motivation. More autonomous forms of motivation are more predictive of sustained PA behaviour (Deci & Ryan, 1985; Ryan & Deci, 2000; Silva et al., 2011; Teixeira,

Carraca, Markland, Silva, & Ryan, 2012). Autonomous motivation can be enhanced by providing support for the basic psychological needs of autonomy, competence, and relatedness, as outlined in basic psychological need theory (Ryan & Deci, 2000). Moreover, basic psychological need satisfaction and autonomous motivation can be enhanced by providing participants with autonomy-support, leading to increased PA participation (Ryan et al., 2008).

Autonomy-supportive environments are those which provide people with rationale for the importance of PA, choices, and positive feedback through empathetic communication strategies (Kayser, Cossette, & Alderson, 2014). Fostering autonomous motivation may also increase the efficacy of using a wearable activity tracker to self-monitor PA participation. A prospective study found that self-monitoring mediated the relationship between autonomous motivation and PA, such that autonomous motivation predicted self-monitoring which predicted PA participation (Nurmi, Hagger, Haukkala, Araujo-Soares, & Hankonen, 2016), suggesting that supplementing the provision of a wearable activity tracker with support for autonomous motivation may lead to greater changes in PA than either strategy in isolation. As such, the combined intervention (Group 1) provided participants with a wearable activity tracker to support self-monitoring, six weekly emails to enhance autonomous motivation for PA, and a paper copy of the Canadian PA guidelines. The purpose of having two comparison groups is to determine if the combined intervention is more effective at increasing PA participation than providing a wearable activity tracker and a paper copy of the Canadian PA guidelines only or providing the Canadian PA guidelines only. The comparison groups will also allow for exploratory analyses examining if there are differences in changes in self-determination theory constructs (i.e., basic psychological need satisfaction and thwarting, motivational regulations) between groups.

The emails provided to participants in the combined intervention (Group 1) contained information and activities that integrated empirically supported behaviour change techniques (Michie et al., 2009). They were presented so as to convey choice, opportunity for striving and success, and empathy; thereby supporting basic psychological need satisfaction and enhancing autonomous motivation for PA (Kayser et al., 2014). For example, participants were asked to make and adjust plans describing what, when, where, and with whom they planned to do their PA of choice and to make contingency plans for actual and potential barriers using if/then statements, as these may be powerful strategies for supporting PA (Hagger & Luszczynska, 2014). Additionally, the weekly emails encouraged participants to self-monitor their efforts towards their *behaviour* (e.g., step count, frequency of activity) rather than towards *outcomes* of their behaviour (e.g., body mass, body fat percentage) because self-monitoring of *behaviour* is a robust predictor of change in PA participation based on two meta-analyses of interventions (Michie et al., 2009; Murray et al., 2017). Other recurring themes throughout the intervention included learning from trial and error, focusing on making small changes, choosing activities that were enjoyable, and aligning plans with personal beliefs and values. A detailed overview of the weekly intervention content, as well as the behaviour change techniques used in the emails, as per the refined CALO-RE taxonomy (Michie et al., 2011), are provided in Table 3. The behaviour change techniques were separately coded by the first author as well as a researcher not involved in the study. Discrepancies were resolved by discussion between both authors.

Procedures

Following the completion of the in-person baseline assessment, group allocation was revealed to participants. The first author provided participants in all groups with a paper copy of the Canadian PA guidelines along with a brief explanation of the guidelines and answered any

questions participants had about PA. Participants who were randomized to Group 1 or Group 2 received a Polar A300 activity monitor, a charging cable, and a username with a password to access the Polar Flow web and smartphone application. Participants were instructed to wear the device during waking hours, except when swimming or bathing, beginning the day following the in-person baseline assessment. The first author provided instructions on how to navigate the device and assisted participants in syncing the device with their smartphone. Only participants in Group 1 received the weekly emails throughout the study. The first email was sent the day following the in-person baseline assessment. The next email was sent one week following the previous email until all six emails were delivered. Participants in Group 2 and Group 3 received a copy of the emails subsequent to the completion of the follow-up assessment to thank them for their participation in the study.

Measures

Primary outcome.

Total PA. The primary outcome of the trial is total metabolic equivalent minutes of PA per week (MET-m/week), which was assessed using the International PA Questionnaire Short Form (IPAQ-S) at baseline, post-intervention, and at follow-up. Participants were asked to report the number of days and average duration over the past week which they engaged in sedentary behaviour, walking, and moderate and vigorous intensity PA. The number of days was multiplied by the average duration to estimate the number of minutes per week for each category. Scores for walking, moderate PA, and vigorous PA were multiplied by their energy requirements (3.3, 4.0, and 8.0 METs, respectively), and then summed to create a composite MET-m/week score. Scores on the IPAQ-S have demonstrated good reliability and validity for use in adult

populations (Craig et al., 2003), and has previously been used to assess PA in interventions with women who are overweight or obese (Quinn, Doody, & O'Shea, 2008).

Secondary outcomes.

Strength training. Strength training was assessed at baseline, post-intervention and at follow-up using a custom set of questions developed by the authors. Participants were asked to report the number of days they completed any strength or resistance activity within the previous 7 days. Additionally, participants reported the average duration and the context (i.e., type of exercises, location, people) of their strength or resistance training activities using a series of open-ended and multiple-choice questions.

Affect. Affect was measured at baseline, post-intervention and at follow-up using the short form of the Positive and Negative Affect Schedule (I-PANAS-SF; Thompson, 2007). Participants were asked to rate the degree to which they felt each of five positive and five negative items within the past week using a 5-point scale ranging from (1) “very slightly or not at all”, (2) “a little”, (3) “moderately”, (4) “quite a bit” and (5) “extremely”. Negative items were reverse coded before averaging positive items and the reversed negative items to create a total affect score. Scores on the I-PANAS-SF have shown good psychometric properties across culturally-diverse samples (Thompson, 2007).

Wellbeing. The Subjective Vitality Scale (Ryan & Frederick, 1997) was used as an indicator of wellbeing at baseline, post-intervention and at follow-up. Participants were asked to rate degree to which they generally agree with 7 statements using a 7-point Likert scale ranging from (1) “not true at all”, (4) “somewhat true”, and (7) “very true”. An average vitality score was calculated by averaging scores for all items. The Subjective Vitality Scale has shown adequate validity for use in adult populations (Bostic, Rubio, & Hood, 2000).

Depressive symptoms. The Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001) was used to assess severity of depressive symptoms at baseline, post-intervention and at follow-up. Participants were asked to indicate how often they had experienced certain symptoms of depression by responding to nine items using a 4-point scale ranging from (0) "not at all", (1) "several days", (2) "more than half of the days" and (3) "nearly every day" within the past two weeks. A total depression score was calculated by summing the scores for each item, whereby higher scores represent a greater presence of depressive symptoms. Scores on the PHQ-9 have been shown to be valid and reliable, and this is a widely used measure of depression severity (Kroenke et al., 2001).

Acceptability and device use. Post-intervention, participants allocated to Group 1 were asked what they liked, disliked, and would improve about the overall intervention through three open-ended questions. Participants allocated to Group 1 and Group 2 were asked questions regarding how often they wore the wearable activity tracker, how often they looked at their PA data on their wrist and through the web application, and how valuable they found having a wearable activity tracker.

Mechanisms of change.

Perceived autonomy support for PA. Post-intervention, perceived autonomy support for PA was measured using the Perceived Autonomy Support Scale for Exercise Settings (PASSES) questionnaire (Hagger et al., 2007) for participants in Group 1. For the purpose of the study, the scale was modified by replacing the words "PE teacher" with "facilitator", and "active sports and/or vigorous exercise" with "PA". The PASSES contains 12 items assessing a broad range of autonomy-supportive behaviours, which were rated by participants on a 7-point Likert scale ranging from (1) "strongly disagree" to (7) "strongly agree". A total perceived autonomy support

score was calculated by averaging scores for all items. Whereas the PASSES was developed to assess students' perceptions of their teachers' autonomy-supportive behaviours and has undergone rigorous development and validation processes (Hagger et al., 2007), it has since been used in the context of a behaviour change intervention with women and has shown good internal consistency and construct validity (Mehrtash & Levent Ince, 2018).

Basic psychological need satisfaction for PA. The extent to which participants perceived that their perceptions of autonomy, competence, and relatedness were satisfied in PA was measured using the Psychological Need Satisfaction in Exercise scale (PNSE; Wilson, Rogers, Rodgers, & Wild, 2006) at baseline, post-intervention and at follow-up for participants in all three groups. The PNSE contains 18 statements divided equally into three subscales which measure perceived autonomy, competence, and relatedness for exercise. All items were rated using a 6-point Likert scale ranging from (1) "false" to (6) "true". For the purpose of the study, the scale was modified by replacing the word "exercise" with "PA". As in previous research (Deci et al., 2001; Sebire, Standage, & Vansteenkiste, 2009), the average for all items was computed to create a global need satisfaction score representing overall basic psychological need satisfaction for PA in order to conserve power. Scores on the original PNSE scale have demonstrated good structural validity and internal reliability (Wilson, Rogers, et al., 2006; Wilson & Rogers, 2008), which have been mirrored in a study employing a similar adaptation (Gunnell, Wilson, Zumbo, Mack, & Crocker, 2012).

Basic psychological need thwarting for PA. The Psychological Need Thwarting Scale (PNTS; Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011) was administered to participants at baseline, post-intervention and at follow-up for participants in all three groups. The scale was used to assess the extent to which participants perceived that their perceptions of

autonomy, competence, and relatedness were actively inhibited by others in PA contexts, which is conceptually different than need satisfaction (Bartholomew et al., 2011; Deci & Ryan, 2000). The PNTS contains 12 items that are rated using a 7-point Likert scale ranging from (1) "strongly disagree" to (7) "strongly agree". The average for all items was computed to create a global need thwarting score representing the overall extent to which basic psychological need were inhibited. Scores on the PNTS have previously shown good reliability and validity for use in adult populations (Bartholomew et al., 2011).

Motivation for PA. Motivation for PA was assessed using the third version of the Behavioural Regulation in Exercise Questionnaire (BREQ-3; Markland & Tobin, 2004; Wilson, Rodgers, Loitz, & Scime, 2006) at baseline, post-intervention and at follow-up for participants in all three groups. The BREQ-3 includes 24 items divided into six subscales assessing all six motivational regulations. For the purpose of the study, the scale was modified replacing the word "exercise" with "PA" Participants were asked to respond to each item using a 5-point Likert scale with anchors (0) "not true for me and (4) "very true for me". A relative autonomy index (RAI; Ryan & Connell, 1989), which is a single score representing overall motivation, was calculated by weighting each BREQ-3 subscale [i.e., amotivation (-3), external (-2), introjected (-1), identified (1), integrated (2), intrinsic (3)] and summing the weighted scores, whereby higher scores represent greater autonomous motivation for PA. Scores on the BREQ-3 have been shown to have good internal consistency (Duncan, Hall, Wilson, & Rodgers, 2012).

Covariates and descriptive information.

Sociodemographic and health information. Sociodemographic and health information were collected from participants in all three groups at baseline. Sociodemographic measures included self-reported age, sex, marital status, ethnicity, level of education, age and number of

children, annual household income, and employment status. Health measures included self-reported history of chronic diseases, smoking history, menstrual status, body mass, weight-related goals, and self-rated health. Self-rated health was measured using the first question of the RAND 36-item Short Form Health Survey (SF-36; Ware & Sherbourne, 1992), which asks "In general, how would you say your health is?" and provides five response categories: (1) "excellent", (2) "very good", (3), "good", (4) "fair", and (5) "poor". Self-reported body mass and health were re-assessed post-intervention and at follow-up.

Anthropometrics. Participants' height (cm), body mass (kg), body composition, and waist circumference (cm) were measured at baseline and post-intervention for participants in all three groups. Body mass and composition were measured using a hospital-grade body weight scale (BWB 800S, Tanita Corporation of America Inc., Arlington Heights, IL, USA). Participants were asked to refrain from drinking alcohol or engaging in MVPA for 12 hours prior to the assessment, eating or drinking for 3 hours prior to the meeting, and eating excessively or restrictively for the 24 hours leading up to the assessment (Tanita, 2013). Height was measured using a portable wall-mounted height rod (HR-200, Tanita Corporation of America Inc., Arlington Heights, IL, USA). Waist circumference was measured with a measuring tape at the visually inspected midpoint between the last rib and the iliac crest.

Statistical Analyses

Data analyses will be performed using SPSS Statistics (version 26; IBM Corporation, Armonk, NY, USA). Initially, descriptive statistics will be calculated for all variables at each time point. Next, data will be screened to explore patterns of missing data, identify outliers, and verify the assumptions of normality. Analyses will be completed using an intent-to-treat model; missing PA data at post-intervention will be imputed by carrying forward baseline values. One-

way analysis of variance will be used to determine if there were significant differences between groups at baseline. If significant differences exist between groups at baseline, those variables may be included as covariates in the analysis. Two-way mixed repeated measures analysis of variance will be used to assess within- and between-group changes in MET-m/week (primary outcome). Additional analyses will be undertaken using descriptive statistics and analysis of variance to examine differences within- and between-groups in self-determination theory constructs (i.e., motivational regulations, basic psychological need satisfaction and thwarting), and wellbeing indicators (i.e., affect, vitality, depression; exploratory outcomes). Results will be considered statistically significant if $p<.05$.

Sample Size

No studies matching this study in terms of intervention type, population, and measure of PA were identified for determining sample size. Therefore, sample size was determined to have sufficient power to detect a moderate effect size of 0.25, based on findings from a meta-analysis of pedometer-based PA interventions (Bravata et al., 2007) and other interventions with overlapping features developed to promote PA in similar populations (Cadmus-Bertram, Marcus, Patterson, Parker, & Morey, 2015; Wang et al., 2015). Assuming a two-tailed $p<0.05$, a total sample of 42 participants (14 participants per group) was needed to achieve 80% power.

Discussion

There is overwhelming evidence to support the benefits of regular PA (King et al., 2009; Warburton et al., 2006), and women who are overweight or obese are one segment of the population who exhibit some of the lowest levels of PA (Colley et al., 2011). It is important to develop, evaluated, and implement to increase PA while considering the barriers to PA participation of the target population. For women who are overweight or obese, factors which

could be addressed include lack of motivation or enjoyment, insufficient time, fatigue, and excessive stress (Dugan et al., 2016; Eyler et al., 2002; Huberty et al., 2008; Im, Lee, Chee, & Stuifbergen, 2011; Leone & Ward, 2013; Yoke, 2017). Providing a wearable activity tracker to participants has been suggested to be a promising strategy as it could enable women to self-monitor their PA, thus assisting women to guide changes in their own behaviour and lessening time constraints associated with participating in more intensive interventions. A recent systematic review shows that interventions that include wearable activity trackers can lead to increases in PA participation (Z. Lewis et al., 2015), but further investigation is warranted considering that using a wearable activity tracker may have a negative impact on motivation for PA (Mendoza et al., 2017) and basic psychological need satisfaction (Kerner & Goodyear, 2017), which could undermine long-term PA behaviour change. The randomized controlled trial described herein seeks to test if an intervention that provides women with (A) six weekly emails to enhance autonomous motivation for PA, (B) a wearable activity tracker to support self-monitoring, and (C) a copy of the Canadian PA guidelines can increase PA among women who are overweight or obese, and if this combined intervention is more effective than providing women with either (B) and (C), or only (C). The study also seeks to examine if there are differences in changes in self-determination theory-based constructs between groups.

The study described in this manuscript will make several noteworthy contributions to the literature. The recent popularity of commercially-available wearable activity trackers has resulted in an explosion of research leveraging this technology in multi-component interventions to increase PA in various populations (B. Lewis et al., 2017; Müller et al., 2017), and the study will be among the first in the field to compare the effects of providing (A) autonomy-support for PA via email, (B) a wearable activity tracker, and (C) a copy of the Canadian PA guidelines to

providing (B+C) or only (C) by implementing a three-armed randomized control trial design. Researchers examining the efficacy of eHealth interventions to promote PA have suggested that multi-component interventions may produce stronger effects on change in PA than single-component eHealth interventions (Maher et al., 2014; Schoeppe et al., 2016; Vandelanotte et al., 2016). The main objective of the study will address a practical research question and provide valuable insights regarding which combination of intervention components is most effective at changing behaviour, which can be used by practitioners and researchers to develop, modify, and enhance future interventions to promote PA participation among insufficiently active women who are overweight or obese.

Additionally, the study will contribute to a growing body of research drawing on self-determination theory to explain the success (or lack thereof) of interventions using wearable activity trackers to increase PA participation, which is highly relevant given the strong evidence linking constructs from self-determination theory with PA (Ryan, Williams, Patrick, & Deci, 2009; Teixeira et al., 2012). A recent systematic review found that, on average, interventions that provide participants with wearable activity trackers can lead to increases in PA participation (Z. Lewis et al., 2015), yet several subsequent studies have noted inconsistencies in responses to the intervention (Gaudet, Gallant, & Bélanger, 2017; Hermsen, Moons, Kerkhof, Wiekens, & De Groot, 2017; Piwek, Ellis, Andrews, & Joinson, 2016). Drawing on research in other populations (Kerner, Burrows, & McGrane, 2019; Kerner & Goodyear, 2017; Mendoza et al., 2017), it is possible that using wearable activity tracker without sufficient self-determined motivation for PA may lead to the device being perceived as controlling, thus leading to discontinuation of device use and inhibited change in PA. As such, the study will be among the first to examine changes in basic psychological need satisfaction/thwarting and motivation for PA among women who are

overweight or obese and have used a wearable activity tracker to monitor their PA participation. Upon completion, the study will provide practical insight into whether a brief, email-based intervention can enhance changes in PA participation, basic psychological need satisfaction and thwarting, motivation for PA above and beyond the provision of a wearable activity tracker.

Nevertheless, certain limitations must also be acknowledged. First, a relatively small sample size was selected for reasons of feasibility. Regardless, the study is sufficiently powered to address the primary and secondary objectives testing if a combined intervention can increase PA among women who are overweight or obese, and if this intervention is more effective than two minimal interventions. To conserve power in exploratory analyses, aggregate measures were created for exploratory outcomes [self-determination theory constructs (i.e., motivational regulations, basic psychological need satisfaction and thwarting) and wellbeing indicators (i.e., affect, vitality, depression)]. Third, there may be selection bias due to the selected recruitment strategies which may have two implications on the results: the sample may not be representative of all women who are overweight, and women who volunteer to participate in this trial may be more motivated to increase their PA than the broader population. Fourth, despite the known benefits of direct measures of physical activity (Prince et al., 2008), a self-report measure of physical activity was chosen to reduce the potential for contamination if participants in Group 3 were to perceive that they are being monitored and inadvertently make changes to their PA participation. Finally, the assessment schedule combined with the brief duration of the intervention will only allow for exploration of short-term (i.e., less than 6 months) change in PA participation, therefore conclusions about the long-term impact of the interventions should be avoided.

Despite these limitations, the study represents an important step towards the long-term need to develop interventions that have an impact on PA participation among women who are overweight or obese. By using flexible delivery methods designed for participants' convenience, exploring the impact of the intervention of PA and motivation for PA simultaneously, and isolating the effect of the wearable activity tracker from other intervention components, the study will contribute important theoretical insights and allow researchers make practical recommendations for developing interventions to promote PA participation among women who are overweight or obese – an important segment of the population among whom PA participation is particularly low.

Figure 1. Diagram of participant flow through study.

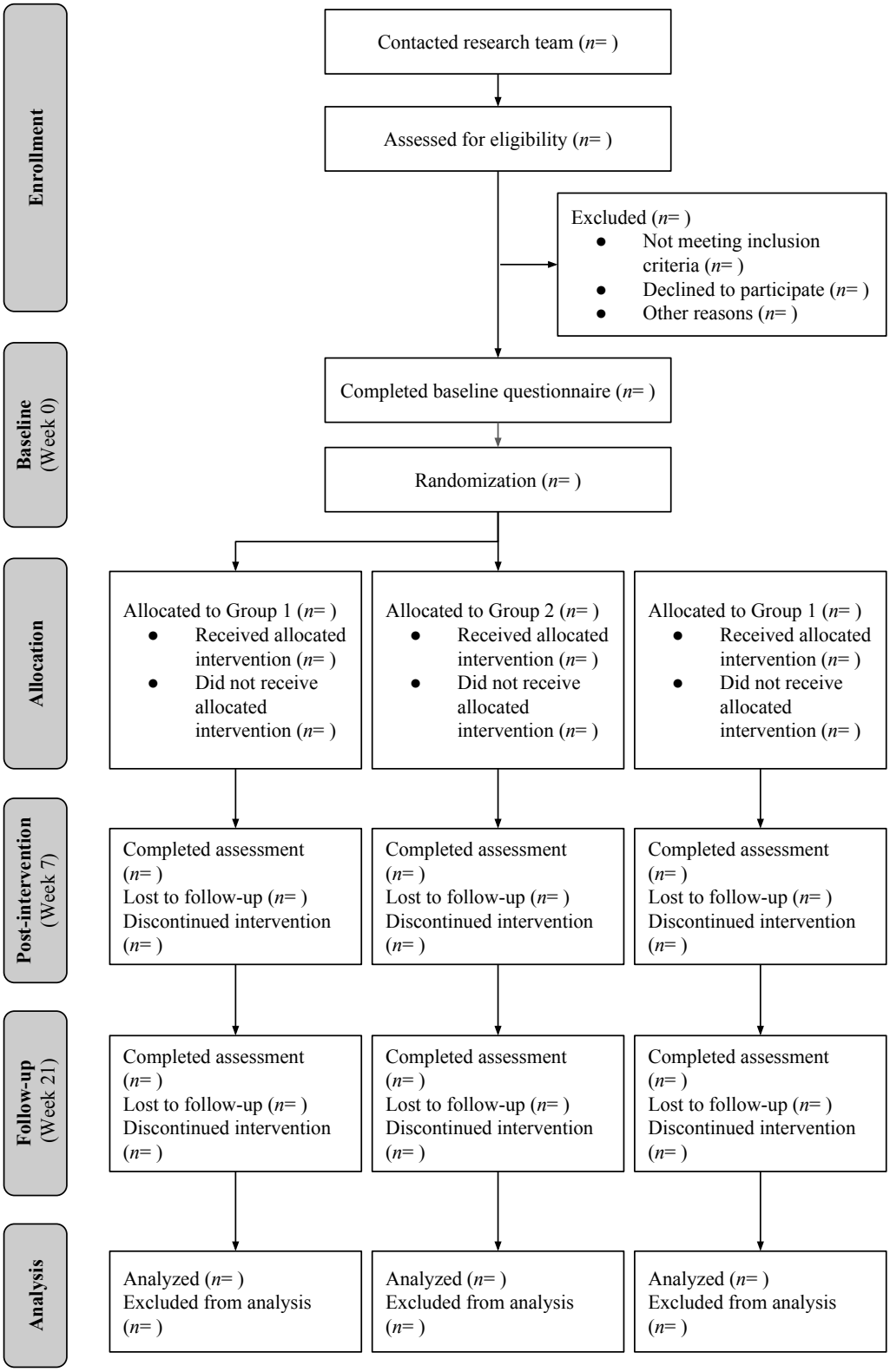

Table 1. Assessment schedule.

Variables	Baseline		Post-intervention		Follow-up
	Online	In-person	Online	In-person	Online
Physical activity	X		X		X
Sedentary behaviour	X		X		X
Sociodemographic information	X				
Self-reported health	X		X		X
Height		X			
Body mass	X	X	X	X	X
Body composition		X		X	
Waist circumference		X		X	
Acceptability of email intervention			X[a]		
Frequency of device use			X[b]		
Perceived autonomy-support			X		
Basic psychological need satisfaction for physical activity	X		X		X
Basic psychological need thwarting for physical activity	X		X		X
Motivational regulations for physical activity	X		X		X
Affect	X		X		X
Wellbeing	X		X		X
Depressive symptoms	X		X		X

[a] Participants in Group 1 only; [b] Participants in Group 1 and 2 only

Table 2. Overview of intervention components and groups.

Component	Group 1	Group 2	Group 3
Canadian physical activity guidelines	X	X	X
Wearable activity tracker	X	X	
Weekly emails	X		

Table 3. Overview of weekly emails.

Week	Purpose	Content	Behaviour change techniques included	Worksheets
1	Getting motivated for PA: To learn about the benefits and explore motives for PA	Overview of program; definitions, benefits, and recommendations for PA; self-assessment of PA behaviour; personal reasons for making a change; confidence	Provide information on consequences of behaviour in general; prompt self-monitoring of behaviour	1.1 Decisional Balance Worksheet 1.2 Importance Ruler 1.3 Confidence Ruler
2	Exploring PA: To expose the truths behind some physical activity myths and explore personal interests	Benefits of PA; pros and cons of making a change; personal reasons for making a change; myths about PA; choosing interesting and enjoyable types of PA	Provide information on consequences of behaviour in general; prompting focus on past success	2.1 Pros and Cons of physical activity Worksheet 2.2 Exploring physical activity Worksheet
3	Making a plan and taking action: To build an initial plan to increase PA	Personal reasons for making a change; setting SMART goals; choosing interesting and enjoyable types of PA; writing if/then statements; learning from experience	Goal setting (behaviour); action planning; agree to a behavioral contract; barrier identification/problem solving	3.1 Action Planning Worksheet
4	Adjusting your plan: To learn from previous experiences and enhance action plans	Learning from experience; barriers to PA; making small adjustments; self-monitoring; social support	Barrier identification/problem solving; prompt review of behavioural goals; prompt self-monitoring of behaviour; plan social support/social change	4.1 Week-in-review Worksheet 4.2 Barriers to physical activity Information Sheet 4.3 Social Support Worksheet
5	Maintaining motivation: To learn	Learning from experience; self-monitoring; positive	Prompt self-monitoring of behaviour; plan social	5.1 Self-monitoring

	strategies to help maintain motivation in the face of challenges	and negative social support; self-talk	support/social change; prompt self-talk	Information Sheet 5.2 Self-talk Worksheet
6	Keep the momentum going: To review the topics covered throughout the program in preparation to continue making changes independently	Benefits and recommendations for PA; personal reasons for making a change; setting SMART goals; choosing interesting and enjoyable types of PA; writing if/then statements; learning from experience; self-monitoring; social support; long-term thinking	Provide information on consequences of behaviour in general; prompt review of behavioural goals; agree to a behavioural contract; goal setting (behaviour); action planning; barrier identification/problem solving; prompt self-monitoring of behaviour; plan social support/social change; relapse prevention/coping planning; barrier identification/problem solving;	6.1 Revised Action Planning Worksheet

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Chapter 4: Results Manuscript

Target Journal: Journal of Physical Activity and Health

Full title: An eHealth physical activity intervention for women who are overweight or obese: A r randomized control trial

Running head: eHealth intervention for physical activity

Manuscript type: Original research

Keywords: intervention; obesity; physical activity; randomized trial; women.

Authors:
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Abstract

Background: Obesity can lead to serious health problems. Physical activity (PA) can aid in weight management and maintaining wellbeing, yet women who are overweight or obese are generally physically inactive. This brief eHealth intervention draws on self-determination theory to promote PA in women with a body mass index (BMI) ≥25kg/m^2. Methods: Women were randomized into a combined intervention group that provides (A) six weekly behavioural support emails, (B) a wearable activity tracker, and (C) a copy of the Canadian PA guidelines (Group 1), a comparison group that provides (B) and (C) (Group 2) or (C) (Group 3). PA was self-reported at baseline and post-intervention. Data were analysed using mixed repeated measures analysis of variance. Results: Forty-six women (M_{age}=37.72±11.87 years, M_{BMI}=31.55±5.96 kg/m^2) were included in the analyses. Mean PA at baseline across all groups was 1148.12±1091.03 metabolic equivalent MET-minutes per week. Overall, PA increased from baseline to post-intervention (F=17.95, p<.001, η^2=.295). There were no significant differences in baseline PA or change in PA between groups (p>.05) and the interaction between group and time was not significant (p>.05). Conclusions: Participants in this study showed a large and significant increase in PA, but the different interventions did not have differential impact on change in PA.

Introduction

Regular engagement in physical activity (PA) is important as it is associated with numerous physical and mental health benefits (Warburton & Bredin, 2017) and can aid in weight management (King, Hopkins, Caudwell, Stubbs, & Blundell, 2009). In Canada, only 32% of people meet the current PA guidelines of 150 minutes of moderate-to-vigorous intensity aerobic activity (MVPA) per week (Statistics Canada, 2015), with lower rates being observed among women who are overweight or obese (Colley et al., 2011). Thus, it is important to design, develop, and implement interventions to promote PA in this largely inactive segment of the population.

Previous interventions designed to increase PA among women who are overweight or obese have shown promising results (Cadmus-Bertram, Marcus, Patterson, Parker, & Morey, 2015; Edmunds, Ntoumanis, & Duda, 2008; Moustaka, Vlachopoulos, Kabitsis, & Theodorakis, 2012; Silva et al., 2010a; Silva et al., 2010b). However, time pressures from work, school, and family commitments remain a barrier to PA for 73% of women (Welch, McNaughton, Hunter, Hume, & Crawford, 2009), and may impair their ability to engage in interventions aimed at promoting PA. Technology-mediated interventions are a promising strategy to promote PA as they allow women to enroll in and access the intervention at their convenience. One such intervention is one that provides women with a device (i.e., wearable activity tracker) that directly measures their PA to facilitate self-monitoring of PA behaviour. Upon reviewing their data, women can make informed adjustments to increase or maintain their PA in order to reach their PA goals. In support of this type of intervention, the authors of a systematic review of interventions that provide participants with wearable activity trackers concluded that device use was associated with increases in PA (Lewis, Lyons, Jarvis, & Baillargeon, 2015). Also, several

other authors have shown that providing wearable activity trackers to women can have an immediate positive impact on PA (Cadmus-Bertram et al., 2015; Cotie et al., 2018). Collectively, this evidence suggests wearable activity trackers are helpful for promoting PA.

Whilst wearable activity trackers may be helpful for promoting PA, using these devices could have a negative long-term impact on PA and wellbeing (Toner, 2018). A growing number of studies have found that using a wearable activity tracker may undermine motivation for PA (e.g., Attig & Franke, 2018; Kerner & Goodyear, 2017; Mendoza et al., 2017). Accordingly, some researchers have suggested that participants may be more likely to increase their PA if they received a theoretically-based behavioural intervention in addition to receiving a wearable activity tracker to support self-monitoring (Ellis & Piwek, 2018; Sullivan & Lachman, 2017).

Self-determination theory is a suitable theory for developing an intervention to supplement the provision of a wearable activity tracker because it provides a powerful framework for explaining women's PA (Markland, 2009; Milne, Wallerman, Guilfoyle, Gordon, & Courneya, 2008; Silva et al., 2011; Silva et al., 2010a) and has previously been used to develop effective interventions (Edmunds et al., 2008; Moustaka et al., 2012; Silva et al., 2010a; Silva et al., 2010b). Self-determination theory is a macro-theory of human motivation which holds that motivation exists along a continuum from amotivation (i.e., complete lack of motivation) through controlled motivation (i.e., engagement in behaviour for external reasons including rewards, pride, or guilt) to autonomous motivation (i.e., engagement in behaviour for its own sake; Deci & Ryan, 1985; Ryan & Deci, 2000). More autonomous forms of motivation are predictive of sustained PA behaviour (Silva et al., 2011; Teixeira, Carraca, Markland, Silva, & Ryan, 2012). Autonomous motivation can be enhanced by offering participants with choices and feedback delivered empathetically (Kayser, Cossette, & Alderson, 2014), which in turns

fosters perceptions of autonomy, competence, and relatedness, as well as autonomous motivation and behaviour (Ryan & Deci, 2000).

The Present Study

Drawing on self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000) and previous research (Kerner & Goodyear, 2017; Mendoza et al., 2017; Toner, 2018), we reasoned that PA would increase more if women with overweight or obesity received an autonomy-supportive intervention to increase autonomous motivation in addition to receiving a wearable activity tracker to facilitate self-monitoring. We therefore developed a 6-week eHealth intervention drawing on self-determination theory to promote PA in women with a body mass index (BMI) $\geq 25 kg/m^2$. Briefly, the combined intervention (Group 1) provided women with (A) six weekly behavioural support emails based in self-determination theory, (B) a wearable activity tracker, and (C) a paper copy and verbal explanation of the Canadian PA guidelines. The first comparison group (Group 2) provided women with (B) and (C). The second comparison group (Group 3) only provided women with (C). We hypothesized that women in Group 1 would increase their PA from baseline to post-intervention, and that women in Group 1 would increase their PA more than those in Group 2 and Group 3.

Methods

Study Design

This study is a 6-week parallel three-armed randomized control trial. Data were collected at baseline (pre-intervention) and post-intervention using a combination of self-report questionnaires and direct measurements. Reporting of this study follows Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomized control trials (Schulz, Altman, Moher, & CONSORT Group, 2010). This trial was registered with www.clinicaltrials.gov (No.

NCT03601663) and was approved by the University of Ottawa Ethics Board (H-06-18-437). All participants provided written informed consent. This study addresses the primary objectives of a broader randomized control trial, which is described in greater detail in Chapter 3: Protocol Manuscript.

Protocol

Recruitment. A convenience sample of women were recruited between September 2018 and March 2019, through advertisements placed on social media (i.e., Facebook) or online boards (i.e., Kijiji, Craigslist, local classifieds) and posters placed in publicly accessible areas (i.e., community centers, physician's offices). Women interested in participating in this study were asked to contact the research team for further information and to be screened for eligibility.

Eligibility. Women were eligible to participate in this study if they: (1) identified as female, (2) were between the ages of 18 and 65 years, (3) had a BMI greater than 25 kg/m^2, (4) could understand, read, and speak in English, (5) were able to safely engage in PA, (6) were not pregnant or lactating, (7) engaged in less than 150 minutes of MVPA and less than two muscle/bone strengthening activities per week, (8) had access to the internet and an email account, (9) had not used a wearable activity tracking device within the previous 12 months, and (10) lived within 50 km of the University of Ottawa. Women were screened for eligibility by the first author over the phone.

Assessments. Participants completed assessments at baseline and post-intervention. PA data were collected in an online survey at both time points. Anthropometric measures (i.e., height, weight, body mass, body composition) were collected in-person at both time points. Sociodemographic and health data were collected in an online survey at baseline.

Intervention Procedures

Following the completion of the in-person baseline assessment, participants were randomized into one of the three groups and received intervention materials based on their group allocation. Participants in all groups received a paper copy and brief verbal explanation of the Canadian PA guidelines. Participants who were randomized to Group 1 or Group 2 also received a Polar A300 activity monitor, a charging cable, and a username and password to access the Polar Flow web and smartphone applications. Participants were instructed to wear the device during waking hours, except when swimming or bathing, beginning the day following the in-person baseline assessment. The first author also provided instructions on how to navigate the device and assisted participants in syncing the device with their smartphone or computer. Participants in Group 1 also received one email each week for 6 weeks.

The weekly emails were designed to enhance autonomous motivation for PA. They included information and resources which participants could use to increase their PA, based on empirically supported behaviour change techniques such as goal setting, action planning, contingency planning, and self-monitoring (Hagger & Luszczynska, 2014; Michie, Whittington, Abraham, McAteer, & Gupta, 2009; Murray et al., 2017). Moreover, the emails were written so as to convey choice, opportunity for striving and success, and empathy in order to foster basic psychological need satisfaction (i.e., perceptions of autonomy, competence, and relatedness) and enhance autonomous motivation for PA (Kayser et al., 2014; Patrick & Williams, 2012). Additional details regarding the content of the weekly emails are available in Chapter 3: Protocol Manuscript. Participants in Group 2 and Group 3 received the weekly emails following the completion of the last study assessment.

Measures

Sociodemographic and health. Sociodemographic and health data were collected from participants at baseline. Sociodemographic measures included self-reported age, marital status, ethnicity, highest level of education attained, number of children and their age, annual household income, and employment status. Health measures included self-reported history of chronic diseases, smoking history, and self-rated health. Self-rated health was measured using the first question of the RAND 36-item Short Form Health Survey (SF-36; Ware & Sherbourne, 1992), which asks "In general, how would you say your health is?" and provides five response categories: (1) "excellent", (2) "very good", (3), "good", (4) "fair", and (5) "poor". Self-reported health was re-assessed post-intervention.

Anthropometrics. Participants' height (m), body mass (kg), body composition, and waist circumference (cm) were measured at baseline and post-intervention. Body mass and composition were measured using a hospital-grade body weight scale (BWB 800S, Tanita Corporation of America Inc., Arlington Heights, IL, USA). Participants were asked to refrain from drinking alcohol or engaging in MVPA for 12 hours prior to the meeting, eating or drinking for 3 hours prior to the meeting, and eating excessively or restrictively for the 24 hours leading up to the meeting (Tanita, 2013). Height was measured using a portable wall-mounted height rod (HR-200, Tanita Corporation of America Inc., Arlington Heights, IL, USA). Waist circumference was measured with a measuring tape at the visually inspected midpoint between the last rib and the iliac crest.

PA. The primary outcome of the trial was PA, which was assessed using the International PA Questionnaire Short Form (IPAQ-S). Participants were asked to report the number of days and average duration over the past week which they engaged in sedentary behaviours, walking, and moderate and vigorous intensity PA. The number of days is multiplied by the average

duration to estimate the number of minutes per week for each category. Scores for walking, moderate PA, and vigorous PA were then multiplied by their energy requirements (3.3, 4.0, and 8.0 METs respectively), and then summed to create a composite PA score in MET-minutes per week. Scores on the IPAQ-S have demonstrated good reliability and validity for use in adult populations (Craig et al., 2003).

Statistical Analysis

Data were analyzed using SPSS Statistics (version 26; IBM Corporation, Armonk, NY, USA). Initially, all data were screened for missingness, outliers, and normality. Missing data for the outcome variable at post-intervention were imputed for four (8.75%) participants by carrying forward baseline values according to the intent-to-treat principle. One participant was missing baseline data for total PA and was removed from analyses. Next, univariate outliers were identified by calculating a z-score, and those greater than ±3 standard deviations from the mean were removed and replaced with the next highest non-outlier value. The distributions for total PA at baseline and post-intervention were not normally distributed as assessed by the Shapiro-Wilk's test ($p<.05$), thus a two-step approach was applied to normalize the data (Templeton, 2011).

Descriptive statistics were calculated for sociodemographic, health information, and PA. One-way analysis of variance was used to determine if there were significant differences between groups at baseline. Two-way mixed repeated measures analysis of variance was used to assess within- and between-group changes in PA. Of note, non-parametric tests (i.e., Wilcoxon signed-rank and Kruskal-Wallis H tests) were also used; similar patterns of results were observed.

Results

Participants

In total, 88 women contacted the first author to express interested in this study. Sixty-three were screened for eligibility, of which 49 provided consent. Two women dropped out after completing the online baseline questionnaire prior to the in-person assessment due to unforeseen time constraints (*n*=1) and unwillingness to comply with the wearable activity tracker protocol (*n*=1). The remaining 47 were randomized; however, only data from 46 participants were analyzed for this study because of missing baseline data for PA (*n*=1). Of note, four (8.75%) participants did not complete the post-intervention assessment for unspecified reasons (*n*=2) or lost to follow-up (*n*=2); missing data were imputed by carrying forward the baseline values for these participants. A diagram of the flow of participants through this study is shown in Figure 1. No significant differences were found between groups for baseline PA, age, or BMI. The baseline sociodemographic characteristics of the analytical sample are presented in Table 1. On average, participants were 37.72±11.87 years, had a BMI of 31.55±5.96 kg/m^2, and a waist circumference of 98.02±14.87cm. The mean PA score for the analytical sample was 1148.12±1091.03 MET-minutes per week at baseline and 2057.44±1671.76 MET-minutes per week post-intervention. Participants reported a history of chronic diseases, including stroke (*n*=1; 2.2%), diabetes (*n*=3; 6.5%), high blood pressure (*n*=7; 15.2%), high cholesterol (*n*=5; 10.9%), arthritis (*n*=7; 15.2%), and asthma (*n*=6; 13.0%).

Effects of the Intervention on PA

The main effect of time was statistically significant, meaning there was a difference in PA between baseline and post-intervention, $F(1, 43)=17.95$, $p<.001$, partial $\eta^2=.295$. The main effect of group was not statistically significant, meaning there was no difference in PA between groups, $F(2, 43)=.509$, $p=.605$, partial $\eta^2=.023$. The interaction effect was not statistically

significant, meaning that there were no differences in the effect between the groups for change in PA, $F(2, 43)=0.959$, $p=.39$, partial $\eta^2=.043$. Figure 2 illustrates the mean PA scores for each group at baseline and post-intervention.

Discussion

Low PA among women who are overweight or obese is cause for concern considering that strong evidence shows that there are numerous mental and physical health benefits associated with regular engagement in PA (Warburton & Bredin, 2017). Previous research has shown that providing a wearable activity tracker to support self-monitoring of PA may lead to increases in PA among adults generally (Lewis et al., 2015), as well as among women who are overweight or obese (Butryn, Arigo, Raggio, Colasanti, & Forman, 2016; Cadmus-Bertram et al., 2015; Reed et al., 2018). Nevertheless, it is possible that using these devices may have a neutral or negative impact on PA (Toner, 2018) as they may undermine autonomous motivation for PA (Kerner, Burrows, & McGrane, 2019; Kerner & Goodyear, 2017; Mendoza et al., 2017). This assertion has not yet been tested in women who are overweight or obese. Therefore, the aims of this study were to determine if: (1) a combined intervention that provides women with (A) six weekly autonomy-supportive emails in addition to (B) a wearable activity tracker, and (C) a paper copy of the Canadian PA guidelines could lead to increases in PA, and (2) if the combined intervention leads to greater changes in PA than providing (B) and (C) or (C) only. The principal finding of this study is that, on average, women in all three interventions increased their PA, with no differences observed in the magnitude of change between the groups. These findings are partially congruent with the hypothesis of this study and suggest that the weekly emails may not have a large short-term effect on PA. Theoretical and methodological interpretations of these findings are discussed herein.

First, the lack of significant differences in change in PA between groups suggests that the weekly emails did not have the intended effect on PA above and beyond the provision of a wearable activity tracker. It is noteworthy that despite a lack of statistical significance, participants in Group 1 and Group 2 had a substantially larger increase in PA (1029.90±1548.50 MET-minutes/week and 1201.22±1302.22 MET-minutes/week respectively) than participants in Group 3 who increased their PA by 511.90±1530.86 MET-minutes/week. This study is among the first in the field to deliver an autonomy-supportive intervention using standard weekly emails tailored generally to women who are overweight or obese. Although email-based interventions grounded in behaviour change theories and models such as social-cognitive theory (Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012; Hatchett, Hallam, & Ford, 2013), the theory of planned behaviour (Davies et al., 2012; Parrott, Tennant, Olejnik, & Poudevigne, 2008), and the transtheoretical model (Davies et al., 2012) have found significant increases in PA following the intervention, the effect sizes have been small. Closer examination of the content of the weekly emails provides several possible explanations for this unexpected finding. For example, some of the emails instructed participants to set realistic goals, make small changes, and adapt goals progressively over time. It is plausible that these techniques may have led to smaller changes in PA over a 6-week time frame when compared to participants who were simply instructed to increase their PA behaviour. Given the intention to promote autonomous motivation and increase physical activity long-term, some content in the weekly emails may have limited change in PA over the short-term.

Moreover, traditional interventions based in self-determination theory have been delivered face-to-face (Fortier, Duda, Guerin, & Teixeira, 2012) or using technologies that allow for interaction between the facilitator and the participant (e.g., telephone, video calls, instant

messaging; Chemtob et al., 2019), which was not the case herein. More interactive delivery modalities may be more beneficial within the context of interventions grounded in self-determination theory as they allow the facilitator to use certain behaviour change techniques to enhance basic psychological need satisfaction and autonomous motivation for PA which may be difficult to convey statically, such as acknowledging participants' perspective, using motivational interviewing, and providing individually tailored information and feedback (Gillison, Rouse, Standage, Sebire, & Ryan, 2019). These techniques may have a stronger effect on motivation for PA and subsequently PA behaviour, albeit at a greater time and resource cost to both intervention providers and participants. However, given that choice, rationale for PA, intrinsic goal orientation, and many other self-determination theory-based behaviour change techniques can easily be conveyed over email, email as a platform for delivering interventions based in self-determination theory to promote PA should be further explored as a potential brief and cost effective option.

Limitations and Directions for Future Research

Certain limitations of this study must be acknowledged when interpreting the findings. First, the assessment schedule combined with the brief duration of the intervention only allowed for exploration of the immediate impact of the intervention on change in PA; therefore, conclusions about the long-term impact of the interventions should be avoided. Researchers and practitioners who are deciding which tools to use when designing an intervention to promote PA should consider both the short- and long-term implication of their decisions. The long-term impact of using a wearable activity tracker on motivation for PA and PA behaviour remains unexplored and thus is an important direction for future research. Second, due to the recruitment strategy of this study, selection bias may have two implications on the results: the sample may

not be representative of all women who are overweight or obese, and women who volunteered to participate in this study may have been more motivated to increase their PA than the rest of the population. Finally, a self-report measure of PA was chosen for this study for reasons of feasibility, despite known benefits of using direct measures of PA (Prince et al., 2008). Future research could examine if the findings from this study are replicable using a masked accelerometer.

Conclusion

This study represents an important step towards developing interventions that promote PA among women who are overweight or obese. Providing participants with (A) six weekly autonomy-supportive emails, (B) a wearable activity tracker, and (C) a paper copy of the Canadian PA guidelines can lead to a significant increase in PA over a 6-week period. Accordingly, providing weekly autonomy-supportive emails in addition to a wearable activity tracker may be a viable intervention strategy for increasing PA, however at present there is insufficient evidence to suggest that it is more effective than other techniques because there were no significant differences in change in PA between participants who received this combined intervention (A, B, C) and those who received (B and C) or (C) only. Future research should examine the impact of all three interventions on putative mechanisms of change (i.e., basic psychological need satisfaction, motivation for PA), as well as on change in PA using a larger sample and a direct measure of PA to identify smaller but potentially meaningful differences between the intervention groups. Future research should also examine whether there are lasting changes in PA within groups at a follow-up assessment.

Figure 1. Study flow diagram.

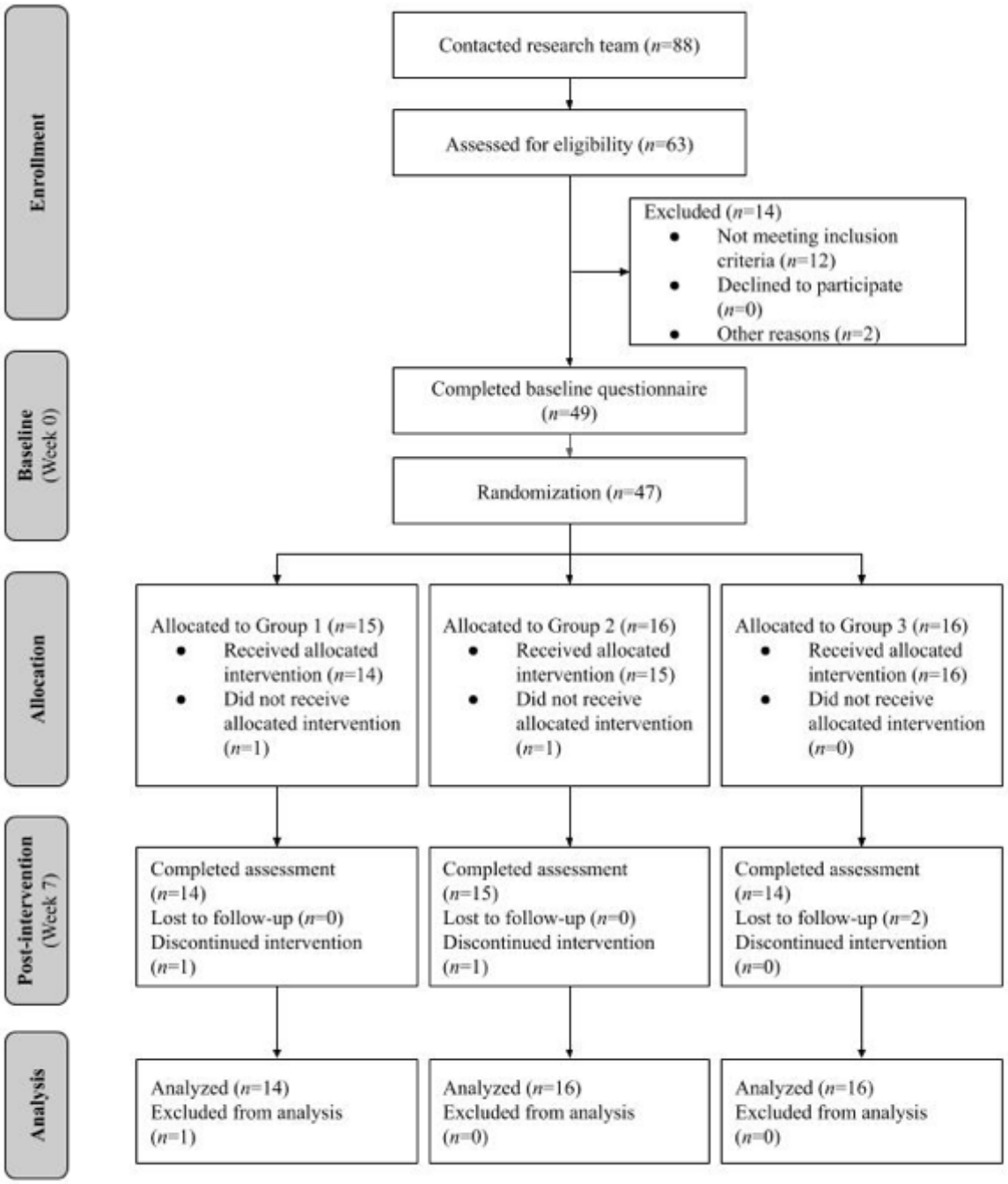

Figure 2. Mean scores of total physical activity by group.

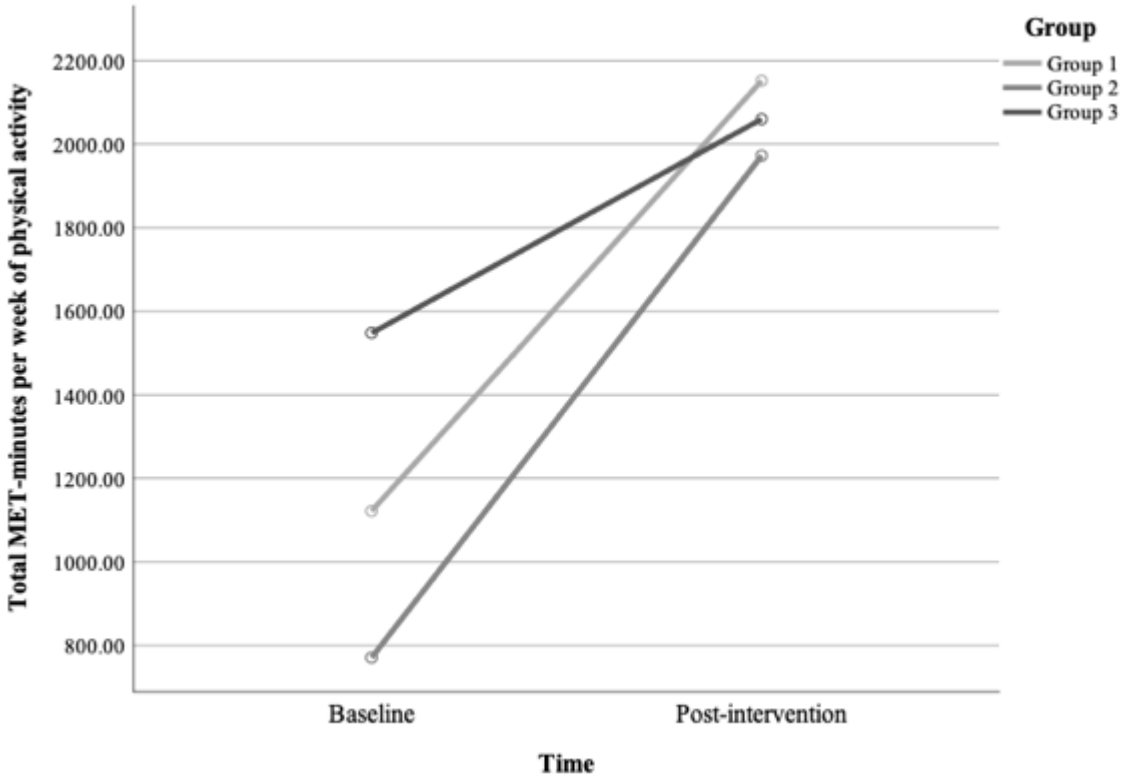

Table 1. Participant characteristics at baseline.

Variable	*n*	Range	Value [Mean (SD) or Frequency (%)]
Age (years)	46	18 – 63	37.72 (11.87)
Height (cm)	46	150 – 185	165.07 (7.46)
Body mass (kg)	46	56.2 – 145.1	86.33 (19.60)
BMI (kg/m^2)	46	23.6 – 45.7	31.55 (5.96)
Body composition (%)	45	24.2 – 55.0	41.06 (6.38)
Waist circumference (cm)	46	71.0 – 141.0	98.02 (14.87)
Self-rated health	46		
Poor			3 (6.5)
Fair			14 (30.4)
Good			24 (52.2)
Very good			5 (10.9)
Excellent			0 (0.0)
Smoking status	46		
Never smoked			32 (69.6)
Previously smoked			7 (15.2)
Currently smokes			7 (15.2)
Education	46		
High school			2 (4.3)
Some college or university			9 (19.6)
College or university			29 (63.0)
Graduate degree			6 (13.0)
Employment	45		
Unemployed			9 (20.0)
Student			7 (15.6)
Part-time worker			6 (13.3)
Full-time worker			23 (51.1)
Annual household income	38		
Up to $19,999			7 (18.4)
$20,000 to $49,999			8 (21.1)
$50,000 to $99,999			10 (26.3)
$100,000 or more			13 (34.2)
Race	46		
Caucasian			38 (82.6)
Other			8 (17.4)

Table 2. Mean MET[a]-minutes of physical activity per week.

	Total (*n*=46)	Group 1 (*n*=15)	Group 2 (*n*=16)	Group 3 (*n*=16)
Baseline	1148.12 (1091.03)	1121.91 (996.47)	771.14 (776.84)	1548.04 (1335.74)
Post-intervention	2057.44 (1671.76)	2151.81 (1494.26)	1972.36 (1521.89)	2059.95 (2029.05)
Change score	909.32 (1459.29)	1029.90 (1548.50)	1201.22 (1302.22)	511.32 (1530.86)

[a]MET=metabolic equivalent

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Chapter 5: Lessons Learned

Completing a Master's thesis is a large task, and the choice to develop and implement a three-armed randomized controlled trial was particularly ambitious. Several decisions were made when designing this study so that it would be feasible to implement within the timeframe of a Master's degree, while maintaining the ability of the study to provide scientifically sound contributions to the literature. Throughout my two years as a Master's student, I continued to learn about methods and theories in the field of health behaviour change and applied these learnings when preparing the final thesis. To help contextualize these decisions and provide recommendations for future research, a discussion of the lessons I learned is presented herein.

Over the past two years, I learned about various models for developing behavioural interventions, including the Obesity Related Behavioural Intervention Trials (ORBIT) model, which heavily influenced my decisions and interpretation of the results (Czajkowski et al., 2015). The ORBIT model describes a pathway for developing behavioural interventions and demonstrating their efficacy towards improving health outcomes. Early on in the design process, we chose to build this study around the primary objective of determining whether our combined intervention could lead to an increase in PA from baseline to post-intervention, which fits within Phase III (i.e., efficacy) of the ORBIT model. However, designing behavioural interventions is an iterative process, thus prior to the final phase (i.e., effectiveness), it is important to collect information which can be used to better understand the results of the intervention. Measures of potential psychological mediators were included to provide exploratory insights, which can be used to iterate on and improve the intervention. Considering that most methodological decisions were intended to support the primary objectives of this study, the decision was made to focus the results manuscript on the primary objective of assessing change in PA from baseline to post-

intervention within groups and comparing potential changes between groups, and to exclude the additional data addressing the tertiary objectives.

The main reason the results manuscript was focused exclusively on the primary objective is that the study was not sufficiently powered to perform multiple statistical analyses. The target sample size was 42, which was mathematically sufficient to detect a moderate effect size in change in PA from baseline to post-intervention and was a feasible number of participants to recruit given the resources available. However, methodological decisions may have lessened the actual power to detect such an effect. First, I was unable to find article which closely matched the study in terms of intervention content, population, and measure of PA. The studies used to provide inputs for the sample size calculations measured PA using accelerometers, which are known to be more reliable than self-report measures of PA such as the International Physical Activity Questionnaire (IPAQ; Prince et al., 2008), thus reducing the power of the current study. Additionally, we sought to recruit a group of women who were relatively inactive. However, setting the eligibility criteria based on the Canadian Physical Activity Guidelines of 150 minutes per week of MVPA allowed substantial variance in baseline PA levels within the sample. Initially, the data for baseline PA were highly positively skewed. A two-step transformation was applied which improved the skewness value so that it was within normal ranges (i.e., less than 2), but visual inspection of the transformed data revealed that it remained positively skewed (Figure 1). Similarly, a one-way analysis of variance revealed no statistically significant differences in PA, age and BMI between groups at baseline, but the variations in the data may still have influenced the results of this study. Several strategies could be applied to maintain power when conducting a study with a small sample size, and to improve the likelihood of finding a significant effect if there is one to detect. Selecting a lower cut-off for baseline PA (e.g., 100

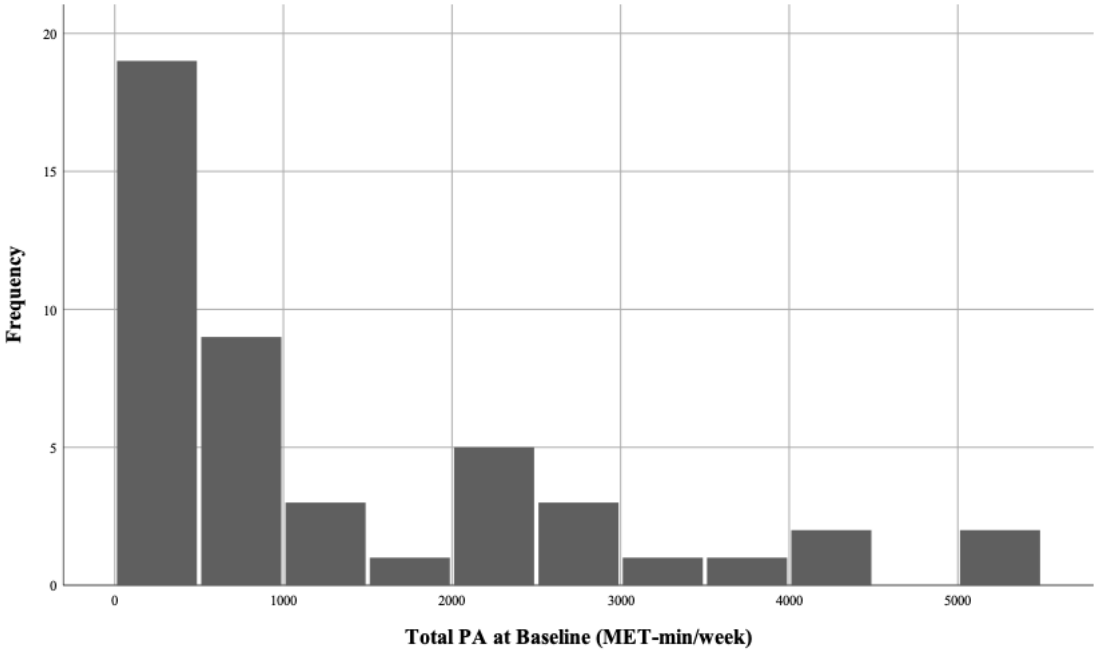
minutes per week of MVPA) may have provided a more homogenous sample and thus more power. Randomization based on potential covariates could have been used to ensure an even distribution between groups in terms of age and/or BMI (Bungi, Canay, & Shaikh, 2018).

Although the decision was made to focus on the primary objective of measuring change in PA from baseline to post-intervention, it is still important to consider the additional data collected. In the discussion of Chapter 4, I speculated that despite observing no significant differences in change in PA between groups, the interventions may have had a differential effect on motivation for PA. Preliminary examination of our exploratory data supports this contention. From baseline to post-intervention, the increase in basic psychological need satisfaction was larger for participants in Group 1 (+0.4) than those in Group 2 (+0.28) or Group 3 (+0.13). Likewise, participants in Group 1 saw a reduction in basic psychological need thwarting (-0.18) which was larger than the reduction observed for those in Group 2 (-0.06) or Group 3 (+0.41). This suggests that the weekly emails likely supported the basic psychological needs of autonomy, competence, and relatedness. Some intervention studies have noted that although most participants increased their PA from baseline to post-intervention, only those who had higher autonomous motivation were more likely to maintain their PA (Silva et al., 2011). Likewise, prospective studies among women who are overweight or obese have shown that higher autonomous motivation is predictive of subsequent PA, regardless of PA levels at baseline (Brunet, Burke, & Sabiston, 2013; Slovinec D'Angelo, Pelletier, Reid, & Huta, 2014). Based on previous research (Brunet, Burke, & Sabiston, 2013; Silva et al., 2011; Slovinec D'Angelo, Pelletier, Reid, & Huta, 2014), and the observation that basic psychological need satisfaction was higher among participants in Group 1 at post-intervention, it is plausible that differences in PA between Groups 1 and 2 would be larger at follow-up than immediately after the intervention.

Examining the data on motivational regulations shows a slightly different pattern than the basic psychological needs. Participants in Group 2 had a larger increase on the RAI score (+1.58) than those in Group 1 (+0.54) and those in Group 3 (-0.36). In accordance with common critiques of the use of the RAI (Wilson et al., 2012), is possible that disproportionally large changes in any one motivational regulation could have contributed to these differences. Noteworthy differences when examining the individual motivational regulation scores were also observed for introjected regulation. Participants in Group 1 showed a larger decrease in introjected regulation (-0.57) than those in Group 2 and 3 who showed minimal change (-0.03 and -0.07, respectively). This finding suggests that the email intervention may have reduced the influence of emotions such as guilt, pride, and shame as motivators for PA, which may be a positive outcome that could contribute to long-term PA behaviour change (Teixeira et. al., 2012).

An important observation is that PA, basic psychological need satisfaction, and certain motivational regulations increased from baseline to post-intervention in all three groups. It would be reasonable to posit that common characteristics of the intervention to all three groups (i.e., provision of the Canadian PA guidelines, participation in a post-intervention assessment, and in-person contact with a facilitator during the baseline and post-intervention assessments) positively influenced PA. Simply knowing that there would be an in-person follow-up assessment may have been sufficient extrinsic motivation to encourage participants to increase their PA. As well, when I provided the Canadian PA guidelines to each participant, I answered their questions about the guidelines in an autonomy-supportive manner, which likely promoted PA among all participants. Future research may remove the Canadian PA guidelines from the study entirely and use a more traditional control group approach to avoid this problem.

Figure 1. Histogram of baseline PA.



Chapter 6: General Discussion

Regular PA engagement can reduce certain health risks that are associated with excess weight and aid in weight management (Warburton & Bredin, 2017); yet, women who are overweight or obese are one segment of the population who report some of the lowest levels of PA (Colley et al., 2011). This thesis reports on the protocol (Chapter 3: Protocol Manuscript), as well as the primary and secondary objectives (Chapter 4: Main Manuscript) of a randomized control trial testing if an intervention that provides participants with (A) six weekly autonomy-supportive emails, (B) a wearable activity tracker, and (C) a paper copy of the Canadian PA guidelines can increase PA participation from baseline to post-intervention, and if this combined intervention led to larger changes in PA than providing (B+C) or only (C). Considering that interventions which are guided by theory lead to larger increases in PA than those which are atheortical (Gourlan et al., 2016), and the utility of theories for examining the benefits and consequences of PA behaviour change interventions (Moore et al., 2019), this study drew on self-determination theory to design and evaluate the intervention. Current and potential implications of this study, and directions for future research will be discussed herein.

The principal finding of this study is that an eHealth intervention grounded in self-determination theory was effective at increasing PA from baseline to post-intervention. Based on this evidence, we suggest that the combination of providing women with six weekly autonomy-supportive emails, a wearable activity tracker, and a paper copy of the Canadian PA guidelines is an intervention that may increase PA among women who are overweight or obese. Contrary to our hypotheses, a secondary finding is that there were no significant differences in change in PA between groups. Given that participants in Group 1 and Group 2 had a substantially larger increase in PA (1029.90±1548.50 MET-minutes/week and 1201.22±1302.22 MET-minutes/week

respectively) than participants in Group 3 (511.90±1530.86 MET-minutes/week), despite the lack of statistical significance, we speculate that using a wearable activity tracker had a strong positive effect on PA from baseline to post-intervention for participants in both Group 1 and Group 2, but the six weekly autonomy-supportive emails did not have the intended effect on PA above and beyond the provision of a wearable activity tracker.

Our hypothesis that participants in Group 1 would increase their PA more than those in Group 2 or 3 was predicated on two assumptions: (1) providing participants with a wearable activity tracker would lead to large initial increases in PA as it supports self-monitoring, which is a highly potent PA behaviour change technique (Dombrowski et al., 2012; Michie et al., 2009; Murray et al., 2017); and (2) providing autonomy-support would lead to changes in PA above and beyond providing a wearable activity tracker by enhancing autonomous motivation for PA, which is a strong predictor of sustained PA behaviour (Deci & Ryan, 1985; Ryan & Deci, 2000; Teixeira et al., 2012). Herein we elaborate on these assumptions and provide more nuanced interpretations that may help to explain the findings of this study.

Wearable activity trackers and controlled motivation

Our findings suggest that it may be important to consider the role of wearable activity trackers in PA behaviour change interventions, as the change in PA from baseline to post-intervention among participants who wore a wearable activity tracker (i.e., those in Group 1 and 2) was larger than those who did not (i.e., those in Group 3). Wearable activity trackers may serve as a form of controlled motivation for PA. Theoretically, using a wearable activity tracker provides a source of feedback about an individual's PA levels, thus this feedback may influence basic psychological need satisfaction. Whereas some researchers have posited that using a wearable activity tracker may support autonomy (by empowering users' to make decisions about

their own PA behaviour), competence (by providing feedback when a user is successful in reaching their step goal), and relatedness (by providing participants with online communities for social support) (Asimakopoulos, Asimakopoulos, & Spillers, 2017; Karapanos, Gouveia, Hassenzahl, & Forlizzi, 2016; Kerner & Goodyear, 2017), interventions examining change in basic psychological need satisfaction and motivation for PA largely contradict this idea (Kerner et al., 2019; Kerner & Goodyear, 2017). Some common features of wearable activity trackers, including algorithmically-determined step-count goals and inactivity notifications, could be perceived as controlling thereby reducing autonomy. Failure to meet goals or recommendations as highlighted by the device could reduce feelings of competence. Social features such as leaderboards may facilitate social comparison thereby diminishing feelings of relatedness. Collectively, using a wearable activity tracker may influence basic psychological needs so as to foster controlled rather than autonomous motivation for PA. Increases in introjected regulation have been observed in two samples of adolescents using wearable activity trackers (Kerner et al., 2019; Mendoza et al., 2017). Studies examining changes in self-determination theory constructs in relation to wearable activity tracker use have yet to be conducted among women who are overweight or obese, though would be a worthwhile avenue for future research.

In light of our findings and a growing body of research that suggests providing women with a wearable activity tracker can increase in PA initially (Z. Lewis et al., 2015), and drawing on the assumption that using a wearable activity tracker may act as a controlled form of motivation among women who are overweight or obese, it may be important to re-evaluate the role of controlled motivation in PA behaviour change. Although controlled forms of motivation may lead to larger increases in PA initially, autonomous motivation is predictive of sustained PA (Deci & Ryan, 1985; Ryan & Deci, 2000; Teixeira et al., 2012). The literature on interventions to

increase PA behaviour, and specifically studies using wearable activity trackers, have noted concerns about poor maintenance of PA following interventions (B. Lewis et al., 2017; Murray et al., 2017). The intention of providing weekly emails was to enhance autonomous motivation for PA and to offset potential negative consequences associated with using a wearable activity tracker. The weekly emails may have enhanced autonomous motivation for PA without having a noticeable effect of PA at post-intervention, above and beyond the effect of using a wearable activity tracker. Some researchers who have conducted interventions to promote PA noted that although most participants increased their PA from baseline to post-intervention, only those who had higher autonomous motivation were more likely to maintain their PA (Silva et al., 2011). Likewise, prospective studies among women who are overweight or obese have shown that higher autonomous motivation is predictive of subsequent PA even among those with similar levels of PA at baseline (Brunet, Burke, & Sabiston, 2013; Slovinec D'Angelo, Pelletier, Reid, & Huta, 2014). It will be important for future research to examine both the short and long-term impacts of intervention techniques on both motivation for PA and PA behaviour. Within the short-term context of changes in PA from baseline to post-intervention, it is possible that controlled motivation for PA may have a stronger effect on PA behaviour than autonomous motivation for PA.

Email as a modality for delivering autonomy-supportive interventions

Alternatively, it is possible that selecting email as a modality to deliver an autonomy-supportive intervention was not potent enough to have an effect on autonomous motivation for PA or PA behaviour. This study is among the first in the field to deliver an autonomy-supportive intervention using standard weekly emails tailored for women who are overweight or obese. Although email-based interventions grounded in behaviour change theories such as social-

cognitive theory (Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012; Hatchett, Hallam, & Ford, 2013), the theory of planned behaviour (Davies et al., 2012; Parrott, Tennant, Olejnik, & Poudevigne, 2008), and the transtheoretical model (Davies et al., 2012) have found significant increases in PA following the intervention, effect sizes have been small. Moreover, traditional interventions based in self-determination theory have been delivered face-to-face (Fortier, Duda, Guerin, & Teixeira, 2012) or using technologies that allow for extensive interaction between the facilitator and the participant (e.g., telephone, video calls, instant messaging; Chemtob et al., 2019). Highly interactive delivery modalities may be more beneficial within the context of interventions grounded in self-determination theory, as they allow the facilitator to use certain behaviour change techniques to enhance basic psychological need satisfaction and autonomous motivation for PA which may be difficult to convey statically, such as acknowledging participants' perspectives, using motivational interviewing, and providing individually tailored information and feedback (Gillison, Rouse, Standage, Sebire, & Ryan, 2019). These techniques may have a stronger effect on motivation for PA and subsequently PA behaviour, albeit at a greater time and resource cost to both intervention providers and participants. However, given that many other self-determination theory-based behaviour change techniques (e.g., providing choice, rationale for PA, intrinsic goal orientation) could easily be conveyed over email, email as a platform for delivering interventions based in self-determination theory to promote PA should be further explored as a potential simple and cost-effective option.

Limitations

Certain limitations of this study design must be acknowledged when interpreting our findings, but also highlight avenues for future research. First, the assessment schedule combined with the brief duration of the intervention only allowed for exploration of the impact of our

intervention on PA behaviour change from baseline to post-intervention, conclusions about the long-term impact of the interventions should be avoided. Maintenance of PA behaviour change interventions remains underexplored in the literature, yet is highly relevant for researchers and practitioners who are deciding which tools to use when designing an intervention to promote PA. Second, the sample size for this study was selected to detect a medium effect size, thus small differences in PA between groups could not be identified and future analysis of data for the tertiary objectives should be considered exploratory. Considering that PA tends to exhibit a dose-response relationship with health outcomes and that small increases in PA can lead to improvements in health outcomes (Warburton & Bredin, 2017), developing larger studies to assess the long-term impact of wearable activity use on motivation for PA and PA behaviour remains an important direction for future research. Third, selection bias may have two implications on the results due to the chosen recruitment strategy: the sample may not be representative of all women who are overweight, and women who volunteered to participate in this study may have been more motivated to increase their PA than the population. Finally, despite known benefits of using direct measures of PA (Prince et al., 2008), in combination with self-reported measures to capture the context of PA, only a self-report measure of PA was selected for reasons of feasibility. In the future, researchers could examine if the findings from this study are replicable using a masked accelerometer.

Conclusion

This study represents an important step in the ongoing mission to develop interventions that can positively affect PA participation among women who are overweight or obese. We hypothesized that by providing women with (A) six weekly autonomy-supportive emails in addition to (B) a wearable activity tracker and (C) a paper copy of the Canadian PA guidelines,

women would increase their PA more than if they received (B+C) or only (C). Although we found that participants receiving our combined intervention did increase their PA from baseline to post-intervention, there were no significant differences in change in PA between groups. Based on this evidence, we suggest that our combined intervention is one of a variety of possible effective interventions to promote PA among women who are overweight or obese. Additional research using a larger randomized control trial is necessary to detect small differences between groups. Further analysis of measures of basic psychological need satisfaction/thwarting and motivational regulations for PA collected in this study will contribute important theoretical insights that will help advance our understanding of the mechanisms of change for using wearable activity trackers, make practical and effective improvements to our intervention, and facilitate evidence-based decision making to increase PA and improve health among women who are overweight or obese.

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Appendices

Appendix A: Descriptive Statistics for Variables Not Included in Chapter 4

Table 1. Descriptive statistics for basic psychological need satisfaction.

			Mean (Standard Deviation)			
	Cronbach's alpha	n	Total	Group 1	Group 2	Group 3
Combined						
Baseline	0.917	43	3.94 (0.93)	3.88 (0.99)	3.89 (1.03)	4.05 (0.82)
Post-intervention	0.878	42	4.21 (0.83)	4.28 (0.77)	4.17 (0.91)	4.18 (0.87)
Autonomy						
Baseline	0.887	45	4.86 (1.06)	5.00 (1.14)	4.97 (1.02)	4.60 (1.05)
Post-intervention	0.763	43	5.38 (0.63)	5.32 (0.71)	5.23 (0.64)	5.60 (0.51)
Competence						
Baseline	0.926	45	3.53 (1.34)	3.56 (1.49)	3.50 (1.27)	3.53 (1.33)
Post-intervention	0.939	42	3.85 (1.30)	3.96 (0.82)	3.79 (1.36)	3.79 (1.66)
Relatedness						
Baseline	0.908	43	3.36 (1.36)	3.10 (1.43)	3.31 (1.46)	3.69 (1.19)
Post-intervention	0.948	43	3.44 (1.62)	3.55 (1.39)	3.59 (1.43)	3.17 (2.06)

Table 2. Descriptive statistics for basic psychological need thwarting.

			Mean (Standard Deviation)			
	Cronbach's alpha	n	Total	Group 1	Group 2	Group 3
Combined						
Baseline	0.881	46	2.49 (1.09)	2.51 (1.10)	2.33 (0.98)	2.63 (1.22)
Post-intervention	0.897	43	2.54 (1.23)	2.33 (1.02)	2.27 (0.94)	3.04 (1.59)
Autonomy						
Baseline	0.767	46	2.33 (1.16)	2.60 (1.23)	2.02 (1.12)	2.40 (1.13)
Post-intervention	0.808	43	2.29 (1.32)	2.23 (1.08)	2.17 (1.04)	2.48 (1.79)
Competence						
Baseline	0.871	46	2.82 (1.51)	2.78 (1.72)	2.92 (1.60)	2.75 (1.29)
Post-intervention	0.927	43	2.95 (1.77)	2.86 (1.59)	2.63 (1.48)	3.38 (2.21)
Relatedness						
Baseline	0.801	46	2.31 (1.30)	2.15 (1.06)	2.05 (1.01)	2.75 (1.70)
Post-intervention	0.825	43	2.39 (1.44)	1.93 (1.03)	2.02 (0.88)	3.25 (1.90)

Table 3. Descriptive statistics for motivational regulations.

	Cronbach's alpha	n	Mean (Standard Deviation) Total	Group 1	Group 2	Group 3
RAI						
Baseline		45	6.48 (6.37)	6.67 (5.39)	7.20 (5.62)	5.46 (8.24)
Post-intervention		41	7.21 (6.84)	7.21 (6.53)	8.78 (6.26)	5.82 (7.80)
Amotivation						
Baseline	0.748	46	0.48 (0.73)	0.37 (0.60)	0.33 (0.50)	0.77 (0.98)
Post-intervention	0.803	43	0.48 (0.69)	0.45 (0.62)	0.28 (0.48)	0.73 (0.90)
External						
Baseline	0.742	45	0.98 (0.82)	1.13 (1.02)	0.88 (0.73)	0.95 (0.70)
Post-intervention	0.863	43	1.05 (1.02)	1.09 (1.28)	0.77 (0.72)	1.32 (0.98)
Introjected						
Baseline	0.713	46	2.34 (0.98)	2.53 (0.86)	2.61 (0.63)	1.87 (1.24)
Post-intervention	0.874	42	2.13 (1.14)	1.96 (1.06)	2.58 (1.04)	1.80 (1.25)
Identified						
Baseline	0.663	46	2.28 (0.72)	2.27 (0.56)	2.48 (0.59)	2.08 (0.94)
Post-intervention	0.789	42	2.46 (0.91)	2.38 (0.85)	2.75 (0.83)	2.21 (1.01)
Integrated						
Baseline	0.789	46	1.67 (0.81)	1.70 (0.71)	1.70 (0.75)	1.60 (1.01)
Post-intervention	0.834	43	1.89 (1.01)	1.86 (0.95)	2.00 (1.02)	1.80 (1.11)
Intrinsic						
Baseline	0.887	46	2.20 (0.99)	2.30 (0.81)	2.22 (1.04)	2.07 (1.13)
Post-intervention	0.922	43	2.31 (1.06)	2.38 (0.89)	2.33 (1.18)	2.21 (1.16)

Table 4. Descriptive statistics for perceived autonomy support.

	Cronbach's alpha	n	Mean (Standard Deviation) Total	Group 1	Group 2	Group 3
Post-intervention	0.973	38	4.52 (1.87)	5.83 (1.15)	3.86 (1.81)	3.83 (1.88)

Table 5. Descriptive statistics for affect.

			Mean (Standard Deviation)			
	Cronbach's alpha	n	Total	Group 1	Group 2	Group 3
Positive						
Baseline	0.837	47	2.91 (0.82)	2.85 (0.93)	2.69 (0.69)	3.20 (0.79)
Post-intervention	0.861	42	2.89 (0.89)	2.93 (0.75)	2.77 (1.12)	2.96 (0.81)
Negative						
Baseline	0.740	47	2.11 (0.80)	2.17 (0.82)	1.99 (0.97)	2.19 (0.58)
Post-intervention	0.842	42	2.01 (0.84)	2.00 (0.85)	1.89 (0.81)	2.16 (0.92)

Table 6. Descriptive statistics for depressive symptoms.

			Mean (Standard Deviation)			
	Cronbach's alpha	n	Total	Group 1	Group 2	Group 3
Baseline	0.920	47	8.04 (6.43)	8.47 (7.35)	7.44 (6.05)	8.25 (6.24)
Post-intervention	0.882	42	7.24 (5.69)	5.14 (4.29)	6.64 (4.48)	9.93 (7.12)

Table 7. Descriptive statistics for wellbeing (i.e., vitality).

			Mean (Standard Deviation)			
	Cronbach's alpha	n	Total	Group 1	Group 2	Group 3
Baseline	0.893	46	3.34 (1.29)	3.61 (1.31)	3.31 (1.34)	3.14 (1.26)
Post-intervention	0.923	43	3.75 (1.34)	3.85 (1.17)	3.97 (1.61)	3.43 (1.23)

Appendix B: Recruitment poster

Figure 1. Recruitment poster.

RESEARCH PARTICIPANTS NEEDED

Exploring the Effect of an Intervention on Women's Physical Activity Behaviour

What is the purpose of this study?

This study is being done to see if a 6-week intervention can help women become more physically active.

Who can participate?

You are eligible to participate in this study if you:

- Are between the ages of 18 and 65
- Identify as a woman and were born female
- Can understand, read, and speak in English
- Are able to safely engage in physical activity
- Are not currently pregnant or lactating
- Currently participating in less than 150 minutes of **moderate or vigorous** intensity physical activity and less than 2 strength training sessions per week
- Are overweight or obese
- Have access to the Internet and an email account
- Have not used a wearable activity tracker within the past year (e.g., Fitbit, Apple Watch, Garmin, Polar)
- Live within 50km of the University of Ottawa

What would be required of me?

- Provide consent for this study.
- Attend two in-person meetings 7 weeks apart. The meetings will take place at a location of your convenience where your height, body mass, body composition, and waist circumference will be measured.
- Complete a questionnaire at three times: when joining the study (1 week prior to your baseline meeting), as well as 7 and 21 weeks later.
- Randomized to one of three groups described below. You will be notified of your group assignment during the baseline meeting.
- If you are in **group 1**, you will receive a wearable activity tracker, a paper copy of the Canadian physical activity guidelines, and weekly emails for 6 weeks from study staff containing information and activities to help you become more physically active. You will be asked to use these resources to make changes in your life and increase your physical activity levels.
- If you are in **group 2**, you will receive a wearable activity tracker and a paper copy of the Canadian physical activity guidelines. Twenty-one weeks later, you will receive a set of emails from study staff containing information and activities to help you become more physically active.
- If you are in **group 3**, you will receive a paper copy of the Canadian physical activity guidelines. Twenty-one weeks later, you will receive a set of emails from study staff containing information and activities to help you become more physically active.

This University of Ottawa Research Ethics Board has approved the ethical components of this study.

Appendix C: Research Informed Consent

Exploring the Effect of an Intervention on Women's Physical Activity Behaviour

Principal Investigator:	Melissa Black
Supervisor:	Jennifer Brunet

Thank you for taking the time to learn about this research study. This form will explain the study and what will happen if you decide to participate. When we say "you" in this form we mean you, and when we say "we" we mean the researchers.

Your consent is required to participate in this study. If you would like to participate in this study, please read the following information and sign where indicated at the end of this form.

Why are you being invited to participate in this study?
Women may suffer from chronic diseases and experience poor physical or mental health. We know that regular physical activity may help to prevent or reduce some of these problems; however, many women are not active enough. We are conducting a research study as part of Ms. Black's Master's thesis to better understand how an intervention we developed can promote physical activity.

How many people will take part in this study?
We estimate that 60 women will be enrolled in this study.

What will you be asked to do if you participate in this study?
If you choose to participate, you will be:

1. Asked to provide consent for this study.
2. Scheduled for 2 in-person meetings 7 weeks apart. The meetings will take place at a location of your convenience where your height, weight, body fat percentage, and waist circumference will be measured.
3. Asked to complete an online questionnaire three times: when joining the study (1 week prior to your first meeting), as well as 7 and 21 weeks later.
4. Randomized to one of three groups described below. You will be notified of your group assignment during the baseline meeting.

    If you are in group 1, you will receive a wearable activity tracker, a paper copy of the Canadian physical activity guidelines, and weekly emails for 6 weeks from study staff containing information and activities to help you become more physically active. You will be asked to use these resources to make changes in your life and increase your physical activity levels.

    If you are in group 2, you will receive a wearable activity tracker and a paper copy of the Canadian physical activity guidelines. Twenty-one weeks later, you will receive a set of emails from study staff containing information and activities to help you become more physically active.

If you are in group 3, you will receive a paper copy of the Canadian physical activity guidelines. Twenty-one weeks later, you will receive a set of emails from study staff containing information and activities to help you become more physically active.

Are there any benefits to taking part in this study? You may experience improvements in your physical health and/or mental health. However, there is a chance that you will not receive any direct benefit from participating in this study. Your participation will allow us to make a contribution to the field of psychology of physical activity.

What are the risks of this study? This study is considered low risk, but you should be informed that there is a possibility that you may feel minor skin irritation from wearing the activity monitor (if you are assigned to a group receiving a monitor). We recommend that you wear the device loosely, take it off occasionally, and keep it clean and dry. The use of technology as part of this study can also present risks. It is possible that private data from your mobile device could be intercepted and accessed by others, which may result in a loss of confidentiality. The research team will make every effort to minimize these risks. We recommend that you use standard safety measures such as signing out of your account, closing your browser and locking your screen or device when you are no longer using them in order to minimize the risk of security breaches.

What about privacy? We will make every effort possible to keep your personal information confidential, but we cannot guarantee complete confidentiality. Your confidentiality will be kept to the degree permitted by the technology being used. To protect your confidentiality the following measures will be taken:

1. You will be assigned an identification key which will be used to link data together, however only the research team will have access to this key.
2. Your name will not be included on questionnaires and other data.
3. We will create an account for you to use with the Polar device, using coded user information. Only you and the research team will have access to this account. The company that manufactures the wearable will have access to your data but they will not have access to your identity, so your data will be anonymous to the company.

How will the data be stored? All of your data will be stored in a secure manner for 5 years following the completion of data collection. Dr. Brunet will keep hard copies of questionnaires in a locked cabinet at the University of Ottawa. Digital copies of questionnaires will be kept on a password protected computer.

What are your rights as a participant? You are under no obligation to participate and if you choose to participate, you can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences. If at any time you would like to have your data destroyed or removed from this study, please contact Ms. Black or Dr. Brunet.

Who can answer questions you might have about this study? If you have any questions about the study, you may contact Ms. Black or Dr. Brunet.

If you have any questions regarding the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research at the University of Ottawa in person at: Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5, by phone at (613) 562-5387, or by email at ethics@uottawa.ca.

Acceptance. You have reviewed the information and understand what participation involves.

I consent to participate in this study.

[ ] Yes
[ ] No

Appendix D: Canadian Physical Activity Guidelines

Figure 2. Canadian Physical Activity Guidelines Pamphlet.

Canadian Physical Activity Guidelines

FOR ADULTS - 18 – 64 YEARS

Guidelines

To achieve health benefits, adults aged 18-64 years should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more.

It is also beneficial to add muscle and bone strengthening activities using major muscle groups, at least 2 days per week.

More physical activity provides greater health benefits.

Let's Talk Intensity!

Moderate-intensity physical activities will cause adults to sweat a little and to breathe harder. Activities like:

- Brisk walking
- Bike riding

Vigorous-intensity physical activities will cause adults to sweat and be 'out of breath'. Activities like:

- Jogging
- Cross-country skiing

Being active for at least **150 minutes** per week can help reduce the risk of:

- Premature death
- Heart disease
- Stroke
- High blood pressure
- Certain types of cancer
- Type 2 diabetes
- Osteoporosis
- Overweight and obesity

And can lead to improved:

- Fitness
- Strength
- Mental health (morale and self–esteem)

Pick a time. Pick a place. Make a plan and move more!

- ☑ Join a weekday community running or walking group.
- ☑ Go for a brisk walk around the block after dinner.
- ☑ Take a dance class after work.
- ☑ Bike or walk to work every day.
- ☑ Rake the lawn, and then offer to do the same for a neighbour.
- ☑ Train for and participate in a run or walk for charity!
- ☑ Take up a favourite sport again or try a new sport.
- ☑ Be active with the family on the weekend!

Now is the time. Walk, run, or wheel, and embrace life.

PARTICIPACTION

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Appendix E: Questionnaires

Sociodemographic Information
The following question will gather information so that we can describe the group of people who are participating in this study.

The information you provide below will be combined with the information provided by other participants and presented as averages or percentages. Your participation is voluntary and your answers will be kept strictly confidential. You are not required to answer any questions you do not feel comfortable answering.

1. What is your age? _____

2. What is your civil (or marital) status?
   - ☐ Single
   - ☐ Married
   - ☐ Common law (i.e., defined as two people who live together in a committed "marriage-like" relationship)
   - ☐ Widowed
   - ☐ Divorced
   - ☐ Separated by still legally married
   - ☐ In a committed relationship, but not living together
   - ☐ Prefer not to answer

3. People living in Canada come from many different cultural and racial backgrounds. Which of the following best describes your background?
   - ☐ Aboriginal (Inuit, Metis, North American Indian)
   - ☐ Arab (e.g., Egyptian, Kuwaiti, Libyan)
   - ☐ Black (e.g., African, Nigerian, Somali)
   - ☐ Chinese (e.g., Chinese, Taiwanese)
   - ☐ Filipino
   - ☐ Japanese
   - ☐ Korean
   - ☐ Latin American (e.g., Chilean, Costa Rican, Mexican)
   - ☐ South Asian (e.g., Bangladeshi, Punjabi, Sri Lankan)
   - ☐ South East Asian (e.g., Vietnamese, Cambodian, Malaysian, Laotian)
   - ☐ West African (e.g., Afghan, Assyrian, Iranian)
   - ☐ White (Caucasian)
   - ☐ Other visible minority not included above, please specify: _____
   - ☐ Multiple visible minorities, please specify: _____
   - ☐ Prefer not to answer

4. What is the highest level of education you attained?
   - ☐ Elementary school
   - ☐ High School

- ☐ Some university/college
- ☐ Completed university/college
- ☐ Completed graduate degree (e.g., MA, MSc, PhD)
- ☐ Prefer not to answer

5. What is your current employment status?
   - ☐ Full-time student
   - ☐ Part-time student
   - ☐ Full-time worker
   - ☐ Part-time worker
   - ☐ Homemaker
   - ☐ Unemployed
   - ☐ Retired
   - ☐ On disability
   - ☐ Other, please specify: _____
   - ☐ Prefer not to answer

6. How many people live in your household (including yourself)? _____

7. Who do you live with?
   - ☐ Spouse/partner
   - ☐ Children
   - ☐ Parents
   - ☐ Roommate
   - ☐ Alone
   - ☐ Other, please specify: _____

8. What is your annual household income in Canadian dollars?
   - ☐ Less than $5,000
   - ☐ $5,000 through $9,999
   - ☐ $10,000 through $14,999
   - ☐ $15,000 through $19,000
   - ☐ $20,000 through $24,000
   - ☐ $25,000 through $29,999
   - ☐ $30,000 through $34,999
   - ☐ $35,000 through $49,000
   - ☐ $50,000 through $74,999
   - ☐ $75,000 through $99,999
   - ☐ $100,000 through $149,999
   - ☐ $150,000 through $199,999
   - ☐ $200,000 through $249,999
   - ☐ $250,000 or more
   - ☐ Do not know
   - ☐ Prefer not to answer

9. Do you have any children?

☐ Yes
☐ No

a. If you have children, please give their ages below and indicate if they live with you. Leave blank if you do not have any children.

Child 1: _____ years ☐ Currently lives with me
Chlld 2: _____ years ☐ Currently lives with me
Child 3: _____ years ☐ Currently lives with me
Chlld 4: _____ years ☐ Currently lives with me
Child 5: _____ years ☐ Currently lives with me
Chlld 6: _____ years ☐ Currently lives with me
…

10. In general, would you say your health is:
    1) Excellent
    2) Very good
    3) Good
    4) Fair
    5) Poor

11. Has a doctor or nurse ever told you that you have the following? (check all that apply)
    ☐ Angina
    ☐ Heart attack
    ☐ Stroke
    ☐ Diabetes
    ☐ High blood pressure
    ☐ High cholesterol
    ☐ Arthritis
    ☐ Asthma/lung disease
    ☐ Osteoporosis/osteopenia
    ☐ Hip/joint replacement

12. At the present time, how often do you smoke cigarettes?
    ☐ Every day
    ☐ Occasionally
    ☐ Not at all

    a. If "Every day" or "occasionally", how many cigarettes do you smoke per day on the days that you do smoke? _____

    b. If "Not at all", have you ever smoked cigarettes daily?
    ☐ Yes
    ☐ No

    c. If "Yes", when did you stop smoking? _____/_____ (month/year)

13. What is your current menstrual status?
    - ☐ Premenopausal Stage -3b: if you have regular menstrual cycles
    - ☐ Premenopausal Stage -3a: if you have subtle changes in flow/length (specifically shorter cycles)
    - ☐ Perimenopausal Stage -2: if your menstrual cycles are variable in length/duration
    - ☐ Perimenopausal State -1: if you experience intervals of amenorrhea (for at least 60 days)
    - ☐ Post-menopausal Stage +1a: it marks the end of 12 months of amenorrhea
    - ☐ Postmenopausal Stage +1b: it makes the end of 24 months of amenorrhea
    - ☐ Postmenopausal Stage +1c: if you are 3-6 years postmenopausal
    - ☐ Postmenopausal Stage +2: late menopause

14. What is your current weight? _____pounds OR _____kilograms

15. Are you concerned about your weight?
    - ☐ No
    - ☐ Yes, I am trying to lose weight
    - ☐ Yes, I am trying gain weight
    - ☐ Yes, I am trying to maintain weight

16. Have you gained or lost more than a 5 kilograms (i.e., 11 pounds) over the past year?
    - ☐ No
    - ☐ Yes

    a. Was this intentional or unintentional? Please explain.

    b. Do you have any current or future weight-related goals?
    - ☐ Yes
    - ☐ No

    c. If yes, please describe your current or future weight-related goals.

Acceptability and Device Use

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 day/week
   - ☐ 0 days/week

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

3. On days that you wore your wearable activity tracker, how often did you look at your physical activity data on your wearable activity tracker?
   - ☐ Very frequently
   - ☐ Frequently
   - ☐ Occasionally
   - ☐ Rarely
   - ☐ Very rarely
   - ☐ I did not wear my wearable activity tracker

4. On average, how often did you use the application provided with your wearable activity tracker on your smartphone?
   - ☐ Very frequently
   - ☐ Frequently
   - ☐ Occasionally
   - ☐ Rarely
   - ☐ Very rarely
   - ☐ I did not use the smartphone application

5. On average, how often did you use the application provided with your wearable activity tracker online?
   - ☐ Very frequently
   - ☐ Frequently
   - ☐ Occasionally
   - ☐ Rarely
   - ☐ Very rarely

- ☐ I did not use the online application

6. How likely are you to use a wearable activity tracker in the future?
   - ☐ Definitely
   - ☐ Very probably
   - ☐ Probably
   - ☐ Possibly
   - ☐ Probably not
   - ☐ Definitely not

7. How valuable was having a wearable activity tracker for you?
   - ☐ Absolutely valuable
   - ☐ Very valuable
   - ☐ Of average value
   - ☐ Of little value
   - ☐ Not valuable at all

8. What did you like about this intervention?

9. What did you dislike about this intervention?

10. In your opinion, what could be done to improve this intervention?

International Physical Activity Questionnaire Short Form (IPAQ-S)

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the vigorous activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ days per week

   ☐ No vigorous physical activities

2. How much time did you usually spend doing vigorous physical activities on one of those days?

   _____ hours per day
   _____ minutes per day

   ☐ Don't know/Not sure

Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ days per week

   ☐ No moderate physical activities

4. How much time did you usually spend doing moderate physical activities on one of those days?

_____ hours per day
_____ minutes per day

☐ Don't know/Not sure

Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

_____ days per week

☐ No walking

6. How much time did you usually spend walking on one of those days?

_____ hours per day
_____ minutes per day

☐ Don't know/Not sure

The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the last 7 days, how much time did you spend sitting on a week day?

_____ hours per day
_____ minutes per day

☐ Don't know/Not sure

Strength Training Questionnaire

1. Have you participated in strength or resistance activities (e.g., free weights, weight machines, resistance bands or exercises using your own body weight) in the past 7 days?
   - ☐ Yes
   - ☐ No

If "Yes", please answer the following questions:

2. How many days did you do strength or resistance activities in the past 7 days?

   _____ days

3. How long did you spend doing strength or resistance activities on those days (i.e., the total time between when you started your first exercise to when you finished your last exercise)?

   _____ hours _____ minutes

4. What types of activities did you do?
   - ☐ Free weights
   - ☐ Bodyweight exercises
   - ☐ Weight machines
   - ☐ Resistance bands
   - ☐ Balance exercises
   - ☐ Plyometrics (i.e., activities that involve jumping, or moving quickly and explosively)
   - ☐ Yoga or Pilates
   - ☐ Other, please specify: _____

5. Please provide additional details on your strength or resistance training routine below.

a. List what activities you did (e.g., pushups, box jumps, squats)?

b. On average, how many times did you do each exercise?

   _____ sets of _____ reps

c. Where did you do your strength or resistance activities?
   - ☐ Home
   - ☐ Weight room
   - ☐ Gymnasium
   - ☐ Fitness studio
   - ☐ Outside
   - ☐ Other, please specify: _____

d. With whom did you do your strength or resistance activities?
   - ☐ On my own
   - ☐ Friend(s)
   - ☐ Coworker(s)
   - ☐ My partner
   - ☐ Personal trainer
   - ☐ Others in a fitness class
   - ☐ Teammates
   - ☐ Other, please specify: _____

The Psychological Need Satisfaction in Exercise Scale (PNSE)

The following statements represent different feelings people have when they engage in physical activity. Please answer the following questions by considering how you typically feel while you participate in physical activity. Circle the number that corresponds to the degree to which each item is true for you.

1. I feel like I am in charge of my physical activity program decisions.

1	2	3	4	5	6
false					true

2. I feel good about the way I am able to complete challenging activities.

1	2	3	4	5	6
false					true

3. I feel free to make my own physical activity program decisions.

1	2	3	4	5	6
false					true

4. I feel like I am the one who decides what activities I do.

1	2	3	4	5	6
false					true

5. I feel close to my physical activity companions who appreciate how difficult exercise can be.

1	2	3	4	5	6
false					true

6. I feel attached to my physical activity companions because they accept me for who I am.

1	2	3	4	5	6
false					true

7. I feel connected to the people who I interact with while we do physical activity together.

1	2	3	4	5	6
false					true

8. I feel that I am able to complete activities that are personally challenging.

1	2	3	4	5	6
false					true

9. I feel like I get along with the people who I interact with while we do physical activity together.

1	2	3	4	5	6
false					true

10. I feel confident I can do even the most challenging activities.

1	2	3	4	5	6
false					true

11. I feel free to do physical activity in my own way.

1	2	3	4	5	6
false					true

12. I feel like I am capable of doing even the most challenging activities.

1	2	3	4	5	6
false					true

13. I feel a sense of camaraderie with my physical activity companions because we exercise for the same reasons.

1	2	3	4	5	6
false					true

14. I feel free to choose which activities I participate in.

1	2	3	4	5	6
false					true

15. I feel capable of completing activities that are challenging to me.

1	2	3	4	5	6
false					true

16. I feel like I have a say in choosing the activities that I do.

1	2	3	4	5	6
false					true

17. I feel confident in my ability to perform activities that personally challenge me.

1	2	3	4	5	6
false					true

18. I feel like I share a common bond with people who are important to me when we do physical activity together.

1	2	3	4	5	6
false					true

Behavioural Regulation in Exercise Questionnaire (BREQ-3)

We are interested in the reasons underlying peoples' decisions to engage or not engage in physical exercise. Using the scale below, please indicate to what extent each of the following items is true for you.

1. It's important to me to do in physical activity regularly.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

2. I don't see why I should have to do physical activity.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

3. I do physical activity because it's fun.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

4. I feel guilty when I don't do physical activity.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

5. I do physical activity because its consistent with my life goals.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

6. I do physical activity because other people say I should.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

7. I value the benefits of physical activity.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

8. I can't see why I should bother doing physical activity.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

9. I enjoy my physical activity sessions.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

10. I feel ashamed when I miss a physical activity session.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

11. I consider physical activity part of my identify.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

12. I take part in physical activity because my friends/family/partner say I should.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

13. I think it is important to make the effort to do physical activity regularly.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

14. I don’t see the point in doing physical activity.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

15. I find physical activity pleasurable.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

16. I feel like a failure when I haven’t done physical activity in a while.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

17. I consider physical activity as a fundamental part of who I am.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

18. I do physical activity because others will not be pleased with me if I don’t.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

19. I get restless if I don’t do physical activity regularly.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

20. I think physical activity is a waste of time.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

21. I get pleasure and satisfaction from participating in physical activity.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

22. I would feel bad about myself if I was not making time for physical activity.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

23. I consider physical activity consistent with my values.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

24. I feel under pressure from my friends/family to do physical activity.

0	1	2	3	4
not true for me		sometimes true for me		very true for me

Psychological Need Thwarting Scale (PNTS)

Considering your physical activity, please indicate how much you agree or disagree with each statement.

1. I feel prevented from making choices with regard to the way I engage in physical activity.

1	2	3	4	5	6	7
strongly disagree						strongly agree

2. I feel pushed to behave in certain ways.

1	2	3	4	5	6	7
strongly disagree						strongly agree

3. I feel forced to follow physical activity decisions made for me.

1	2	3	4	5	6	7
strongly disagree						strongly agree

4. I feel under pressure to agree with the physical activity regimen I am provided.

1	2	3	4	5	6	7
strongly disagree						strongly agree

5. Situations occur in which I am made to feel incapable.

1	2	3	4	5	6	7
strongly disagree						strongly agree

6. There are times when I am told things that make me feel incompetent.

1	2	3	4	5	6	7
strongly disagree						strongly agree

7. There are situations where I am made to feel inadequate.

1	2	3	4	5	6	7
strongly disagree						strongly agree

8. I feel inadequate because I am not given opportunities to fulfill my potential.

1	2	3	4	5	6	7
strongly disagree						strongly agree

9. I feel I am rejected by those around me.

1	2	3	4	5	6	7
strongly disagree						strongly agree

10. I feel others can be dismissive of me.

1	2	3	4	5	6	7
strongly disagree						strongly agree

11. I feel other people dislike me.

1	2	3	4	5	6	7
strongly disagree						strongly agree

12. I feel other people are envious when I achieve success.

1	2	3	4	5	6	7
strongly disagree						strongly agree

Positive and Negative Affect Schedule (PANAS)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then circle the number that corresponds to the degree to which you have felt this way during the past week.

1. Upset

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

2. Hostile

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

3. Alert

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

4. Ashamed

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

5. Inspired

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

6. Nervous

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

7. Determined

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

8. Attentive

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

9. Afraid

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

10. Active

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

Vitality Scale

Please respond to each of the following statements by circling the number that indicates the degree to which the statement is true for you in general in your life.

1. I feel alive and vital.

1	2	3	4	5	6	7
not true at all			somewhat true			very true

2. I don't feel very energetic.

1	2	3	4	5	6	7
not true at all			somewhat true			very true

3. Sometimes I feel so alive I just want to burst.

1	2	3	4	5	6	7
not true at all			somewhat true			very true

4. I have energy and spirit.

1	2	3	4	5	6	7
not true at all			somewhat true			very true

5. I look forward to each new day.

1	2	3	4	5	6	7
not true at all			somewhat true			very true

6. I nearly always feel alert and awake.

1	2	3	4	5	6	7
not true at all			somewhat true			very true

7. I feel energized.

1	2	3	4	5	6	7
not true at all			somewhat true			very true

Patient Health Questionnaire (PHQ-9)

Over the last 2 weeks, how often have you been bothered by any of the following problems?

1. Little interest or pleasure in doing things.

0	1	2	3
not at all	several days	more than half of the days	nearly every day

2. Feeling down, depressed, or hopeless.

0	1	2	3
not at all	several days	more than half of the days	nearly every day

3. Trouble falling or staying asleep, or sleeping too much.

0	1	2	3
not at all	several days	more than half of the days	nearly every day

4. Feeling tired or having little energy.

0	1	2	3
not at all	several days	more than half of the days	nearly every day

5. Poor appetite or overeating.

0	1	2	3
not at all	several days	more than half of the days	nearly every day

6. Feeling bad about yourself – or that you are a failure or have let yourself or your family down.

0	1	2	3
not at all	several days	more than half of the days	nearly every day

7. Trouble concentrating on things, such as reading the newspaper or watching television.

0	1	2	3
not at all	several days	more than half of the days	nearly every day

8. Moving or speaking so slowly that other people could have noticed? Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual.

0	1	2	3
not at all	several days	more than half of the days	nearly every day

9. Thoughts that you would be better off dead or of hurting yourself in some way.

0	1	2	3
not at all	several days	more than half of the days	nearly every day