YOUR (VIRTUAL) TRAINER IN THE PALM OF YOUR HAND: EFFICACY OF A THEORY-BASED EXERCISE APPLICATION TO ENHANCE EXERCISE ADHERENCE

by

Elizabeth Christine Voth

B.PhysEd., Brock University, 2012

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE COLLEGE OF GRADUATE STUDIES

(Interdisciplinary Studies)

THE UNIVERSITY OF BRITISH COLUMBIA

(Okanagan)

September 2015

Abstract

Background: Use of mobile health (mHealth) technology is on an exponential rise. mHealth applications (apps) have the capability to reach a large number of individuals, but until now have lacked the integration of evidence-based theoretical constructs to increase exercise behaviour in users.

Objective: The purpose of this study was to assess the effectiveness of a theory-based, self-monitoring app on exercise and self-monitoring behaviour over 8-weeks.

Methods: Fifty-six adults (M_{age} = 40 years ± 13) were randomly assigned to either receive the mHealth app (experimental; n = 28), or control (control; n = 28). All participants engaged in an exercise goal setting session at baseline. Experimental condition participants received weekly SMS (short-messaging service) text messages grounded in social cognitive theory and were encouraged to self-monitor exercise bouts on the app on a daily basis. Exercise behaviour, frequency of self-monitoring exercise behaviour, self-efficacy to self-monitor, and self-management of exercise behaviour was collected at baseline and post-testing.

Results: Engagement in exercise bouts was greater in the experimental condition (M = 7.24, SD = 3.40) as compared to the control condition (M = 4.74, SD = 3.70, P = .03, d = .70) at week-8 post-testing. Frequency of self-monitoring increased significantly over the 8-week investigation between the experimental and control conditions (P < .001, partial η^2 = .599), with the experimental condition self-monitoring significantly more at post (M = 6.00, SD = 0.93) in comparison to the control condition (M = 1.95, SD = 2.58, P < .001, d = 2.10). Self-efficacy to self-monitor, and perceived self-management of exercise behaviour were unaffected by this intervention.

Conclusions: The successful integration of social cognitive theory into an mHealth exercise self-monitoring app provides support for future research to: i) feasibly integrate theoretical constructs into existing exercise apps, and ii) increase self-monitoring and exercise behaviour.

Preface

The study idea was conceived by Ms. Elizabeth Voth and Dr. Mary Jung. Ms. Voth was responsible for data collection at baseline and post-testing sessions, performing data analysis and interpretation, and the writing and editing of the manuscript and thesis documents. Dr. Mary Jung was responsible for overseeing all aspects of the study, contributing to data interpretation, and editing of the manuscript and thesis documents. Ethics approval was obtained from the University of British Columbia Research Ethics Board (H14-00282).

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ANOVA: analysis of variance

Apps: applications

mHealth: mobile health

SESM: self-efficacy to self-monitor

SMS: short-messaging service

Acknowledgements

To my mentor Dr. Mary Elizabeth Jung: thank you for your continual guidance over these past two years. From the get go you have encouraged me to do my best while also pushing me out of my 'comfort zone', providing me with new and exciting experiences. From the day-to-day tasks of recruiting participants, to exciting road trips and conference talks, you have always been there for a pat on the back and a "You Rocked That!" Thank you for welcoming me to Kelowna and HEPL with open arms.

A great big thank you goes out to my committee members, Dr. Paul van Donkelaar and Dr. Nelly Oelke. I so appreciate the time and consideration you have given to me throughout my thesis. Thank you for your guidance and support throughout the proposal and defense process.

To my fantastic collection of lab mates! You have helped me more than words can say. Thank you for being the sounding board to which my ideas were bounced from, the co-workers that felt like family and the friends with whom many fantastic meals and experiences were shared. I'm not sure where I would be in this process without you all!

Lastly, to my family and friends. Thank you for your unconditional love and support. To my parents who taught me to never give up on my goals. To my siblings and friends (near and far, biological and 'adopted') who kept me going with pep talks and Facetime sessions. And my nieces and nephews who taught me that a game of Trouble, and building with Lego is a perfectly acceptable study break. Thank you!

Chapter 1: Introduction

1.1 Exercise Drop Out Rates on the Rise

Regular engagement in exercise is positively associated with physical health, resistance to disease and emotional well-being. Recognized as a major preventative health behaviour, engaging in exercise is likely to reduce morbidity and mortality, combating the effects of over 25 chronic conditions (Warburton, Katzmarzyk, Rhodes, & Shephard, 2007). The effectiveness of exercise for improving health outcomes is irrefutable (Vina, Sanchis-Gomar, Martinez-Bello, & Gomez-Cabrera, 2012; Warburton, Nicol, & Bredin, 2006) and has been demonstrated for individuals of all ages (Tremblay et al., 2011). The ability of individuals to maintain an exercise program, however, is worrisome (Annesi, 2003).

According to current statistics, only approximately 15% of Canadian adults engage in the recommended 150 minutes of moderate-to-vigorous physical activity per week (Colley et al., 2011; Knight, Stuckey, Prapavessis, & Petrella, 2015). Further, the past several decades have witnessed a decrease in fitness levels amongst Canadian adults (Tremblay et al., 2011). The benefits of all types of physical activity, including *purposeful* bouts of leisure physical activity (herein referred to as exercise, as defined by Lox, Ginis & Petruzzello (2011) and most commonly used in the field of Health and Exercise Psychology) have been well publicized and are easily accessible for individuals of all ages. *Canada's physical activity guide to healthy active living* (Canadian Society for Exercise Physiology, 2015) was first released in 1998 (with subsequent age-specific guides released in the following years; Tremblay et al., 2011; Warburton et al., 2007), and remains a well-respected authority on guidelines to physical activity. However,

even when combined with widespread distribution, such publications have been rendered ineffective for facilitating sustained behaviour change (Anessi, 2003; Dishman, 1991).

With the continual development of fitness facilities and exercise classes, opportunities to participate in exercise are available in a variety of preferences and ability levels. This extensive range of opportunities would lead one to believe that all individuals have access to a facility or exercise style that fits their needs. In actuality, hundreds of thousands of individuals start and then fail in their attempts to maintain an exercise program in fitness facilities each month (Anessi, 2003). Subsequently, 40-65% of those individuals who begin an exercise program fail to maintain this behaviour, relapsing to inactivity within the first six months (McAuley & Jacobson, 1991, Annesi, 2003).

As previously mentioned, more traditional avenues of education are not proving effective, therefore, fitness facilities must determine how to better facilitate exercise adherence in Canadians. Such low activity levels and drastic dropout rates demonstrate a need for developing new, effective tactics for improving exercise adherence. By shifting focus from drop out statistics, to examining the antecedents underlying the loop of continual drop out, a more in depth, evidence-based understanding of exercise adherence can be obtained. As any given individual may not possess such background knowledge, it is important that Canadian health care professionals as well as fitness facilities are provided with attractive, novel techniques and strategies that effectively aid individuals in maintaining a regular routine of exercise.

1.2 Self-Regulation: A necessary skill for adherence to exercise

To better understand exercise dropout rates, one avenue of exploration is the study of psychological factors related to adherence of a volitional behaviour. Without the capacity to exert influence over one's own motivation and behaviour, neither intention nor desire is likely to

have much influence on an individual's exercise behaviour (Bandura, 1991). Humans work to regulate goal directed behaviour based on self-reflective and self-reactive capabilities. Without self-regulation, individuals would constantly shift their behaviour based on external outcomes and circumstances, as every distraction or temptation would result in a change in behaviour. According to social cognitive theory (Bandura, 1986), self-regulation involves i) self-monitoring, ii) self-evaluation, and iii) modification of current behaviour in order to meet one's goal (Bandura, 1991; Sniehotta, Scholz & Schwarzer, 2005). In this sense, self-regulation can be considered a continual feedback loop driven by human motivation to attain valued goals.

Successful self-regulation is reliant on the fidelity, consistency and timeliness of self-monitoring the targeted behaviour (Bandura, 1991; Burke, Wang, & Sevick, 2011). In Bandura's seminal paper on self-regulation, he articulates that the act of self-monitoring is not of a passive nature, but rather, employs the individual to take an active role by constructing their own standards (Bandura, 1991), which may take the form of logging acts of adherence to a prescribed behaviour. Past health promotion studies involving self-monitoring have typically used paper-based diaries, which are used to monitor many aspects of behaviour, but most commonly incorporate the tracking of eating habits and exercise that a participant engages in over the course of a study (Burke et al., 2011). The act of self-monitoring is then further utilized through the process of self-evaluation. Self-evaluation provides the individual with direction on a given behaviour, creating motivation to continue an action, or the cue to change behaviour when necessary (Bandura, 1991).

Without active engagement in the process of self-regulation, an individual may not recognize a decline in exercise behaviour and subsequently fall into the aforementioned 6-month drop out pattern (Sniehotta et al., 2005). In contrast, an individual who actively engages in self-

regulation will observe the decline in exercise engagement prior to relapsing to inactivity and be able to adjust behaviour accordingly. Such self-regulatory processes are central to health-enhancing behaviour change (Michie, Abraham, Whittington, McAteer, & Gupta, 2009), allowing individuals to not only make sound decisions based on the situation at hand but also recognize significant determinants of success or failure through personal examination and reflection (Bandura, 1991). Through the process of self-regulation, and personal consideration of one's progress towards the goal directed behaviour (e.g., adherence to exercise), an individual can develop an understanding of important patterns that trigger a decline in exercise behaviour. For example, by self-monitoring exercise behaviour, an individual can look back and evaluate whether certain days of the week or certain social pressures trigger skipping exercise bouts. Then, upon reflection, the individual can process this information and formulate a new plan (e.g., scheduling exercise on days that do not have the likelihood of that barrier occurring, or by purposefully planning a new response to such triggers).

In a recent meta-analysis by Michie and colleagues (2009), the authors examine multiple behaviour change interventions that have incorporated self-regulation to bolster physical activity and healthy eating behaviours. This review has proven seminal to the field of health behaviour change for a number of reasons. First, Michie and colleagues made a point to examine interventions in comparison to standard care conditions rather than matched no-intervention control conditions. In contrast, previous research has focused on the presence or absence of a behavioural change technique associated with effectiveness. Placing focus on an observed behaviour change in an intervention group in comparison with an intervention control or standard-care condition, as opposed to a matched no-intervention control allows for the inclusion of significantly more databases and provides a more conservative estimate of effects.

Second, this review eloquently reiterated the importance of behaviour change theories when attempting to modify health behaviours. While the utility of such theories has been discussed in past literature (Brawley, 1993), Michie and colleague's systematic review is the first to confirm this earlier message through summation of evidence-based findings. Theory-based behaviour change models are advantageous for three main reasons: i) they target determinants of behaviour and behaviour change, ii) evaluations of interventions can only be tested and improved upon if the intervention is theoretically informed and iii) theory-based interventions facilitate an understanding of what works and *why*, and thus are a basis for developing better theory across different contexts, populations and behaviours (Michie, Johnston, Francis, Hardeman, & Eccles, 2008).

Within the meta-analysis, Michie et al. (2009) examined 101 papers reporting 122 evaluations. Fifty-one evaluations targeted physical activity only, 35 targeted healthy eating only and 18 targeted both physical activity and healthy eating. Overall, results indicated that those participants who received an intervention inclusive of behaviour change techniques reported a significantly better outcome than those in a control condition. Intriguingly, studies that incorporated self-monitoring were significantly more effective than interventions that did not include the same technique regardless of the targeted behaviour (i.e., healthy eating or physical activity).

1.3 Self-Monitoring in Exercise Interventions

Part of the greater concept of self-regulation, self-monitoring continues to gain considerable attention in the research world for its contributions to exercise adherence studies. Self-monitoring as a process is not simply a reflection of one's performance or behaviour, but utilizes pre-existing cognitive structures and self-beliefs which exert influence on an aspect of

functioning, and how information and feedback on performance are organized for future reflection (Bandura, 1991). Engaging in the act of self-monitoring further promotes the process of self-regulation, which results in individuals taking an active role in their own change. Such an approach has had considerable success among those with long-term illnesses (Michie et al., 2009), but up until recently, has not been used extensively in the examination of adherence to exercise programs.

The recognition of patterns in behaviour is a key component of self-monitoring. This aspect is essential, as it provides individuals with immediate feedback to recognize past patterns and pit falls, thus allowing them to adjust future behaviour accordingly in order to succeed in attaining the desired outcome (Wing, 2004). Active engagement in self-monitoring each day is likely to reduce difficulties in the attainment of exercise goals (Carels et al., 2005; Burke et al., 2012). A prime example of the utility of self-monitoring for promoting health behaviour change is presented in a 6-month weight loss and exercise intervention by Carels and colleagues. Participants in this study were 40 obese, sedentary adults who were enrolled in the study to promote gradual weight loss and increase exercise behaviour. All participants received the same exercise prescription, and were instructed to record the type and duration of exercise engaged in each day in a paper diary. Diaries were collected every 4 to 5 weeks, for a total of 21-weeks of self-monitoring diaries. At the end of the study, participants had completed on average 15.8 weeks of self-monitoring via submitted diaries. Upon analysis of self-monitoring diaries, Carels and colleagues were able to conclude that a higher frequency of exercise self-monitoring was significantly associated with fewer reported difficulties with exercise. Further, those that consistently self-monitored their exercise throughout the program exercised more and lost more weight than those who only inconsistently self-monitored.

1.3.1 Self-monitoring Strategies

The use of diaries to record behaviour is of great benefit to self-monitoring studies. Specifically, this mode of data collection allows investigators to understand the behaviour of participants through self-report entries, with recordings being reflective of the purpose of the study at hand. Until recently, the practice of self-monitoring has been solely carried out in paper and pen format. Such self-monitoring practices are used in a variety of research areas (e.g., pain management, drug therapy, and smoking cessation), including studies investigating healthy eating and exercise habits (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014; Burke et al., 2005). While paper-based self-monitoring is easily accessible, the practice is also associated with inherent limitations.

In 2005, Burke and colleagues reviewed the use of paper diaries related to the self-monitoring of food intake, identifying strengths and limitations of current practice, providing comparison to the up and coming counterpart: electronic diaries or logs. Paper-based diaries or logbooks are simple to use, require little training and are readily available with minimal cost. However, along with the benefits of simplicity also come associated limitations. Use of a paper-based diary assumes a certain level of literacy in study participants. Additionally, investigators and providers run the risk of receiving diaries that are possibly illegible, or incomplete (Burke et al., 2005). While electronic devices also encounter certain issues concerning literacy, strategic programming helps to reduce burden on both the researcher and the participant.

Reducing burden on both the researcher and the participant is a beneficial aspect of electronic self-monitoring devices, and a major focus of current research studies. Within the context of paper-based diaries, participants are expected to record by hand their exercise behaviour daily, often for months or years, and submit this to the researchers. On the other end,

the research staff must collect the logs (dealing with inevitably low response rates if mailed in), and manually compile and enter the data for statistical analyses. In comparison, the use of electronic self-monitoring devices has the capability to automatically summarize and analyze data.

Self-monitoring diaries have been critiqued for susceptibility to over- or underreporting (Aittasalo, Miilunpalo, Kukkonen-Harjula, & Pasanen, 2006) of data, a result reflective of a probable time lag in logging. Such a vulnerability makes it difficult for the investigator to determine when the act of self-monitoring occurred. Past observations of self-monitoring behaviour has demonstrated that participants delay recording behaviour, and subsequently complete multiple self-report logs at one time. This act, often referred to as 'back-fill', is detrimental as a long delay in the recording of behaviour (e.g., weekly or monthly) makes the reports unreliable, and susceptible to recall bias (Burke et al., 2005). Backfill is also detrimental to the effectiveness of self-monitoring for the individual participant. Active involvement in self-monitoring positively influences progress towards a health behaviour change, thus an individual who does not actively self-monitor loses the opportunity for evaluation and subsequent modification (i.e., self-regulation) of a behaviour.

A time lapse between the recording of exercise bouts and the provision of feedback is common in paper-based self-monitoring. This lapse in time is detrimental to an individual's progress as a delay between a recording and provision of feedback results in limited support between the pair (Burke et al., 2012). The opportunity for immediate transfer of data and subsequent feedback can raise awareness of individualized barriers to a health behaviour, providing the researcher/ health professional an opportunity to bolster the participant's self-regulatory skills and self-efficacy in order to overcome the challenge. Most importantly, this

instantaneous communication provides an opportunity for increased rapport between participant and trainer, an aspect that is often lost when paper logs are used due to a lack of connection between the pair.

1.3.2 Self-monitoring: The age of technology

In light of these limitations, researchers have begun to explore electronic and online options for self-monitoring. Burke and colleagues (2005) have cited that the benefits and enhanced capabilities of electronic diaries far outweighed the costs of such devices, and highly encourage their use over conventional paper-based diaries. The electronic nature of computer-based self-monitoring diaries removes the issue of illegible handwriting, enables various computations for participants (e.g., instantaneous counting of calories, estimates of caloric expenditure for exercise bout), and with the continual improvement of the Internet and technology, collected data can be analyzed in a context appropriate and sophisticated manner (Al Ayubi, Parmanto, Branch & Ding, 2014). Such computations provide tremendous advantages over paper-based logs by greatly reducing researcher analytic time.

Electronic diaries allow investigators to discern when a participant has provided reports, an improvement over paper-based diaries and their susceptibility to 'back-fill', or the untimely provision of self-monitoring reports. With the use of a companion website, electronic self-monitoring allows for the instantaneous transfer of data to investigators, removing any past issues with time lag and unreliable and/or costly mail service (Burke et al., 2005). Most importantly, as adherence to self-monitoring behaviour is typically reported based on the number of diaries completed (Burke et al., 2011; Burke et al., 2012), the use of electronic monitoring systems ensures that adherence cannot be manipulated or "back filled" as reports can be date and time stamped (Burke et al., 2005).

The advantages of electronic versions of self-monitoring over paper-based versions have been explored with numerous weight loss and lifestyle behaviour change studies (Mattila, Lappalainen, Parkka, Salminen, & Korhonen, 2010; Burke et al., 2005; Burke et al., 2012). One such study comparing the utility of paper-based and electronic-based self-monitoring diaries was a 2-year randomized controlled clinical weight loss trial. Developed by Burke and colleagues, the referenced study focused on Self-Monitoring and Recording Using Technology (SMART). Results of the investigation reported that participants with access to electronic diaries showed a higher rate of adherence to self-monitoring, and lost significantly more weight than those randomized to paper-based self-monitoring diaries (Burke et al., 2012).

1.3.3 Self-monitoring via the pedometer: A step in the right direction

Adjacent to the emerging interest in self-monitoring devices is the field of exercise and activity measurement. In order to monitor an individual's exercise, one must know how much exercise he/she is engaging in. Accordingly, such exercise tracking devices warrant review in this overarching background rationale. With advancement in technology, many resources have become available to aid in the process of tracking exercise behaviour. One such device is the pedometer. Pedometers have been demonstrated as a beneficial tool to develop a self-monitoring routine if accompanied with a formal process of recording daily values (Tudor-Locke, 2009; Tudor-Locke & Lutes, 2009; Croteau, 2004). The combination of pedometer wearing plus self-monitoring in an associated log helps to reinforce activity behaviours (Tudor-Locke & Lutes, 2009), creating short-term positive influences on activity levels (Tudor-Locke, 2009). While short-term positive influence has been demonstrated, the long-term impact of wearing a pedometer and self-monitoring steps is not well supported. As reported by Kaminsky, Jones,

Riggin, & Strath (2013); along with Croteau's 2004 review of pedometer-based studies, most research to date has focused on the short-term effects of pedometer use.

In attempts to explore longer-term effects of pedometers and associated self-monitoring logs, Tudor-Locke (2009) conducted a pedometer-based intervention with an initial 4-week adoption phase, followed by a 24 week follow up. While initial findings support that the use of a pedometer (along with their First Steps Program) created a dramatic increase in walking behaviour, follow up at 24 weeks indicated that the act of wearing a pedometer alone did not maintain a lifestyle change. Findings confirm earlier suspicions that the novelty of wearing such a device wanes when the study is extended past a couple of months, with a relapse to inactivity evident at 24 weeks. To prevent relapse, the authors suggested future interventions integrate additional strategies such as a booster session in order to maintain lifestyle changes. Likewise, Azar et al. (2013) has suggested that engagement of the user in logging systems is necessary for eliciting long-term improvements in exercise.

Pedometers alone lack the ability to engage or interact with the user as the device simply reports a frequency score based on a participant's steps. While a frequency score displayed can be helpful to understand whether there is an increase in steps, this score does not provide: i) accountability to an exercise program, ii) tools to self-monitor progress or any opportunities to use feedback to modify behaviour, or iii) meaningful, contextual advice. While research has shown that providing participants with a target number of steps per day has been effective at increasing activity levels (Tudor-Locke, 2009) in the short-term, this set number is wrought with limitations that minimize the meaningfulness of such advice. The practice of prescribing a number of steps per day goal (generally 10, 000 steps) is based on a crude estimate of how many steps one would take accruing 30 minutes of activity. However, pedometers do not take into

account i) intensity, ii) hill grade, iii) any type of activity other than walking/running, and iv) as the pedometer is meant to sit on the hips of the wearer, an overweight or obese individual may not have proper fit and therefore results in an inaccurate estimates of activity levels (Tudor-Locke, 2009). Those variables in mind, the goal of a number of steps per day is often not appropriate as an exercise prescription.

1.3.4 Self-monitoring & Exercise Tracking Devices Improved: Mobile Applications

To improve upon the shortfalls of pedometers and paper-based self-monitoring, whilst maintaining the ease and convenience central to devices used in one's daily life, a shift of focus has been made to mobile phone applications. To date, approximately 90% of citizens in developing countries utilize mobile devices, accounting for nearly 7 billion mobile phone subscriptions worldwide (Hall, Cole-Lewis, & Bernhardt, 2015). Mobile devices are becoming increasingly important to our daily lives, with 80% of Canadians using a smart phone (Knight et al., 2015), and 8 in 10 smart phone owners reporting that they don't leave home without their mobile device (The Canadian Press, 2013). This widespread use of mobile devices has led to the creation of a new aspect of health-based interventions called mobile health (mHealth). Simultaneously, advances in technology have shifted traditional means of health promotion materials from read-only (e.g., pamphlets, websites with non-interactive content) to interactive and responsive means (e.g., mobile applications [apps]). Such mobile technologies have the ability to directly effect change on the previously mentioned barriers to using paper-based self-monitoring. mHealth technology has the ability to i) engage users in the self-management of a health related behaviour, ii) deliver behaviour change interventions, and iii) reduce burden on involved parties while further facilitating behaviour change through features such as scheduling capabilities, and prompts related to adherence of the behaviour (Knight et al., 2015).

Interest in mHealth self-monitoring applications is on an exponential rise – demonstrating the potential utility and widespread use of such self-monitoring tools. Apple 'App' store reports currently show approximately 200 apps for purchase within the 'Top Paid iPhone Apps' section, specifically related to Health and Fitness. Such 'apps' cover topics from bluetooth pedometer tracking, fitness plan generators, and even calorie counters. With the growing availability of downloadable apps, mobile phone users are becoming increasingly reliant on applications. As of 2012, 84% of smartphone owners had downloaded at least one app to their phone, with 19% of those individuals having downloaded an app specifically related to tracking or managing a health-related behaviour (Raine & Fox, 2012). Although a comparatively new technology, these apps show promise in the field of behavioural lifestyle interventions (Azar et al., 2013). Research on the use of health and fitness apps is limited, however, preliminary evidence of the benefits to using technology such as the Internet and mobile technologies to deliver health behaviour interventions has recently emerged (Azar et al., 2013).

While app use is increasing in popularity, current apps are not without limitations. A majority of health-related apps currently available are developed on the traditional model of dissemination. Apps can provide valuable information through messages to an individual user and content on a dedicated website, however, they may neglect to integrate content on established behaviour change theories and evidence-based strategies (Al Ayubi et al., 2014; Knight et al., 2015; Patel, Asch & Volpp, 2015; Rabin & Bock, 2011).

In 2012, Cowan and colleagues conducted a review of 127 apps from Apple's Health and Fitness category (within the App store). The purpose of this review was to develop a greater understanding of the prevalence of health behaviour theory used in the development of publicly available apps. Investigators rated the inclusion of theoretical constructs on a 100-point scale,

with the inclusion of any given construct allotted one point towards a respective app's score. Examining Cowan's findings, the lack of theoretical content in apps is strongly evident. The app entitled 'Sport and Fitness Excellence' represents the highest content with a score of 28 out of a possible 100, with the two lowest scoring apps reporting scores of one point each. Overall, the 127 apps selected result in a mean score of only 10.01 points. While the reported mean demonstrates a poor utilization of theoretical content, such reports are not surprising. App developers are not necessarily experts in the field of health behaviour, but rather are typically better versed in software development. Such evidence highlights the growing need for collaboration among software developers and health behaviour change experts.

The presence of behaviour change techniques was further studied in 2014, evaluating the 40 most popular physical activity and dietary apps from the New Zealand Apple 'App' store (Health and Fitness category). The investigation, conducted by Direito and colleagues, examined the top 20 paid, and top 20 free apps for the presence or absence of 26 behaviour change techniques. Comparing each app to the taxonomy of behaviour change techniques (Abraham & Michie, 2008), the investigation reported an average meager inclusion of 8.1 behaviour change techniques, with slightly more techniques present in paid apps (M_{paid} = 9.7, M_{free} = 6.6). Direito and colleagues (2014), among others (Abroms, Padmanabhan, Thaweethai, & Phillips, 2011; Cowan et al., 2012; Doshi, Patrick, Sallis, & Calfas, 2003; Riley et al., 2011), strongly recommend that future apps in the health domain be improved by incorporating evidence-based practice that we know enhance behaviour change.

Although rare to find, research-derived programs such as the HEART mobile phone trial (Maddison et al., 2014) demonstrate the benefits of integrating theoretical content. Established utilizing principles of behaviour change from social cognitive theory (Bandura, 1986), HEART

uses a personalized, automated package of text messages aimed at increasing levels of exercise behaviour in individuals with ischaemic heart disease. With an aim of increasing exercise behaviour to 30 minutes of moderate to vigorous exercise most days of the week, HEART provided assistance through goal setting, exercise scheduling, and self-efficacy to overcome exercise barriers and engage in regular exercise. Following the intervention, significant main effects were reported in favour of leisure-time activity and walking, providing support for the use of theory-based constructs to increase exercise behaviour, as well as self-efficacy to engage in exercise. Such findings can be seamlessly translated to the current study regarding the goal of increasing exercise behaviour.

The use of theory is of monumental importance for furthering our understanding of what works and why. By scientifically evaluating the temporal influence of malleable psychological influences on behaviour change, theory advancement can improve the ability of future interventions to service multiple health behaviours, populations and behaviours (Michie et al., 2008). Currently, there is no standardized measure or tool to understand which theory is best suited for an app based on exercise adherence. Therefore, more research is necessary to provide further understanding of which technique(s) is (are) most appropriate. A recent study by Knight and colleagues (2015) cite that additional research is warranted to explore the inclusion of techniques grounded in behaviour change theory. Of that list, social cognitive theory is provided as a possible source, a theory that assisted in the development of our current app. By integrating theoretical reasoning and evidence-based strategies into the development of an application, both developers and users alike will benefit.

The second limitation amongst the current selection of apps is the absence of human connection. As previously mentioned, a lack of engagement of the user means an app or tracking

system is not as likely to be used and therefore is not as effective (Azar et al., 2013). While all available apps, free or purchased, can assist individuals in tracking his/her exercise behaviour and provide endless resources for new activities, these systems are likely to be discarded as easily as initiated if there is a missing connection with another individual, and by extension, a lack of accountability.

The most effective apps are proposed to be those that will continually engage users over extended periods of time in order to provide encouragement, tips on how to overcome barriers, overall accountability and rapport – all of which are known to facilitate maintenance of a new health behaviour. Continued engagement is possible with mHealth tools and effective when the researcher, or health care professional, utilizes triggers to help prepare clients for upcoming challenges, responds to user input with personalized feedback, and provides incentives (Azar et al., 2013). In this way, continued engagement entices participants to continually self-monitor, tracking exercise behaviour and the occurrence of barriers, as they are more likely to expect the investigators or trainers will be providing immediate support or suggestions when necessary.

1.4 Self-Monitoring Through Mobile Devices: Utility of Short Message Service to Enhance User Engagement

The advent and increasing popularity of short message service (SMS) has led researchers to begin delivering health behaviour change programs in this format. To date, most studies use SMS to deliver reminders to increase adherence to the targeted behaviour. However, the usefulness of SMS messages is dependent on the manner in which a message is composed. Fjeldsoe, Marshall, & Miller (2009) propose that untailored messages are found to be less engaging, a notion that is echoed by Dale and colleages (2014). In their review of mHealth technology, Dale et al. (2014) demonstrates that personalized interventions are more effective at

changing behaviour. This finding is also supported by Lau, Lau, Cai and Archer (2015), but surprisingly remains an aspect that few researchers have utilized to date to increase exercise adherence. In a systematic review by Fjeldsoe et al. (2009), the effectiveness of SMS for delivering health behaviour change interventions was examined, while also comparing the level of adherence to the specified behaviour change program (e.g., smoking cessation, diabetes self-management). The review compared the program adherence of those receiving tailored health SMS messages versus those receiving untailored health SMS messages. Of the papers reviewed, those that utilized untailored mass SMS were in the top three ranked studies for highest attrition rates. Within their own work, Lau and colleagues (2015) examined the effects of culturally tailored text message content on login rate of an Internet based physical activity program. Set within six Hong Kong secondary schools, the investigation tracked login rates over the course of the eight-week investigation. Week eight findings suggest that use of culturally tailored text messages may be beneficial over the use of generic messages.

Examining new and novel technology against past technology, Maddison and colleagues (2011) examined the use of SMS as a behavioural intervention tool in comparison to a telephone-based intervention. In a single-blinded parallel two-arm randomized controlled trial of 170 participants, the investigators demonstrated the advantages of SMS over telephone-delivered materials. Maddison and colleagues concluded that use of SMS messaging has the ability to reach many individuals as mobile phones are carried by majority of adults, and allows communication to be made regularly, in a convenient manner, with messages being sent in an appropriate and timely manner. The advantages of SMS messages results in a much greater likelihood of receipt from the end user when compared to phone calls. The methodology employed by Maddison and colleagues, and every study published to date that has utilized SMS

as a vehicle for intervention content, is to deliver information through the use of *automated* messaging, which lacks the availability of a human individual for support, rapport, and arguably, true engagement. While improvements in human-computer interactions can now make automated messages tailored (e.g., include the end user's name when sending a message, providing reminders at times the end user has pre-specified would be of benefit to her, etc.), human interaction far outweighs automated responses for authenticity, responsivity, and establishing a meaningful supportive relationship - all of which increase the likelihood of continued user engagement.

In summary, the use of SMS has thus far been demonstrated as an ideal communication channel in the study of health behaviour change. The use of SMS can be used to cover a vast number of individuals feasibly. Initial findings in this research domain appears to suggest that tailored health SMS are i) more engaging, and ii) effective at changing behaviour in comparison to untailored SMS (Fjeldsoe et al., 2009; Lau et al., 2015). These aspects suggest that personalized SMS health behaviour interventions might be a potent strategy for eliciting health behaviour change. Human interaction through the interface of SMS maintains the major benefits of automated SMS (e.g., low cost and time involvement, potential for widespread use), but could also provide further benefits: development of accountability, provision of instantaneous feedback, higher perceptions of rapport, and timeliness of message and content receipt.

Technology has made possible an interactive, non-burdensome way in which to connect those wishing to receive knowledgeable support in interactive format. The integration of SMS technology not only allows for instantaneous feedback via the delivery of short messages, but users are also given the freedom to check these messages at the time that best suits the individual. Not only does this new technology allow for effective and time efficient transfer of

knowledge from the expert to the client, but also interactions have become quantifiable so that a record of engagement is easily maintained for future reference (Fjeldsoe et al., 2009). Regardless of the type of technology, a common theme is expressed in the literature: continual contact from user to interventionist, in a tailored messaging system (Fjeldsoe et al., 2009), is the most beneficial way of reaching and retaining users over time.

1.5 Summary of Evidence-Based Self-Monitoring Programs

Strategies to actively self-monitor have undergone a dramatic transition, beginning with the initial use of paper and pen diaries, to the development, and increasing prevalence of mHealth app technology. Use of mHealth technology is on an exponential rise and has the capability to reach a large number of individuals. As of 2012, 84% of smartphone owners had downloaded at least one app to their phone; 19% of those individuals had downloaded an app specifically related to tracking or managing a health-related behaviour (Raine & Fox, 2012). While the increased use of apps shows promise for this continually developing technology, apps currently available have neglected to integrate evidence-based strategies from established health behaviour change theories (Al Ayubi et al., 2014; Cowan et al., 2012; Patel, Asch, & Volpp, 2015; Rabin & Bock, 2011). Support for the utility of incorporating theory-based content into existing mHealth technology is substantive (Cowan et al., 2012; Direito et al., 2014). Further, a call for the improvement of apps through incorporating evidence-based practice has been established (Abroms et al., 2011; Cowan et al., 2012; Doshi et al., 2003; Riley et al., 2011), highlighting the need for collaboration between health behaviour change experts and app developers.

When deciding upon which theory-based content to incorporate into new or existing apps, the context of the particular mHealth technology being utilized and the behaviour to be

changed must also be taken into consideration. As demonstrated in the HEART trial (Maddison et al., 2014), social cognitive theory is particularly well suited for mHealth interventions as the tenets of the theory are grounded in i) self-monitoring, ii) self-evaluation, and iii) the modification of current behaviour based on this self-reflection (Bandura, 1991; Sniehotta, Scholz, & Schwarzer, 2005) – tasks that mHealth apps have incredible capacity to assist users with. An individual's progression toward a goal directed behaviour is attributed to his/her ability to self-regulate behaviour, and is partly dependent on the fidelity, consistency, and timeliness of self-monitoring (Burke, Wang, & Sevick, 2011). The instantaneous nature of an mHealth app allows self-monitoring to be carried out promptly and accurately with minimal inconvenience for the user. While the process of self-monitoring alone is not likely to help an individual to self-regulate, the recording and storing of information electronically allows for quick and efficient review of behaviour, allowing the user opportunity to evaluate behaviour when necessary to remain in line with one's goal (i.e., self-regulate his/her behaviour).

While active engagement in self-monitoring and self-regulation are essential for the maintenance of health-related behaviour, the provision of personalized feedback is essential to goal progression. Personalized mHealth interventions have been demonstrated to be more effective than non-personalized interventions at changing health behaviour (Dale et al., 2014; Fjeldsoe et al., 2009). Likewise, the integration of tailored SMS messages has confirmed the effectiveness of this messaging format for promoting health behaviour change (Fjeldsoe et al., 2009).

1.6 The Present Study

The purpose of this feasibility study is to examine the utility of a theory-based, exercise self-monitoring application (app) for improving exercise adherence over eight weeks. When

compared to a control group who did not receive a self-monitoring app, it is expected that participants in the experimental group (app users) will experience a greater increase in exercise and self-monitoring behaviour.

Hypothesis 1: Participants in the experimental condition (app users) will engage in exercise more frequently in comparison to participants in the control condition over the 8-week study.

Use of the self-monitoring app in conjunction with an individualized exercise frequency goal will help to facilitate the process of self-regulation as developed by Bandura (1991). To successfully influence and increase exercise behaviour, active engagement in self-monitoring behaviour is necessary, leading to our secondary hypothesis.

Hypothesis 2: Participants in the experimental condition will engage in self-monitoring more frequently than participants randomized to the control condition throughout the 8-week study.

Self-monitoring and further evaluation of a goal directed behaviour is a catalyst for the regulation of behaviour. Initiating the process of self-regulation, an increase in self-monitoring behaviour will influence an individual's perceived ability to manage a health-related behaviour. Active self-regulation will foster a vested interest in an individual's exercise behaviour, raising awareness of perceived barriers, and experiencing success toward his/her specific exercise frequency goal. Combined, these acts are anticipated to result in an increase in perceived self-management of exercise behaviour.

Hypothesis 3: Post-intervention, participants in the experimental condition will report higher perceived self-management of exercise behaviour in comparison to participants in the control condition.

Active engagement in self-monitoring should facilitate the process of self-regulation and management of behaviour. Actively practicing self-monitoring results in past performance experiences of self-monitoring. According to Bandura (1977), the strongest enhancement to one's self-efficacy comes from looking back at past successful experiences. Active engagement in self-monitoring therefore has the ability to influence a users' belief in his/her own ability to complete a given behaviour in the future (i.e., self-efficacy to self-monitor in the future).

Hypothesis 4: Post-intervention, participants in the experimental condition will report higher self-efficacy to self-monitor exercise behaviour in comparison to participants in the control condition.

Chapter 2: Manuscript

2.1 Background

2.1.1 Benefits of Exercise

The benefits of exercise are irrefutable [2], and have been demonstrated for individuals of all ages [3]. In Canada, the government encourages engagement in exercise through the publication of *Canada's Physical Activity and Sedentary Behaviour Guidelines Handbook* [4]. While it is often assumed that knowledge of the benefits of exercise will increase exercise levels, informational campaigns have been rendered as ineffective for sustaining behaviour change [5, 6]. This is exemplified by the steady decline in physical activity and fitness levels amongst Canadians [3] despite the promotion of these physical activity guidelines, with only 15% of Canadian adults currently meeting daily physical activity recommendations [7].

2.1.2 Mobile Health (mHealth) Technology

One strategy that may provide an effective medium to target physical inactivity at the population level is mobile health technology. To date, there are nearly 7 billion mobile phone subscriptions worldwide, with the use of mobile devices reaching 90% in developing countries, and 96% globally [8]. This widespread use of mobile devices has led to the creation of mobile health-based (mHealth) products. Simultaneously, advances in technology have shifted traditional means of health promotion materials from read-only (e.g., pamphlets, websites with read-only content) to interactive and responsive means (e.g., mobile applications [apps]). mHealth apps offer many advantages over traditional information materials. Data from users can now be analyzed in a context appropriate, timely, and sophisticated manner [9]. More than ever before, there is opportunity to provide real-time support to the masses, outside of costly traditional personal training or counseling appointment times.

As of 2012, 84% of smartphone owners had downloaded at least one app to their phone; 19% of those individuals had downloaded an app specifically related to tracking or managing a health-related behaviour [10]. The continually increasing prevalence of app use further demonstrates the potential reach for mHealth exercise interventions. While app use is increasing in popularity; existing apps are not without limitations.

2.1.3 Use of Evidence-Based Strategy

The majority of health-related apps currently available are developed on the traditional dissemination model. Generic, automated text messages are typically sent to individual users on a standardized time of day or week, or access to content is on a dedicated website in which users are referred to go read. While these apps provide valuable information to the user, such apps have neglected to integrate evidence-based strategies from established health behaviour change theories [1, 9, 11, 12]. In a 2012 review of the Health and Fitness category in the Apple 'App' store, Cowan and colleagues [1] concluded that there was an overarching lack of theoretical constructs used within 127 surveyed apps. Similar findings were reported in Direito and colleagues' 2014 study evaluating the presence of 26 behaviour change techniques in the 40 most popular physical activity and dietary apps from the Apple 'App' store [13]. While some incorporation of behaviour change techniques is evident, Direito and colleague's conclusions remained consistent with Cowan's review, in that an absence of behaviour change strategies exists in physical activity and dietary apps [13]. Cowan, Direito and colleagues are not alone. Several other reports have also strongly recommended that future apps in the health domain be improved by incorporating evidence-based practices that are known to enhance health behaviour change [1, 14, 15, 16]. These findings highlight the need for collaboration between health behaviour change experts and app developers.

Although rare to find, research-derived programs such as the HEART mobile phone trial [17] demonstrate the benefits of integrating evidence-based behaviour change strategies. Established utilizing principles of behaviour change from social cognitive theory [18], HEART uses a personalized, automated package of text messages aimed at increasing levels of exercise behaviour in individuals with ischaemic heart disease. HEART SMS texts were developed to assist users with goal setting, exercise scheduling, and self-efficacy to overcome exercise barriers and engage in regular exercise in a positive and cost-effective manner. Results of the trial support the continued use of SMS texts to increase exercise engagement through a significant main effect for leisure time physical activity in those receiving the SMS theory-based texts, which was mediated by task self-efficacy.

2.1.4 Social Cognitive Theory in mHealth Apps

As demonstrated in the HEART trial, social cognitive theory is particularly well suited for mHealth interventions as the tenets of the theory are grounded in i) self-monitoring, ii) self-evaluation, and iii) modification of current behaviour based on this self-reflection [19, 20] – tasks that mHealth apps have the capacity to assist the user with. The majority of apps allow the user to record their exercise sessions as a form of self-monitoring. Relatedly, many apps allow the user to look back at past exercise sessions in a summative format (e.g., number of sessions completed last week) – an opportunity for self-evaluation and reflection. Together, these tasks provide the opportunity for the user to modify current behaviour in order to meet one's goals. As such, most mHealth apps have the capacity to allow the user to self-regulate behaviour based on past experience and future goals, *if* guided appropriately.

2.1.5 Importance of Self-Monitoring

The success of self-regulation is partly dependent on the fidelity, consistency and timeliness of self-monitoring [21]. Given the instantaneous nature of real-time feedback that mHealth apps can provide, self-monitoring may be carried out promptly and accurately with minimal inconvenience for the individual. However, the process of self-monitoring is not simply an audit of one's performance [19], and the act of self-monitoring alone is not likely to help an individual self-regulate. Further investment must be taken by looking at past exercise patterns and recognizing barriers. This provision of feedback can provide the individual with an opportunity to evaluate behaviour when necessary to remain in line with one's goal.

2.1.6 Tailored Feedback

While active engagement in self-monitoring and self-regulation are essential for the maintenance of health-related behaviour, it is also imperative to provide individuals with personalized feedback on their behaviour. Personalized mHealth interventions have been demonstrated to be more effective than non-personalized interventions at changing health behaviour [22, 23], however few interventions utilize this technique. Likewise, a systematic review of mHealth app interventions confirmed the effectiveness of tailored SMS messages for promoting health behaviour change (see literature review [23]). In the context of mHealth apps, a personalized intervention would allow a health professional to provide tailored feedback to an individual user in a time-efficient manner.

The present study sought to examine the utility of a theory-based exercise self-monitoring app for increasing independent exercise adherence over 8-weeks. It was hypothesized that the use of this app would result in i) more frequent exercise bouts, ii) more frequent self-monitoring,

iii) higher perceived self-management of exercise behaviour, and iv) higher self-efficacy to self-monitor exercise behaviour in comparison to individuals not using the app.

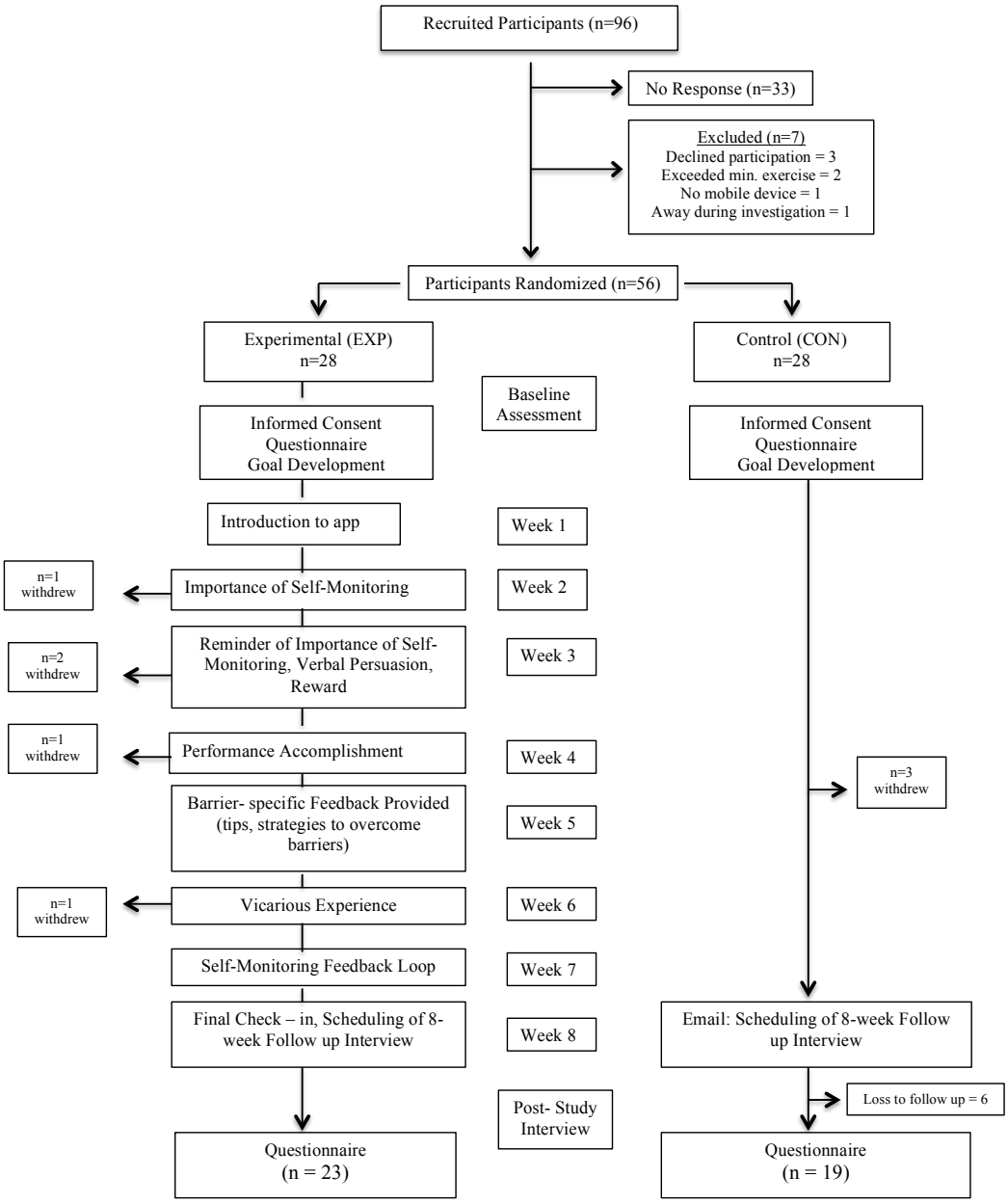
2.2 Methods

The study was approved by the University of British Columbia: Okanagan Research Ethics Board.

2.2.1 Participants

Participants were recruited from a local YMCA fitness facility by means of announcements in fitness classes, posters located throughout the facility, and an information booth in the lobby. In addition, front desk YMCA staff members were instructed to inform individuals about the study opportunity. Eligible participants were current facility members aged 19-70, with access to a mobile device. Ninety-four individuals expressed interest in participating. Following initial screening via email, fifty-six members were deemed eligible (see Figure 1 for detailed information regarding eligibility), and were randomized through a computer random numbers generated table to either receive the app for 8 weeks (experimental; n=28, 64% females), or to the control condition (n=28, 71% females), which did not receive the app.

Figure 1. Participant flow.



2.2.2 Procedures

Eligible participants provided written consent and subsequently completed baseline questionnaires. All participants then engaged in a goal setting discussion using the "SMART" goal setting framework (i.e., Specific, Measureable, Attainable, Relevant, and Time-bound), to self-set a weekly exercise frequency goal (e.g., I will visit the gym three days this week) for the 8-week study duration.

2.2.2.1 Experimental condition protocol

Each participant's profile was created on the app within 24 hours, at which time he/she was prompted by a text message to sign in and begin monitoring exercise behaviour. Participants were encouraged to monitor exercise behaviour on a daily basis (i.e., record exercise into the app) regardless of whether purposeful exercise was planned or completed that day (from here on referred to as 'check in'). Planned non-exercise days were personalized within the app based on planned bouts of exercise for each week (i.e., if an individual's goal was to exercise three times per week, that participant's program included four "rest" days). Participants in the experimental condition were reminded via text message to check in to the app if they had not checked in by 9:00pm.

At the beginning of each week, participants were sent a message based on social cognitive theory. Messages ranged from 65 to 135 words in length, and were delivered via the app messaging system to which users were alerted via a text message. These theory-based messages targeted the components of self-monitoring, verbal persuasion, performance accomplishment, and vicarious experience (Table 1).

Table 1. Overview of weekly theory-based messages to participants.

Week	Theoretical Content
1 Introduction (establishing rapport)	Hi (insert name)! My name is (insert counselor's name) and I am your virtual exercise counselor. I can't wait to see the progress you make as you monitor and modify your behaviour. I know you are super motivated and ready to kick start your exercise so let's get you moving! Check in each day to report your activity and keep an eye on your message center. I'll be checking in frequently to see how you're doing. Feel free to contact me if you have any questions or concerns ☺
2 Importance of Self-Monitoring	Hey (insert name)! Just wanted to say you're doing a great job! You're already one week in to using this app and you have tracked your behaviour each day! Keeping track of your behaviour allows you, and me, to see what a great job you are doing, and helps remind you of your goals. It can also show us where improvements are needed or whether there are any patterns that are problematic. Some people say that keeping track of what exercise they have done is the hardest part – you are excelling in this and this is what will keep you accountable to your personal goals! Keep checking in everyday and let's rock this!
3 Reminder of importance of self-monitoring, use of verbal persuasion and self-set rewards.	Week 2 down and look at how far you have come! You have now been tracking your exercise behaviour for 2 weeks. Keep in mind that self-monitoring is the key to making lasting behaviour changes. With this app, tracking your behaviour is easy and you are showing yourself that you can do it. You are holding yourself to those goals that you care about so much – doesn't it feel great? Now is a great time to plan a reward for yourself. Keep up the great work performing and monitoring your exercise – you can do it!
4 Performance Accomplishment	(insert name) – Wow look at all you've done so far! Take a look at your progress graph - all of those green bars you've accumulated are proof that you are well on your way to achieving your goals! You really are using this app to its full potential and you are in control of your exercise. You are doing fantastically – keep up this great momentum
5 Feedback tailored to participant's goals/overcoming perceived barriers.	Example Barrier = family time As the weather gets warmer, take the family out on the weekend to kick around a soccer ball, ride bikes, or walk to the park and toss a Frisbee.
6 Establishing Vicarious Experience	Did you know that you are not the only one going through this program right now? There are 40 other facility members just like you that are monitoring their exercise, trying to achieve their personal exercise goals and using this app to help them reach those goals. These individuals have been recording their bouts of exercise on the app, and have been overcoming their exercise barriers. So far, the app has been keeping people honest and committed to their exercise goals.

Table 1. Overview of weekly theory-based messages to participants.

7 Self-monitoring Feedback Loop	It's week 7! You're doing such a fantastic job taking charge of your own exercise regime by consistently monitoring your behaviour and achieving positive scores each day. Now is a good time to look back and search for patterns of when you typically find it most difficult to stick with your exercise regimen. This can give you clues on how to circumvent those less-than-optimal motivational days. Notice weekends are your weak point? Be sure to get all your exercise in during the week and take the weekends off on purpose! Finding AM workouts unbearable? Modify your nighttime routine so that getting up and out the door isn't so hard. By seeking out problematic trends, we can revise our plans and will be more likely to succeed.
8 Final Check-in	Today marks the final week of goal tracking for the study. Think about where you started and look at where you are now, the physical and mental barriers that you have been able to break down, and all about what you have learnt about yourself. You are in control of your behaviour and you are in the habit of self-monitoring. You should feel proud of the progress you've made. Now use this feeling to rock your last week of workouts and use this as you move forward. Great job!

On the fourth day of each week, a second message was sent through the app, delivering tailored feedback and support based on the participant's personal performance that week. An additional message was sent through the app if a participant failed to check in to the app on two consecutive days (Table 2).

Table 2. Exercise counselor intervention timeline.

Point Value	Intervention Message
Complete Daily Goal Achievement	First occurrence Great job yesterday! You successfully completed all your set goals and rocked it! Keep up the great work ☺ Continuous achievement (Do not repeat until 1 week after first congratulatory message) Wow! You continually rock it! You're a rock star! Keep up the 100's! You deserve a gold star. Keep rocking it!
Partial Daily Goal Achievement	You've had some challenges but you did it! Good job for facing your barriers and getting out there. Keep up the good work.
Partial Goal Achievement on Multiple Days	Good job for checking into the app. I know that can be hard when barriers present themselves but you are aware of what is not working. I know you are able to reach those goals you set out to achieve. You can do this!

Table 2. Exercise counselor intervention timeline.

Missed check in for 2+ days	Hey (insert name)! Just checking in to see how it's going! 2 days have gone by since your last checked in to the system. Every day is a new one so let's get you back on track and start monitoring that exercise! The hardest part is checking in and keeping track of what you are doing. If you have any questions or concerns please do not hesitate to contact me.

In the event of three consecutive missed check-ins, app users were contacted by the research assistant via SMS text message. If this progressed to four consecutive missed check-ins, the research assistant phoned the participant to discuss any difficulties encountered.

2.2.2.2 Control condition protocol

Following goal development, participants in the control condition were encouraged to implement their newly developed goals over the following 8-weeks. Control condition participants did not receive any support from the research assistant throughout the 8-week duration.

2.2.2.3 Follow-up protocol for all participants

At the beginning of week 8, participants in both conditions were contacted via email to schedule a 30-minute follow-up interview for the following week. During this interview, participants completed the post-questionnaire.

2.3 Measures

2.3.1 Demographics

Participants were asked to provide basic demographic information including: year of birth (Table 3); height, weight (presented as mean BMI in Table 4); sex, highest level of education completed, and current occupation status (Table 5).

Table 3. Mean Age of Participants.

	Control	**Experimental**
	Age (years)	Age (years)
Mean Age	41.53	37.45

Table 4. Mean BMI of Participants.

	Control	**Experimental**
	kg/m^2	kg/m^2
Mean BMI	25.87	28.24

Table 5. Participant demographic characteristics.

	Control	**Experimental**
	(%)	(%)
Sex		
Female	71	64
Male	29	36
Education		
Less than high school	0	0
High school	21	22.7
Apprenticeship or trades or diploma	10.5	9.1
College	15.8	22.7
University diploma or degree	42.1	36.4
Post-graduate degree	10.5	9.1
Occupation		
Working full-time	47.4	40.9

Table 5. Participant demographic characteristics.

Working part-time	21.1	13.6
Working occasion/contract work	10.5	4.5
Student	0	22.7
Retired	5.3	9.1
Other	15.8	9.1

2.3.2 Self-Reported Exercise

Purposeful exercise behaviour was measured using a modified version of the Godin Leisure Time Exercise Questionnaire (GLTEQ [24]) at baseline and post-intervention (8-weeks). Participants were asked to report the frequency in which they engaged in moderate (e.g., fast walking), and strenuous (e.g., jogging) activity during their free time over the past 7 days. The GLTEQ was modified by asking participants to report exercise bouts of thirty minutes or more. Consistent with past literature [25, 26], moderate and strenuous bouts of exercise were summed together for analyses.

2.3.3 Self-Monitoring of Exercise Behaviour

Assessing the frequency of self-monitoring throughout the 8-week study duration required condition-specific measures. At baseline, all participants' self-reported frequency of self-monitoring exercise behaviour over the past 7 days. Post intervention, frequency of self-monitoring exercise behaviour in the app users (experimental condition) was assessed using the total number of completed app check-ins, averaged over the 8-week duration. Participants in the control condition were asked to provide an average weekly self-monitoring frequency over the previous 8-weeks.

2.3.4 Self-Management of Exercise Behaviour

Self-management of exercise was measured using 6 items from Hallam & Petosa's [27] measure of self-regulation. Responses were rated on a 5-point Likert scale ranging from 1 (*strongly disagree*), to 5 (*strongly agree)*. Relevant items selected assessed plans to participate in exercise (*i.e., It is difficult for me to find opportunities to participate in exercise*) and confidence to self-manage time (i.e., *I am able to find or make time to participate in exercise*). These items were modified from the original measure by replacing the reference from 'my condition' to 'exercise'. Cronbach alpha values at pre and post ($\alpha > 0.8$, see Table 10 and 11 for specific scores) suggest a reliable relationship for analysis [28, 29].

2.3.5 Self-Efficacy to Self-Monitor Exercise

Self-efficacy to self-monitor (SESM) exercise was assessed using 3 items. Participants rated their confidence to self-monitor exercise bouts on an 11-point Likert scale (*0% not at all confident to 100% extremely confident*)**.** The items assessed participants' confidence to record exercise (*record your exercise bouts*), track and adjust behaviour (*keep track of how many times you exercise and adjust your behaviour accordingly),* and manage their daily schedule to allow for exercise (*manage your daily schedule to allow time for participation in exercise)* over the next 7 days. The 3 items were averaged to reflect an overall SESM score. In this study, scores derived from this instrument demonstrated acceptable levels of reliability (Cronbach $\alpha > 0.7$, see Tables 12 and 13 for specific scores) at both pre and post [28, 29].

2.4 Analytic Plan

Data were analyzed using SPSS Statistics (Version 21, 2012). A series of independent *t*-tests and chi-square tests were conducted to examine equivalency between conditions on all demographic, dependent and independent variables at baseline. Repeated measures analyses of variance (ANOVA) were used to test the hypotheses that exercise bouts, self-monitoring exercise, self-efficacy to self-monitor, and self-management of exercise will be greater in the experimental condition as compared to the control condition following the 8-week study period. All effects are reported as significant at P value < 0.05. Effect size estimates were calculated using partial eta squared (partial η^2) for ANOVA and Cohen's d for t-test statistics. Effect size derived from partial η^2 was interpreted as small (.01), medium (.06), and large (.14) in accordance with conventional practices within the social sciences [30, 31]. Likewise, effect sizes derived from Cohen's d were interpreted as small (.20), medium (.50) and large (.80; [31, 32]). Differences between conditions, and time x condition interactions yielding medium to large effect sizes were further explored with t-test statistics.

2.5 Results

2.5.1 Demographics

A total of 56 adults (M_{age} = 40 years ± 13, M_{BMI} = 26.8 ± 5.3) participated in this study, with 35% of participants having achieved a university level degree or higher, and 50% were working either part- or full-time. Twenty-eight individuals were randomized to the experimental condition (M_{age} = 38 years ± 14.13, M_{BMI} = 28.2 ± 6.5), and 28 were randomized to the control condition (M_{age} = 42 years ± 10.9, M_{BMI} = 25.9 ± 3.6). In total,

41 out of 56 participants provided follow-up data 8-weeks post-intervention (see Figure 1 for participant flow chart).

There were no statistical differences in demographic, dependent, or independent variables between conditions at baseline with the exception of current exercise self-monitoring behaviour. At baseline, participants in the control condition (M = 1.89, SD = 2.28) reported a higher frequency of self-monitoring in the past 7 days than participants in the experimental condition (M = .52, SD = 1.61); t (37) = -2.34, P = .02, d =.69. There was no statistical difference in dropout rate between conditions ($\chi(1) = 1.19$, P = .28).

2.5.2 Self-Reported Exercise

A repeated measures ANOVA examining self-reported exercise frequency revealed no main effect for time, F (1,38) = 2721, P = .11, partial η^2 = .067; or condition, F (1,38) = 2.45, P = .13, partial η^2 = .061. The time (pre, post) x condition (experimental, control) interaction, although not meeting statistical significance, yielded a medium to large effect size, F (1, 38) = 3.87, P = .056, partial η^2 = .092. Exploratory post hoc analysis revealed a significant difference between conditions, such that those in the experimental condition (M = 7.24, SD = 3.40) were engaging in significantly more bouts of exercise per week than those in the control condition (M = 4.74, SD = 3.70); t (38) = 2.23, P = .03, d = .70.

2.5.3 Self-Monitoring of Exercise Behaviour

A repeated measures ANOVA examining self-monitoring frequency showed a main effect for time, F (1, 33) = 59.55, P < .001, partial η^2 = .643, and condition, F (1,33) = 15.38, P < .001, partial η^2 = .318. These main effects were superseded with a

significant time (pre, post) x condition (experimental, control) interaction, F (1, 33) = 49.39, $P < .001$, partial $\eta^2 = .599$. Post hoc analysis revealed a significant difference between conditions at post-intervention, such that those in experimental condition (M = 6.00, SD = .93) were engaging in a significantly higher frequency of self-monitoring compared to the control condition (M = 1.95, SD = 2.58); t (40) = 6.88, $P < .001$, d = 2.10.

2.5.4 Self-Management of Exercise Behaviour

A repeated measures ANOVA examining self-management of exercise behaviour revealed no main effect for time, F (1,38) = 1.91, P = .18, partial $\eta^2 = .048$; or condition, F (1,38) = .408, P = .53, partial $\eta^2 = .011$. The time (pre, post) x condition (experimental, control) interaction was not significant, F (1,38) = .039, P = .85, partial $\eta^2 = .001$.

2.5.5 Self-Efficacy to Self-Monitor Exercise

A repeated measures ANOVA examining SESM was conducted, revealing no main effect for time, F (1,39) = .092, P = .76, partial $\eta^2 = .002$; or condition F (1,39) = .665, P = .42, partial $\eta^2 = .017$. Further, the time (pre, post) x condition (experimental, control) interaction was not significant, F (1,39) = .021, P = .89, partial $\eta^2 = .001$.

2.6 Discussion

The current study investigated the utility of a theory-based self-monitoring app for improving exercise adherence. To our knowledge, this study is the first to integrate behaviour change theory in an app, using personalized goals, and interaction with a virtual exercise counselor, for the promotion of exercise behaviour. Findings provide preliminary evidence that individuals with access to such an app engage in a higher frequency of exercise behaviour in comparison to individuals who did not have the app. Specifically, app users experienced an

increase in exercise behaviour as represented by a medium to large effect size (partial $\eta^2 = .092$), findings that are similar to those reported in other mHealth trials [33, 34]. Possible reasons for these positive findings is that mHealth apps allow feedback messages to be sent in a time-sensitive manner, designed around the individual user to further facilitate communication [34]. Use of an app is found to be a simple self-monitoring tool, serving as a means of encouragement and motivation. When combined with feedback, both visual and verbal, the use of an app encourages users to work towards their activity goals [33].

Findings from the current study also provide partial support for our secondary hypothesis that use of a theory-based self-monitoring app will result in a higher frequency of self-monitoring in comparison to individuals without access to an app. From baseline to 8-weeks later, app users' self-monitoring frequency increased from less than one event per week, to an average of six self-monitoring events per week. Self-reported self-monitoring of exercise behavior was unchanged from baseline ($M = 1.54$, $SD = 1.52$) to post ($M = 1.79$, $SD = 2.15$) in the control condition. Such an increase in self-monitoring can be partially accredited to the electronic nature of our mHealth app. Electronic diaries facilitate i) the instantaneous transfer of data between user and counselor or health care provider [35], and ii) have been shown to be associated with higher rates of adherence when compared to traditional self-monitoring via paper and pen diaries [36].

Despite increases in both exercise and self-monitoring behaviour, our hypotheses that use of the app would result in an improved self-management of exercise behaviour, or self-efficacy to self-monitor (SESM) exercise behaviour was not supported. Use of the app did not result in a significant effect on self-management of exercise from pre ($M = 3.42$, $SD = 0.86$) to post-testing time points ($M = 3.29$, $SD = 0.29$); or self-efficacy to self-monitor exercise behaviour ($M_{pre} =$

83.71, *SD* = 14.38; M_{post} = 84.70, *SD* = 14.82). In regards to the control condition, participants showed no significant change in self-management of exercise (M_{pre} = 3.34, *SD* = 0.82; M_{post} = 3.16, *SD* = 0.32), or self-efficacy to self-monitor (M_{pre} = 80.71, *SD* = 13.22; M_{post} = 81.05, *SD* = 16.69) across time points. In light of our non-significant findings for self-management of exercise behaviour, further evaluation is warranted to understand the manner in which our intervention targeted self-regulatory principles. The purpose of this intervention was to increase the practice of self-monitoring as a key component of self-regulation, and not overcoming exercise barriers. As such, one plausible explanation for the failure to change perceived self-management of exercise behaviour in the experimental condition is that this construct was not adequately addressed in the intervention content.

It is also possible the items used to measure self-regulation did not adequately measure the construct within the context of exercise. Although Hallam & Petosa's [27] measure is highly regarded with respect to self-management of a condition, it is plausible that the measure was not context appropriate. Further, as can be seen by examination of the means for self-efficacy to self-monitor, a possible ceiling effect may have occurred during this intervention, with baseline self-efficacy scores of over 80% being reported by both conditions. Interestingly, Hallam and Petosa [27] also suggested a problematic ceiling effect in their 2004 study integrating social cognitive theory in a work-site intervention. The purpose of this study was to directly impact self-monitoring through tangible use of an app. However, given the widespread use of apps, one possible explanation for the observed ceiling effect is that all participants were familiar with the act of self-monitoring through other generic apps (e.g., tracking work or time spent on social media) prior to the investigation, and therefore their belief (self-efficacy) to self-monitor was not significantly impacted through the intervention material.

2.6.1 Strengths and Limitations

The integration of theory in the development of a self-monitoring app was the primary strength of this study. To date, principles from theories of health behaviour have been used sparingly within mHealth apps [11], despite evidence to suggest the integration of theory (e.g., social cognitive theory) lends support to behaviour change [17]. In this study, app users received a social cognitive theory-grounded message once per week over 8 weeks. Such an automated strategy could feasibly be incorporated into many existing mHealth apps. Further, each app user set a personalized 8-week goal, allowing for tailored feedback from a virtual exercise counselor. Lack of tailored feedback has been a limitation in previous trials [33]. The current trial was able to integrate the use of tailored, real-time feedback in a non-burdensome manner, facilitated by one exercise counselor. Daily review of users' self-monitoring was made manageable due to the electronic nature of the app, taking approximately one minute per day, per participant to review and respond to users' questions and comments. As the system is developed with a pre-existing bank of messages for weekly theory-based content (Table 1), and an established timeline of when to intervene (Table 2), contact between the exercise counselor and user is as simple as choosing a situation-specific message and further specifying details based on the individual.

The present study is not without limitations. Recruitment for the current study was limited to one fitness facility due to restrictions placed by the app industry partner, resulting in limited power to detect group differences as well as an inability to conduct more complex analyses to better understand why potential differences existed (e.g., mediation, multiple mediation). These findings may not be generalizable to individuals who are not able to afford fitness facility memberships; however it should be noted that the facility utilized in this study offers subsidized memberships based on gross income. Given the general recruitment criteria (19

– 70 years of age, access to a smartphone device), the heterogeneity of our sample may have weakened our ability to draw concise conclusions as not all participants were new to exercise, and may have had prior experience with mHealth app technology. Self-monitoring behaviour was the secondary focus of this intervention. While app users' self-monitoring frequency was calculated using data from the app, participants in the control condition (no-app) self-monitoring frequency was based on self-report data, as the control aspect of this study design prohibited measurement via an app in participants in the control condition. The use of self-report data is inherent to recall bias [34], potentially resulting in unreliable results in the comparison of conditions. Lastly, the current study looked at changes in exercise behaviour over the duration of an 8-week intervention. As 40-65% of new exercisers drop out within the first 6 months [5] of a new program, an extended trial of the application is warranted to draw conclusions on long-term efficacy.

2.6.2 Future Directions

Wearable devices (e.g., fitness trackers, pedometers, accelerometers) have become sophisticated, with continued development of technology bringing credibility to such devices. Continued research on the development of mHealth devices could help to establish user's trust in the integration of technology (e.g., smartphone apps, wearable devices) to monitor health behaviours. Overall, an enhanced trust in the use of technology could have a meaningful effect on the ability of a device to impact the health of the public in general, as well as specialized populations [37].

2.6.3 Conclusion

Eight weeks of mHealth app use resulted in increased exercise and self-monitoring behaviour, providing some support for the use of a self-monitoring app to increase adherence to

exercise, and self-monitoring of exercise behaviour. This study protocol also demonstrates the feasibility of incorporating theory-based messages into existing mHealth apps, although the inclusion of such content did not lead to anticipated changes in self-efficacy to self-monitor, or self-management of exercise behaviour. Multiple inoculations of theory-based messages may be needed for sizable changes to be made in these constructs. Future research is warranted to understand long-term efficacy of an mHealth app and it's effect on exercise and self-monitoring behaviour.

2.7 Acknowledgements

The study idea was conceived by Elizabeth Voth and Dr. Mary E. Jung. Ms. Voth was responsible for the collection of data, performing data analysis and interpretation, and the writing and editing of the manuscript. Dr. Jung was responsible for overseeing all aspects of the study, working with the industry mHealth app development team, contributing to data interpretation, and editing of the manuscript. Dr. Nelly D. Oelke assisted with conceptualization of the study idea and review of the manuscript

2.8 Conflicts of Interest

None declared.

2.9 Abbreviations

ANOVA: analysis of variance

apps: applications

mHealth: mobile health

SMS: short-messaging service

SESM: self-efficacy to self-monitor

2.10 References

1. Cowan LT, Van Wagenen SA, Brown BA, et al. Apps of steel: Are exercise apps providing consumers with realistic expectations?: A content analysis of exercise apps for presence of behaviour change theory. *Health Education & Behaviour*. 2012;40:133.
2. Vina J, Sanchis-Gomar F, Martinez-Bello V, Gomez-Cabrera M. Exercise acts as a drug; the pharmacological benefits of exercise. *British Journal of Pharmacology*. 2012;167:1.
3. Tremblay MS, Warburton DER, Janssen I, et al. New Canadian physical activity guidelines. *Applied Physiology, Nutrition, and Metabolism*. 2011;36:36.
4. Canadian Society for Exercise Physiology. Canadian physical activity and sedentary behaviour guidelines handbook. Available at: http://www.csep.ca/english/view.asp?x=804. Accessed July 12, 2015. (Archived by WebCite® at http://www.webcitation.org/6ZyewEg0E)
5. Annesi J. Effects of a cognitive behavioral treatment package on exercise attendance and drop out in fitness centers. *European Journal of Sport Science*. 2003;3:1-16.
6. Dishman RK. Increasing and maintaining exercise and physical activity. *Behavior Therapy*. 1991;22:345-378.
7. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. . 2011.
8. Hall AK, Cole-Lewis H, Bernhardt JM. Mobile text messaging for health: a systematic review of reviews. *Annu Rev Public Health*. 2015;36:393-415.
9. Al Ayubi SU, Parmanto B, Branch R, Ding D. A Persuasive and social mHealth application for physical activity: A Usability and Feasibility Study. *JMIR mHealth and uHealth*. 2014;2.
10. Rainie L, Fox S. Just-in-time information through mobile connections. Available at: http://www.pewinternet.org/2012/05/07/just-in-time-information-through-mobile-connections/. Accessed July 12, 2015. (Archived by WebCite® at http://www.webcitation.org/6ZyeoBYCE)
11. Patel MS, Asch DA, Volpp KG. Wearable devices as facilitators, not drivers, of health behavior change. *JAMA*. 2015;313:459-460.
12. Rabin C, Bock B. Desired features of smartphone applications promoting physical activity. *Telemedicine and e-Health*. 2011;17:801-803.
13. Direito A, Dale LP, Shields E, Dobson R, Whittaker R, Maddison R. Do physical activity and dietary smartphone applications incorporate evidence-based behaviour change techniques? *BMC Public Health*. 2014;14:646.
14. Abroms LC, Padmanabhan N, Thaweethai L, Phillips T. iPhone apps for smoking cessation: a content analysis. *Am J Prev Med*. 2011;40:279-285.
15. Doshi A, Patrick K, Sallis JF, Calfas K. Evaluation of physical activity web sites for use of behavior change theories. *Annals of Behavioral Medicine*. 2003;25:105-111.
16. Riley W, Rivera D, Atienza A, Nilsen W, Allison S, Mermelstein R. Health behavior models in the age of mobile interventions: are our theories up to the task? *Transl Behav Med.2011 Mar; 1 (1): 53–71.doi: 10.1007/s13142-011-0021-7*.
17. Maddison R, Pfaeffli L, Stewart R, et al. The HEART mobile phone trial: the partial mediating effects of self-efficacy on physical activity among cardiac patients. *Frontiers in public health*. 2014;2.

18. Bandura A. *Social Foundations of Thought and Action: A Social Cognitive Theory.* Prentice-Hall, Inc; 1986.
19. Bandura A. Social cognitive theory of self-regulation. *Organ Behav Hum Decis Process*. 1991;50:248-287.
20. Sniehotta FF, Scholz U, Schwarzer R. Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychol Health*. 2005;20:143-160.
21. Burke LE, Wang J, Sevick MA. Self-monitoring in weight loss: a systematic review of the literature. *J Am Diet Assoc*. 2011;111:92-102.
22. Dale LP, Whittaker R, Jiang Y, Stewart R, Rolleston A, Maddison R. Improving coronary heart disease self-management using mobile technologies (Text4Heart): a randomized controlled trial protocol. *Trials*. 2014;15:71-6215-15-71.
23. Fjeldsoe BS, Marshall AL, Miller YD. Behavior change interventions delivered by mobile telephone short-message service. *Am J Prev Med*. 2009;36:165-173.
24. Godin G, Shephard R. Godin leisure-time exercise questionnaire. *Med Sci Sports Exerc*. 1997;29:S36.
25. Amireault S, Godin G. The Godin-Shephard leisure-time physical activity questionnaire: Validity evidence supporting it's use for classifying healthy adults into active and insufficiently active categories 1, 2. *Perceptual & Motor Skills*. 2015;120:605-622.
26. Parrott MW, Tennant LK, Olejnik S, Poudevigne MS. Theory of planned behavior: Implications for an email-based physical activity intervention. *Psychol Sport Exerc*. 2008;9:511-526.
27. Hallam JS, Petosa R. The long-term impact of a four-session work-site intervention on selected social cognitive theory variables linked to adult exercise adherence. *Health Educ Behav*. 2004;31:88-100.
28. Gliem JA, Gliem RR. Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education; 2003.
29. Slavec A, Drnovšek M. A perspective on scale development in entrepreneurship research. *Economic and business Review*. 2012;14.
30. MRC Cognition and Brain Sciences Unit. Rules of thumb on magnitudes of effect sizes. Available at: http://imaging.mrc-cbu.cam.ac.uk/statswiki/FAQ/effectSize. Accessed July 11, 2015.
31. Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* London: England: Routledge; 1988.
32. Fritz CO, Morris PE, Richler JJ. Effect size estimates: current use, calculations, and interpretation. *J Exp Psychol : Gen*. 2012;141:2.
33. Fukuoka Y, Lindgren T, Jong S. Qualitative exploration of the acceptability of a mobile phone and pedometer-based physical activity program in a diverse sample of sedentary women. *Public Health Nursing*. 2012;29:232-240.
34. Maddison R, Pfaeffli L, Whittaker R, et al. A mobile phone intervention increases physical activity in people with cardiovascular disease: Results from the HEART randomized controlled trial. *Eur J Prev Cardiol*. 2015;22:701-709.
35. Burke LE, Warziski M, Starrett T, et al. Self-monitoring dietary intake: current and future practices. *Journal of Renal Nutrition*. 2005;15:281-290.

36. Burke LE, Styn MA, Sereika SM, et al. Using mHealth technology to enhance self-monitoring for weight loss: a randomized trial. *Am J Prev Med*. 2012;43:20-26.
37. Case MA, Burwick HA, Volpp KG, Patel MS. Accuracy of smartphone applications and wearable devices for tracking physical activity data. *JAMA*. 2015;313:625-626.

Chapter 3: Conclusion

3.1 Discussion

Regular engagement in exercise is recognized as a major preventative health behaviour (Warburton et al., 2007). While the benefits and effectiveness of adhering to exercise have been demonstrated for individuals of all ages (Tremblay et al., 2011), 85% of Canadian adults fail to accumulate the recommended level of weekly exercise (Colley et al., 2011; Knight et al., 2015). Further, traditional means of education through *Canada's physical activity guide to healthy active living* (Canadian Society for Exercise Physiology, 2015) have been rendered ineffective for facilitating sustained behaviour change (Anessi, 2003; Dishman, 1991). New and innovative means of increasing exercise behaviour in the general population are necessary. The current study aimed to investigate the utility of a theory-based self-monitoring application (app) for improving exercise adherence. To our knowledge, this study is the first to integrate social cognitive theory, personalized goals and tailored feedback from a virtual exercise counselor in a mobile Health (mHealth) app.

Findings from the current study show support for the use of a self-monitoring app grounded in social cognitive theory for adherence to an exercise frequency goal. Following week-8 of the study, app users reported an increase in exercise behaviour as represented by a medium to large effect size, as well as a significant change in app users' frequency of self-monitoring. Both exercise frequency and self-monitoring results are presented in relation to a control group who did not have access to the self-monitoring app. Explanation of our findings and implications of these results are offered below.

3.2 Increase in Purposeful Exercise Bouts

Evaluation of purposeful exercise bouts performed by app users revealed an increase in exercise frequency from baseline to week-8 follow-up. This impressive change in exercise frequency in app users as compared to those in the control condition translates to a medium to large effect size (partial $\eta^2 = .092$). By intervention end, participants in the experimental condition were engaging in, on average, 3 more purposeful bouts of moderate-to-vigorous exercise per week as compared to participants in the control condition. Our primary hypothesis that use of the theory-based app would result in greater increases in exercise behavior than those without access to the app, was thus confirmed, and is consistent with previous mobile health (mHealth) trials targeting exercise (Fukuoka, Lindgren, & Jong, 2012; Maddison et al., 2015).

Fukuoka and colleagues (2012) explored select components of a mobile phone-based program to increase physical activity. Similar to the current trial, Fukuoka and colleagues' investigation was based on daily SMS (short messaging service), individualized goal setting (based on step count), and individualized feedback to the user. The aim of Fukuoka and colleagues' study was to gain a qualitative understanding of the motivators and barriers participants face when working towards the goal of increasing physical activity levels. Qualitative findings support the applicability of daily messages sent via a mobile phone, however, in comparison to programming used in the current study, Fukuoka's mobile phone program was wrought with explicit limitations. Specifically, Fukuoka's trial utilized an 'automated' increase in steps as a goal, which was not personalized to the individual user. In weeks 2 and 3 (of the 3 week program), participants were asked to increase steps by 20% from previous weeks reports. While daily total and aerobic step counts increased significantly over the three weeks, this approach to improving activity levels is associated with multiple challenges.

Automated increases fail to personalize the progression of activity to the individual user (i.e., does not account for failure or lack of progress being made by the user). Although few studies individualize interventions, personalized mHealth interventions are demonstrated to be more effective than non-personalized at changing health behaviour (Dale et al., 2014; Fjeldsoe et al., 2009). In the current study we were able to integrate individualized goal setting based on current exercise status and future exercise progression, weekly evidence-based messages, and subsequent feedback provided to the user based on individualized performance. As stated by Fukuoka and colleagues, the provision of feedback is important as the 'cycle of feedback' is shown as a motivator to attain future exercise goals.

Maddison and colleagues (2015) also reported similar findings in their investigation, which utilized personalized SMS intervention messages aimed at increasing exercise behaviour. The use of personalized SMS texts resulted in significant increases in walking behaviour and total leisure time physical activity in their trial, mirroring findings of the current study. SMS technology allows messages to be sent in a time-sensitive manner, which may be integral to avoiding or overcoming barriers to exercise engagement.

The present study findings on changes in exercise behaviour add to existing evidence on the effectiveness of SMS-based exercise interventions. Findings from Fukuoka et al. (2012) and Maddison et al. (2015) provide preliminary support for our observed increase in exercise behaviour. While this study design was guided by past successful use of SMS messages, our methodology is strengthened through the inclusion of personalized goals and tailored feedback, seen sparingly in current research. Taken together, these findings provide evidence for the continued use of SMS messages within mHealth apps. The use of SMS appears to be an efficacious and feasible strategy to increase exercise behaviour.

3.3 Self-Management of Exercise Behaviour

Without the capacity to exert influence over one's own motivation and behaviour, neither intention nor desire is likely to have much influence on an individual's actions (Bandura, 1991). The ability to exert influence over one's actions is particularly pivotal when working towards exercise goals. Hallam and Petosa (2004) describe the act of self-management as "the skills used by [an individual] to implement exercise intentions and to *overcome personal and situational barriers* to a regular exercise program" (italics added, pg. 89). Related to the current study, an individual who does not actively self-manage their exercise behaviour may not recognize a decline in exercise engagement and may subsequently drop off from engagement.

Perceived self-management of exercise behaviour was assessed before and after the 8-week investigation period in the present study. It was hypothesized that individuals with access to the mobile health (mHealth) app would report greater perceived self-management of exercise behaviour at post-intervention in comparison to the individuals without use of the app. This hypothesis was not supported. Comparison of data from baseline to post-testing revealed no significant change over time, or between app users (pre = 3.42, post = 3.29) and non-app users (pre = 3.34, post = 3.16). To assess perceived self-management, six items from Hallam and Petosa's perceived self-management of chronic conditions published measure were modified and used. Participant ratings remained at a 'neutral' average regardless of condition (1 = strongly disagree to 3 = neutral to 5 = strongly agree).

In light of our non-significant findings post-intervention, reflection was warranted to understand the manner in which our intervention actually targeted self-management principles, as defined by Hallam and Petosa. The purpose of this intervention was to increase the practice of self-monitoring as a key component of self-regulation, not specifically overcoming exercise

barriers. As such, one plausible explanation for the failure to change perceived self-management of exercise behaviour in the experimental condition is that the way self-management was operationalized and assessed within the measure was not consistent with the way in which self-management was addressed in the intervention content. The measure developed by Hallam and Petosa (2004) was designed in reference to a general health condition, thus wording was slightly altered to reflect the purpose of the study (i.e., reference to 'my condition' was altered to reflect participation in/management of exercise behaviour). Although Hallam & Petosa's measure is highly regarded with respect to self-management of a condition, it is plausible that the measure was not context appropriate.

It was expected that the intervention material (which was heavily premised around self-monitoring) would increase users' frequency of self-monitoring. According to Bandura's process of self-regulation, the act of self-monitoring and reviewing exercise behaviour is all part of self-managing exercise behaviour. Failure to see changes in perceived self-management of exercise behaviour in this trial, despite sizable improvements in self-monitoring and exercise behaviour, suggest that the measure used in this study may not have been an appropriate tool to assess exercise self-management.

3.4 Self-Monitoring Behaviour

The act of self-monitoring has been used as a research tool for quite some time. Over the past several years, the manner in which self-monitoring is carried out has taken a dramatic shift. Traditionally, self-monitoring has been carried out through tracking adherence to a goal directed behaviour using paper-based journals. More recently however, active engagement in self-monitoring has been seen through the use of electronic devices, beginning with online journals

and companion websites, and evolving to more mobile means of self-monitoring through the development of mHealth apps.

In 2012, Burke and colleagues investigated differences between more traditional paper-based self-monitoring, and the development of electronic self-monitoring, taking an in-depth look at the use of PDA devices. The review provides evidence to support the use of electronic self-monitoring devices through a greater rate of adherence with PDA self-monitoring. The investigation noted that the provision of a daily feedback message delivered through the self-monitoring system was shown to increase rates of adherence.

The present study findings are in alignment with the results presented by Burke and colleagues. Following the 8-week intervention, app users were self-monitoring i) at a higher frequency than reported at baseline, and ii) more frequently in a given week in comparison to the control, no-app group. These results show promise for the use of electronic self-monitoring via an mHealth app.

Such an increase in self-monitoring can be attributed to a variety of factors. The most common attribute to electronic self-monitoring is their relative ease and convenience as compared to past paper logs. As noted in previous studies, use of traditional paper-based diaries is burdensome and further, is inherently vulnerable to recall bias (Maddison et al., 2015). Along with the development of electronic self-monitoring came a sense of convenience, which was further enhanced with the development of mHealth apps. An increase in self-monitoring behaviour can be also attributed to the increased reliance on mobile devices and the fact that adults within Canada rarely leave the home without them. The ease and convenience to self-monitor from virtually anywhere via an Internet connection has brought about a new and innovative field of self-monitoring.

3.5 Self-Efficacy to Self-Monitor

Self-efficacy is the belief one has in his/her ability to perform an action or complete a given task in order to produce a specific outcome (Bandura, 1977, 1986). According to self-efficacy theory (Bandura, 1986), the most influential manner through which to bolster self-efficacy is through successful past performances of that specific behaviour. Self-monitoring one's exercise behaviour in the past should thus increase one's self-efficacy to self-monitor in the future. The current study worked to actively encourage app users to self-monitor through multiple messages over the 8-week period. At three separate time points (week 2, 3, & 7), messages grounded in social cognitive theory were delivered to each individual user, touching on the importance of self-monitoring, and a reminder of past success in self-monitoring over previous weeks. It was hypothesized that with an increase in self-monitoring behaviour, individuals using the app would then be even more confident to self-monitor their exercise behaviour in the future. However, this hypothesis was not supported. Participants in the experimental condition were no more confident to self-monitor their exercise behaviour than those in the control condition by the end of the intervention.

Hallam and Petosa (2004) also failed to see improvements in self-efficacy in their workplace intervention, and have reported similar findings. Like Hallam and Petosa, one possible reason for our failure to increase self-efficacy in those using the app was a 'ceiling effect'. At baseline, the mean self-efficacy score was 83.71%, indicative of a very high level of confidence to actively self-monitor. The observed ceiling effect suggests that participants were already very familiar with the act of self-monitoring prior to the investigation and therefore, their self-efficacy was not significantly impacted through the intervention material. Given the widespread use of apps, an additional explanation for the observed ceiling effect is that all

participants were familiar with the act of self-monitoring through other generic apps (e.g., tracking work or time spent on social media) prior to the investigation, and therefore their belief (self-efficacy) to self-monitor was not significantly impacted through the intervention material. To further increase self-efficacy scores above this already high mean score may not be possible within the confines of a virtual intervention. In an attempt to control such a situation, future studies may aim to recruit participants with no prior experience self-monitoring exercise behaviour.

3.6 Strengths

3.6.1 Provision of Tailored Feedback

Use of an app is not only a simple tool for self-monitoring, but also has the capability of attaining encouragement and motivation. The instantaneous nature of an mHealth app not only allows for self-monitoring to take place virtually anywhere, but also allows feedback to be provided as promptly as data is recorded. Provision of timely and tailored feedback was one of the major strengths of the current study. At baseline, each app user was guided towards the development of a personalized 8-week goal. The establishment of this goal allowed for the provision of feedback to be tailored to his/her specific exercise preferences and history. Lack of tailored feedback has been a limitation in previous trials (Fukuoka et al., 2012). Until recently, self-monitoring interventions were based on paper-based monitoring, which meant that the provision of feedback was often delayed. Through the development of electronic self-monitoring, and the instantaneous nature of self-monitoring through one's phone, timely provision of feedback is now possible. A major strength in the present study was the ability to combine personalized goal setting with the provision of real time, 'tailored' feedback to each individual user.

3.6.2 Evidence-based Content

Relatedly, another strength of the present trial was the theory-derived, feasibility, and responsivity of feedback provided. Each of these attributes will be discussed in turn.

The grounding framework for all messages provided to app users in this study was social cognitive theory (Bandura, 1986). Social cognitive theory is particularly well suited for mHealth interventions. This theory details the explicit mechanisms through which to elicit change. The current study is unique as, "many mobile health applications have not yet leveraged principles from theories of health behaviour" (Patel et al., 2015 p. E1), despite evidence suggesting the integration of theory (i.e., social cognitive theory), lends support to behaviour change (Maddison et al., 2014). Our study design has answered the call to numerous reviews and research papers (Abroms et al., 2011; Cowan et al., 2012; Direito et al., 2014; Doshi et al., 2003; Riley et al., 2011) that have clearly stated that mHealth applications would be greatly enhanced if they were to include theory-based content. With respect to which behaviour change theory to utilize, researchers have specifically recommended the incorporation of social cognitive theory, in particular: "the grounding of an [app] in social cognitive theory may increase its appeal and efficacy" (Rabin & Bock, 2011).

3.6.3 Virtual Exercise Counselor: Feasible and Responsive

The interactive nature of current technology has modernized automation – and this is no exception for mHealth apps. The opportunity to 'respond' to a self-monitoring entry offers a signal for apps to send out an automated text message from a stock list. The rationale is simple: keep user engagement at a very low cost. This, unfortunately, comes at the price of rapport and credibility, which are based on trust and irreplaceable human (albeit virtual) connection. Many suggest that human interaction is seminal to providing feedback (Anderson, Winett, Wojcik, &

Williams, 2010; Bauman et al., 2012; Shumaker & Hill, 1991), and as such will always plague app-based platforms for eliciting behaviour change. In this study, tailored real-time feedback was provided in a non-burdensome manner, feasibly facilitated by one exercise counselor. This was made possible by summary reports on all users' self-monitoring activities being instantaneously available to the exercise counselor after logging in as the 'trainer' in the app. This feature subsequently reduced the time necessary to review each users' profiles separately, enhancing the speed at which the counselor could respond to a barrier reported by a user, or a question posed to the counselor. The review of self-monitoring records and response to user's questions and comments took on average one minute per day. To put this in context, an average hourly personal training session is $50 - $80/hr, in which a client may receive guidance on types of exercises to do once per week. For the same price of one personal training session, a knowledgeable exercise counselor could provide guidance to 60 individuals on how to adhere to exercise through the use of an interactive app-based platform such as the one used in this study. The present study demonstrates the relative low cost to users while receiving support from an expert in evidence-based behavioural change techniques.

In the present study, app users were privy to a highly responsive system, closely monitored by one exercise counselor. As noted previously, self-monitoring apps, which utilize automated messages, can quickly loose trust and credibility in users. Participants in the experimental condition in this study received regular messages, tailored to current status and overall goal progression. In working with the app developer, the mHealth system itself was developed with our theory-based bank of messages for weekly evidence-based content (Table 1), and an established timeline of when to intervene (Table 2), making contact between the exercise counselor and user as simple as choosing a situation-specific message and further specifying

details based on the user. As one exercise counselor facilitated the intervention, an inherent level of consistency existed within the study, lending fidelity to the program as all users receive the same level of intervention, in a consistent manner, on a consistent timeline. In addition to the pre-scheduled theory-based messages, the speed of this mHealth app system enabled the exercise counselor to respond to app user's successes or challenges within hours of reporting – making the time spent counseling each day more valuable.

3.7 Limitations

3.7.1 Sample Size

Overall, the total number of participants enrolled in the study was 56. As a result, a major limitation of the present study was the limited power to detect group differences, as well as an inability to conduct more complex analyses to better understand why potential differences existed (e.g., mediation, multiple mediation). The nature of this pilot intervention, however, minimizes this limitation. In total, 6 statistical tests (4 repeated measures ANOVA and 2 post-hoc t-tests) were performed at $p < .05$. We do not feel that this is an undue increase of type 1 error, nor was this a concern for any of the peer reviewers in the accepted manuscript. The purpose of pilot studies such as the present one is to i) examine the efficacy of the intervention, and ii) to assess the feasibility and functionality of applying the intervention to the public. Developing and administering theory-based SMS messages in an integrated format within an mHealth app needed to be trialed prior to more costly, randomized controlled clinical trials.

3.7.2 Heterogeneity of the Sample and Participant Demographics

Eligibility for participation in the study was YMCA facility members between the ages of 19-70 years, with access to a smartphone device. Given the general recruitment criteria, our potential participants may have come from a variety of exercise backgrounds, with a wide range

of experience using an app. The heterogeneity of our sample is a potential point of weakness as it limits our ability to generalize our findings. The majority of our participants were pre-existing members at that specific fitness facility. In hindsight, restriction of participation to new, non-exercising members would have provided a better means in which to assess the efficacy of the intervention in those most vulnerable to drop-out. Likewise, prior experience using an mHealth app (whether for the purpose of self-monitoring exercise behaviour or not) has the potential to influence an app users' experience with self-monitoring. As 84% of smartphone owners have downloaded at least one app (as of 2012), with 19% of those individuals having downloaded an app specifically related to health behaviour (Raine & Fox, 2012), it is probable that our participants had past experience using app technology. Past experience using an app in general may have been a confounding factor in the present study. New smartphone users may, for example, not be familiar with the workings of his/her phone, leading to a neglect in using the app provided in this study.

Finally, recruitment for the current study was limited to one fitness facility due to restrictions placed by the app industry partner. As such, participation was subsequently limited to members of our local YMCA located in a higher SES neighborhood bracket of the city. Findings may not be generalizable to individuals who are not able to afford fitness facility memberships or choose not to belong to a fitness facility. It should be noted, however, that this facility offers subsidized memberships based on gross income.

3.7.3 Study Duration

The current study examined changes in exercise behaviour over the duration of an 8-week intervention. Given the time necessary for recruitment and follow-up, an 8-week investigation period was feasible for the purpose of a master's thesis. However, as 40-65% of

new fitness facility members drop out within the first 6 months (Anessi, 2003) of a new program, an extended trial of the application is warranted to draw conclusions on long-term efficacy. While study duration presents an important limitation, assessing independent exercise adherence (i.e., outside of a lab, in a non-supervised setting) is not unique to the realm of feasibility studies. The majority of pilot exercise interventions attempting to increase exercise behaviour range from a few weeks to 3 months (Fukuoka et al., 2012).

3.7.4 Collection of Self-Monitoring Data

A final limitation of the present study was the manner in which self-monitoring behaviour was measured. At baseline, all participants reported frequency of self-monitoring in the past 7 days. At post, app users' self-monitoring behaviour was measured using data direct from the app, specifically, the average number of self-monitoring reports over the 8-week study duration. In contrast, participants in the control condition (no-app) were asked to self-report an average frequency of self-monitoring per 7-day period, over the previous 8-weeks. As noted by Maddison and colleagues (2015), self-report data is inherent to recall bias, potentially resulting in unreliable results in comparison of conditions. Future studies should look to assess self-monitoring of exercise behaviour similarly in both conditions at both pre- and post-intervention to diminish biases and associated complications regarding self-report data. It should be noted, however, that the mean frequency of self-reported self-monitoring in the control condition remained literally unchanged from pre- to post-intervention ($M_{pre} = 1.54$; $M_{post} = 1.79$), suggesting that their self-reported frequency reliably demonstrated no change in self-monitoring when not privy to an app.

3.8 Future Directions

3.8.1 Accuracy of Wearable Devices

The use of wearable fitness devices by the general public began with the widespread use of pedometers. More recently, wearable devices (e.g., accelerometers, fitbit) have become more sophisticated, with the continued development of such technology bringing credibility to measurement accuracy and applicability. Wearable devices now have the capability to measure variables such as heart rate, blood pressure, and calories expended, in addition to the traditional step count. Continued development of such devices necessitates ongoing evaluation for i) quality assurance, and ii) reliability of information gathered. Such evaluation has begun, but must be expanded. On the forefront of such evaluations are Case, Burwick, Volpp, and Patel. In 2015, Case and colleagues tested the accuracy of 10 wearable devices and smartphone apps to track step counts. Findings of Case and colleagues' study not only work to reinforce the accuracy of such devices, but also "may help [to] reinforce individuals' trust in using smartphone applications and wearable devices to track health behaviour, further establishing a level of reliability which could have important implications for strategies to improve population health" (Case, Burwick, Volpp & Patel, 2015 p. 626). Without a sense of accuracy and reliability, the potential for wearable devices to increase health related behaviour may not be as promising. In 2011, Rabin and Bock reported users' desired features of smartphone apps to promote physical activity. Among the desired features is an emphasis on the automatic collection of data. This integration of tracking technology (i.e., an accelerometer), would be beneficial as it can provide accurate results on actual movement completed by the user, further allowing real-time feedback to be provided based on specific data. All together, the integration of a wearable device, whether it be an app that assists your phone in tracking your physical movement, or a supplementary

devices such as an accelerometer than transfers information directly to associated technology, is of high importance to users.

3.8.2 Objective Measures of Exercise Behaviour

In regards to testing the use of mHealth self-monitoring and exercise apps and how and why they work, further research must be conducted. A drawback to previous research in the field, present study included, is reliance on self-report data. As noted by Maddison and colleagues (2015), self-report data is inherently vulnerable to recall bias. To reduce issues related to recall bias, desire for an objective measure of exercise adherence is highly recommended. A 2015 study conducted by Amireault & Godin has utilized fitness center attendance records (i.e., attendance 'swipes') to bring validity to self-report exercise levels in their investigation. Analysis of attendance 'swipes' may be a reliable avenue of data collection, however, is still designated to studies affiliated with a facility capable of collecting such information, and only assesses whether they walked through the gym doors or not. This method cannot accurately assess whether an individual has exercised once in the gym, and also fails to account for any outside activity the individual may have completed. As mentioned above, an additional avenue of data collection could be conducted through the use of activity monitors such as accelerometers. While associated with a higher cost than typical self-report measures, the integration of an activity monitor greatly increases accuracy when collecting information on exercise engagement, hence further promoting the study of exercise behaviour change with the ability to draw meaningful conclusions. mHealth apps (such as the one utilized in this study) are most frequently accessed on one's smartphone, meaning data from a built-in accelerometer could be incorporated into the exercise feedback. Currently, such linkages remain costly and technically challenging, and was not available during this intervention.

3.8.3 True Control Group

The present study demonstrated that use of a self-monitoring exercise app increases exercise behaviour as compared to not using an app. An investigation including the comparison of a true control, non-evidence based app vs. an experimental group with an evidence-based app would more clearly tease apart the effectiveness of theory-based messages. To date, the majority of research has looked at the use of an app vs. a no app control group (Carter, Burley, Nykjaer, & Cade, 2013; Maddison et al., 2014). Such research begs the question as to which aspect of the investigations have influenced exercise adherence. By including a true control, non-evidence based app, a research team can draw more conclusive answers to the mechanism at hand.

3.9 Implications

The present study adds a dimension to the literature that is previously untouched. While past studies have investigated the use of mobile devices to increase exercise behaviour (Al Ayubi et al., 2014; Fukuoka et al., 2012; Maddison et al., 2014; Maddison et al., 2015), the integration of theoretical constructs (Al Ayubi et al., 2014; Burke et al., 2012; Maddison et al., 2014; Maddison et al., 2015), electronic self-monitoring (Burke et al., 2012; Carter et al., 2013; Fukuoka, Vittinghoff, Jong, & Haskell, 2010; Kirwan, Duncan, Vandelanotte, & Mummery, 2012; Maddison et al., 2014; Mattila et al., 2010; Dantzig, Geleijnse, & Halteren, 2013), and tailored feedback (Burke et al., 2012; Fukuoka et al., 2012; Maddison et al., 2015; van Drongelen et al., 2014), to our knowledge, no study has integrated all three aspects in one investigation. A review of the literature shows a need for more in-depth research of the potential benefits of such a system. Our current study adds to the literature as our results show use of a self-monitoring mHealth app grounded in social cognitive theory has a positive effect on increasing exercise behaviour. However, due to the limited power and time frame of the

investigation, replication of the current research is necessary. As most mHealth app developers are not experts in the field of health behaviour or health behaviour change, but rather are typically more well versed in software development, collaboration between health professionals and software developers is sorely needed (Cowan et al., 2012). Collaboration would bring strength to the development of evidence-based mHealth apps, along with the integration of theoretical constructs for behaviour change (i.e., social cognitive theory). Overall, the ongoing development of mHealth technology will bring numerous benefits to the population. Through continued testing, developers can ensure products are evidence-based, utilize credible technology and have the potential to bring benefit to the user.

3.10 Conclusion

The use of mHealth technology (i.e., applications (apps)) is rapidly growing, creating new avenues for the development of future health related technology (Fukuoka et al., 2012). Despite such growth in technology, few investigations have integrated theoretical content and evidence-based practice to encourage behaviour change. The purpose of the current study was to investigate the utility of a self-monitoring app grounded in social cognitive theory for improving exercise adherence. The app integrated aspects of social cognitive theory, personalized goals, and interaction with a virtual exercise counselor for the promotion of exercise and self-monitoring behaviour. Our study provides preliminary evidence that when grounded in evidence-based theory, a self-monitoring exercise app can bolster exercise behaviour and may lead to increases in the frequency of self-monitoring behaviour.

Bibliography

Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology, 27*(3), 379.

Abroms, L. C., Padmanabhan, N., Thaweethai, L., & Phillips, T. (2011). iPhone apps for smoking cessation: A content analysis. *American Journal of Preventive Medicine, 40*(3), 279-285.

Aittasalo, M., Miilunpalo, S., Kukkonen-Harjula, K., & Pasanen, M. (2006). A randomized intervention of physical activity promotion and patient self-monitoring in primary health care. *Preventive Medicine, 42*(1), 40-46.

Al Ayubi, S. U., Parmanto, B., Branch, R., & Ding, D. (2014). A persuasive and social mHealth application for physical activity: A usability and feasibility study. *JMIR mHealth and uHealth, 2*(2)

Amireault, S., & Godin, G. (2015). The Godin-Shephard leisure-time physical activity questionnaire: Validity evidence supporting its use for classifying healthy adults into active and insufficiently active categories 1, 2. *Perceptual & Motor Skills, 120*(2), 605-622.

Anderson, E. S., Winett, R. A., Wojcik, J. R., & Williams, D. M. (2010). Social cognitive mediators of change in a group randomized nutrition and physical activity intervention: Social support, self-efficacy, outcome expectations and self-regulation in the guide-to-health trial. *Journal of Health Psychology, 15*(1), 21-32. doi:10.1177/1359105309342297 [doi]

Annesi, J. (2003). Effects of a cognitive behavioral treatment package on exercise attendance and drop out in fitness centers. *European Journal of Sport Science, 3*(2), 1-16.

Azar, K. M., Lesser, L. I., Laing, B. Y., Stephens, J., Aurora, M. S., Burke, L. E., & Palaniappan, L. P. (2013). Mobile applications for weight management: Theory-based content analysis. *American Journal of Preventive Medicine, 45*(5), 583-589.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Prentice-Hall, Inc.

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes, 50*(2), 248-287.

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J., Martin, B. W., & Lancet Physical Activity Series Working Group. (2012). Correlates of physical activity: Why are some people physically active and others not? *The Lancet, 380*(9838), 258-271.

Bort-Roig, J., Gilson, N. D., Puig-Ribera, A., Contreras, R. S., & Trost, S. G. (2014). Measuring and influencing physical activity with smartphone technology: A systematic review. *Sports Medicine, 44*(5), 671-686.

Brawley, L. R. (1993). The practicality of using social psychological theories for exercise and health research and intervention. *Journal of Applied Sport Psychology, 5*(2), 99-115.

Burke, L. E., Styn, M. A., Sereika, S. M., Conroy, M. B., Ye, L., Glanz, K., . . . Ewing, L. J. (2012). Using mHealth technology to enhance self-monitoring for weight loss: A randomized trial. *American Journal of Preventive Medicine, 43*(1), 20-26.

Burke, L. E., Wang, J., & Sevick, M. A. (2011). Self-monitoring in weight loss: A systematic review of the literature. *Journal of the American Dietetic Association, 111*(1), 92-102.

Burke, L. E., Warziski, M., Starrett, T., Choo, J., Music, E., Sereika, S., . . . Sevick, M. A. (2005). Self-monitoring dietary intake: Current and future practices. *Journal of Renal Nutrition, 15*(3), 281-290.

Canadian Society for Exercise Physiology. (2015). Canadian physical activity and sedentary behaviour guidelines handbook. Retrieved from http://www.csep.ca/english/view.asp?x=804

Carels, R. A., Darby, L. A., Rydin, S., Douglass, O. M., Cacciapaglia, H. M., & O'Brien, W. H. (2005). The relationship between self-monitoring, outcome expectancies, difficulties with eating and exercise, and physical activity and weight loss treatment outcomes. *Annals of Behavioral Medicine, 30*(3), 182-190.

Carter, M. C., Burley, V. J., Nykjaer, C., & Cade, J. E. (2013). Adherence to a smartphone application for weight loss compared to website and paper diary: Pilot randomized controlled trial. *Journal of Medical Internet Research, 15*(4), e32. doi:10.2196/jmir.2283

Case, M. A., Burwick, H. A., Volpp, K. G., & Patel, M. S. (2015). Accuracy of smartphone applications and wearable devices for tracking physical activity data. *Jama, 313*(6), 625-626.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. London: England: Routledge.

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of canadian children and youth: Accelerometer results from the 2007 to 2009 canadian health measures survey.

Cowan, L. T., Van Wagenen, S. A., Brown, B. A., Hedin, R. J., Seino-Stephan, Y., Hall, P. C., & West, J. H. (2012). Apps of steel: Are exercise apps providing consumers with realistic expectations?: A content analysis of exercise apps for presence of behaviour change theory. *Health Education & Behaviour, 40*(2), 133. doi:10.1177/1090198112452126

Croteau, K. A. (2004). A preliminary study on the impact of a pedometer-based intervention on daily steps. *American Journal of Health Promotion, 18*(3), 217-220.

Dale, L. P., Whittaker, R., Jiang, Y., Stewart, R., Rolleston, A., & Maddison, R. (2014). Improving coronary heart disease self-management using mobile technologies (Text4Heart): A randomised controlled trial protocol. *Trials, 15*, 71-6215-15-71. doi:10.1186/1745-6215-15-71 [doi]

Dantzig, S., Geleijnse, G., & Halteren, A. T. (2013). Toward a persuasive mobile application to reduce sedentary behavior. *Personal and Ubiquitous Computing, 17*(6), 1237-1246.

Direito, A., Dale, L. P., Shields, E., Dobson, R., Whittaker, R., & Maddison, R. (2014). Do physical activity and dietary smartphone applications incorporate evidence-based behaviour change techniques? *BMC Public Health, 14*(1), 646.

Dishman, R. K. (1991). Increasing and maintaining exercise and physical activity. *Behavior Therapy, 22*(3), 345-378.

Doshi, A., Patrick, K., Sallis, J. F., & Calfas, K. (2003). Evaluation of physical activity web sites for use of behavior change theories. *Annals of Behavioral Medicine, 25*(2), 105-111.

Fjeldsoe, B. S., Marshall, A. L., & Miller, Y. D. (2009). Behavior change interventions delivered by mobile telephone short-message service. *American Journal of Preventive Medicine, 36*(2), 165-173.

Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General, 141*(1), 2.

Fukuoka, Y., Lindgren, T., & Jong, S. (2012). Qualitative exploration of the acceptability of a mobile phone and Pedometer-Based physical activity program in a diverse sample of sedentary women. *Public Health Nursing, 29*(3), 232-240.

Fukuoka, Y., Vittinghoff, E., Jong, S. S., & Haskell, W. (2010). Innovation to motivation—pilot study of a mobile phone intervention to increase physical activity among sedentary women. *Preventive Medicine, 51*(3), 287-289.

Gliem, J. A., & Gliem, R. R. (2003). Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for likert-type scales.

Godin, G., & Shephard, R. (1997). Godin leisure-time exercise questionnaire. *Med Sci Sports Exerc, 29*(6s), S36.

Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H., . . . IMAGE Study Group. (2011). Systematic review of reviews of intervention components

associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health, 11*, 119-2458-11-119. doi:10.1186/1471-2458-11-119 [doi]

Hall, A. K., Cole-Lewis, H., & Bernhardt, J. M. (2015). Mobile text messaging for health: A systematic review of reviews. *Annual Review of Public Health, 36*, 393-415. doi:10.1146/annurev-publhealth-031914-122855 [doi]

Hallam, J. S., & Petosa, R. (2004). The long-term impact of a four-session work-site intervention on selected social cognitive theory variables linked to adult exercise adherence. *Health Education & Behavior : The Official Publication of the Society for Public Health Education, 31*(1), 88-100. doi:10.1177/1090198103259164

Kaminsky, L. A., Jones, J., Riggin, K., & Strath, S. J. (2013). A pedometer-based physical activity intervention for patients entering a maintenance cardiac rehabilitation program: A pilot study. *Cardiovascular Diagnosis and Therapy, 3*(2), 73.

Kirwan, M., Duncan, M. J., Vandelanotte, C., & Mummery, W. K. (2012). Using smartphone technology to monitor physical activity in the 10,000 steps program: A matched case-control trial. *Journal of Medical Internet Research, 14*(2), e55. doi:10.2196/jmir.1950 [doi]

Knight, E., Stuckey, M. I., Prapavessis, H., & Petrella, R. J. (2015). Public health guidelines for physical activity: Is there an app for that? A review of android and apple app stores. *JMIR mHealth and uHealth, 3*(2), e43.

Lau, E. Y., Lau, P. W., Cai, B., & Archer, E. (2015). The effects of text message content on the use of an internet-based physical activity intervention in hong kong chinese adolescents. *Journal of Health Communication,* (ahead-of-print), 1-11.

Lox, C. L., Ginis, K. A. M., & Petruzzello, S. J. (2011). *The psychology of exercise*. Holcomb Hathaway.

Maddison, R., Whittaker, R., Stewart, R., Kerr, A., Jiang, Y., Kira, G., Carter, K. H., & Pfaeffli, L. (2011). HEART: heart exercise and remote technologies: A randomized controlled trial study protocol. *BMC Cardiovascular Disorders, 11(26).*

Maddison, R., Pfaeffli, L., Stewart, R., Kerr, A., Jiang, Y., Rawstorn, J., . . . Whittaker, R. (2014). The HEART mobile phone trial: The partial mediating effects of self-efficacy on physical activity among cardiac patients. *Frontiers in Public Health, 2*

Maddison, R., Pfaeffli, L., Whittaker, R., Stewart, R., Kerr, A., Jiang, Y., . . . Rawstorn, J. (2015). A mobile phone intervention increases physical activity in people with cardiovascular disease: Results from the HEART randomized controlled trial. *European Journal of Preventive Cardiology, 22*(6), 701-709. doi:10.1177/2047487314535076 [doi]

Mattila, E., Lappalainen, R., Parkka, J., Salminen, J., & Korhonen, I. (2010). Use of a mobile phone diary for observing weight management and related behaviours. *Journal of Telemedicine and Telecare, 16*(5), 260-264. doi:10.1258/jtt.2009.091103 [doi]

McAuley, E., & Jacobson, L. (1991). Self-efficacy and exercise participation in sedentary adult females. *American Journal of Health Promotion, 5*(3), 185-207.

Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology, 28*(6), 690.

Parrott, M. W., Tennant, L. K., Olejnik, S., & Poudevigne, M. S. (2008). Theory of planned behavior: Implications for an email-based physical activity intervention. *Psychology of Sport and Exercise, 9*(4), 511-526.

Patel, M. S., Asch, D. A., & Volpp, K. G. (2015). Wearable devices as facilitators, not drivers, of health behavior change. *Jama, 313*(5), 459-460.

Rabin, C., & Bock, B. (2011). Desired features of smartphone applications promoting physical activity. *Telemedicine and e-Health, 17*(10), 801-803.

Rainie, L., & Fox, S.Just-in-time information through mobile connections. Retrieved from http://www.pewinternet.org/2012/05/07/just-in-time-information-through-mobile-connections/

Riley, W., Rivera, D., Atienza, A., Nilsen, W., Allison, S., & Mermelstein, R. *Health Behavior Models in the Age of Mobile Interventions: Are our Theories Up to the Task? Transl Behav Med.2011 Mar; 1 (1): 53–71.Doi: 10.1007/s13142-011-0021-7,*

Shumaker, S. A., & Hill, D. R. (1991). Gender differences in social support and physical health. *Health Psychology, 10*(2), 102.

Slavec, A., & Drnovšek, M. (2012). A perspective on scale development in entrepreneurship research. *Economic and Business Review, 14*(1)

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychology & Health, 20*(2), 143-160.

The Canadian Press. (2013). Smartphone use way up in canada, google finds. Retrieved from http://www.cbc.ca/news/business/smartphone-use-way-up-in-canada-google-finds-1.1384916

Tremblay, M. S., Warburton, D. E. R., Janssen, I., Paterson, D. H., Latimer, A. E., Rhodes, R. E., . . . Duggan, M. (2011). New canadian physical activity guidelines. *Applied Physiology, Nutrition, and Metabolism, 36*, 36. doi:10.1139/H11-009

Tudor-Locke, C. (2009). Promoting lifestyle physical activity: Experiences with the first step program. *American Journal of Lifestyle Medicine, 3*(1 suppl), 50S-54S.

Tudor-Locke, C., & Lutes, L. (2009). Why do pedometers work? *Sports Medicine, 39*(12), 981-993.

van Drongelen, A., Boot, C., Hlobil, H., Twisk, J., Smid, T., & van der Beek, Allard J. (2014). Evaluation of an mHealth intervention aiming to improve health-related behavior and sleep and reduce fatigue among airline pilots. *Scand J Work Environ Health, 40*(6), 557-568.

Vina, J., Sanchis-Gomar, F., Martinez-Bello, V., & Gomez-Cabrera, M. (2012). Exercise acts as a drug; the pharmacological benefits of exercise. *British Journal of Pharmacology, 167*, 1. doi:10.1111/j.1476-5381.2012.01970.x

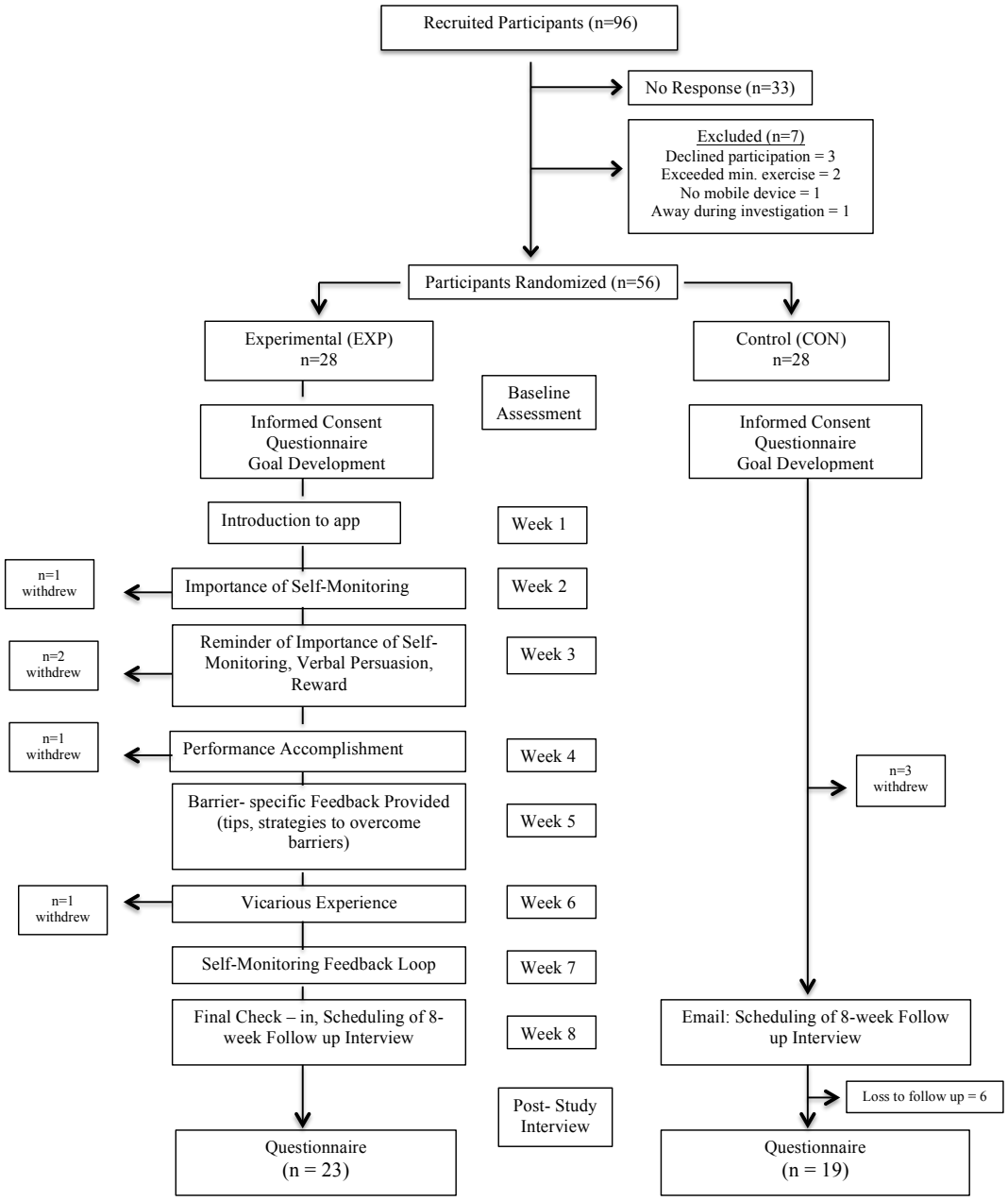
Warburton, D. E.R., Katzmarzyk, P. T., Rhodes, R. E., & Shephard, R. J. (2007). Evidence-informed physical activity guidelines for Canadian adults. *Applied Physiology, Nutrition and Metabolism*, *32*.

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: The evidence. *CMAJ : Canadian Medical Association Journal = Journal De l'Association Medicale Canadienne, 174*(6), 801-809. doi:174/6/801 [pii]

Wing, R. R. (2004). Behavioral approaches to the treatment of obesity. In: Bray, G. A., Bouchard, C., & James, W. P. T. (Eds.) Handbook of obesity: clinical applications. 2nd edition. Location: New York

Figure

Figure 2. Participant flow



Tables

Table 6. Overview of weekly theory-based messages to participants

Week	Theoretical Content
1 Introduction (establishing rapport)	Hi (insert name)! My name is (insert counselor's name) and I am your virtual exercise counselor. I can't wait to see the progress you make as you monitor and modify your behaviour. I know you are super motivated and ready to kick start your exercise so let's get you moving! Check in each day to report your activity and keep an eye on your message center. I'll be checking in frequently to see how you're doing. Feel free to contact me if you have any questions or concerns ☺
2 Importance of Self-Monitoring	Hey (insert name)! Just wanted to say you're doing a great job! You're already one week in to using this app and you have tracked your behaviour each day! Keeping track of your behaviour allows you, and me, to see what a great job you are doing, and helps remind you of your goals. It can also show us where improvements are needed or whether there are any patterns that are problematic. Some people say that keeping track of what exercise they have done is the hardest part – you are excelling in this and this is what will keep you accountable to your personal goals! Keep checking in everyday and let's rock this!
3 Reminder of importance of self-monitoring, use of verbal persuasion and self-set rewards.	Week 2 down and look at how far you have come! You have now been tracking your exercise behaviour for 2 weeks. Keep in mind that self-monitoring is the key to making lasting behaviour changes. With this app, tracking your behaviour is easy and you are showing yourself that you can do it. You are holding yourself to those goals that you care about so much – doesn't it feel great? Now is a great time to plan a reward for yourself… consider treating yourself to something special once you crack 2000 points. Keep up the great work performing and monitoring your exercise – you can do it!
4 Performance Accomplishment	(insert name) – Wow look at all you've done so far! Take a look at your progress graph - all of those green bars you've accumulated are proof that you are well on your way to achieving your goals! You really are using this app to its full potential and you are in control of your exercise. You are doing fantastically – keep up this great momentum.
5 Feedback tailored to participant's goals/overcoming perceived barriers.	Example <u>Barrier = family time</u> As the weather gets warmer, take the family out on the weekend to kick around a soccer ball, ride bikes, or walk to the park and toss a Frisbee.
6 Establishing Vicarious Experience	Did you know that you are not the only one going through this program right now? There are 40 other facility members just like you that are monitoring their exercise, trying to achieve their personal exercise goals and using this app to help them reach those goals. These individuals have been recording their bouts of exercise on the app, and have been overcoming their exercise barriers. So far, the app has been keeping people honest and committed to their exercise goals.

7 Self-monitoring Feedback Loop	It's week 7! You're doing such a fantastic job taking charge of your own exercise regime by consistently monitoring your behaviour and achieving positive scores each day. Now is a good time to look back and search for patterns of when you typically find it most difficult to stick with your exercise regimen. This can give you clues on how to circumvent those less-than-optimal motivational days. Notice weekends are your weak point? Be sure to get all your exercise in during the week and take the weekends off on purpose! Finding AM workouts unbearable? Modify your night time routine so that getting up and out the door isn't so hard. By seeking out problematic trends, we can revise our plans and will be more likely to succeed.
8 Final Check-in	Today marks the final week of goal tracking for the study. Think about where you started and look at where you are now, the physical and mental barriers that you have been able to break down, and all about what you have learnt about yourself. You are in control of your behaviour and you are in the habit of self-monitoring. You should feel proud of the progress you've made. Now use this feeling to rock your last week of workouts and use this as you move forward. Great job!

Table 7. Exercise counselor intervention timeline

Achievement	Intervention Message
Complete Daily Goal Achievement	First occurrence Great job yesterday! You successfully completed all your set goals and rocked it! Keep up the great work ☺ Continuous achievement (Do not repeat until 1 week after first congratulatory message) Wow! You continually rock it! You're a rock star! Keep up the 100's! You deserve a gold star. Keep rocking it!
Partial Daily Goal Achievement	You've had some challenges but you did it! Good job for facing your barriers and getting out there. Keep up the good work.
Partial Goal Achievement on Multiple Days	Good job for checking into the app. I know that can be hard when barriers present themselves but you are aware of what is not working. I know you are able to reach those goals you set out to achieve. You can do this!
Missed check in for 2+ days	Hey (insert name)! Just checking in to see how it's going! 2 days have gone by since your last checked in to the system. Every day is a new one so let's get you back on track and start monitoring that exercise! The hardest part is checking in and keeping track of what you are doing. If you have any questions or concerns please do not hesitate to contact me.

Table 8. Mean age of participants

Variable	Control Age (years)	Experimental Age (years)
Mean Age	41.53	37.45

Table 9. Mean BMI of participants

Variable	Control kg/m^2	Experimental kg/m^2
Mean BMI	25.87	28.24

Table 10. Participant demographic characteristics

Variable	Control (%)	Experimental (%)
Sex		
Female	71	64
Male	29	36
Education		
Less than high school	0	0
High school	21	22.7
Apprenticeship or trades or diploma	10.5	9.1
College	15.8	22.7
University diploma or degree	42.1	36.4
Post-graduate degree	10.5	9.1
Occupation		
Working full-time	47.4	40.9
Working part-time	21.1	13.6
Working occasion/contract work	10.5	4.5
Student	0	22.7
Retired	5.3	9.1
Other	15.8	9.1

Table 11. Self-reported exercise frequency

Variable	Control (number of bouts/week)		Experimental (number of bouts/week)	
	Pre	Post	Pre	Post
Strenuous + Moderate Bouts	4.92	4.74	5.14	7.24

Table 12. Self-monitoring of exercise behaviour

	Control (#/7 days)		Experimental (#/7 days)	
	Pre	Post	Pre	Post
Self-monitoring frequency	1.54	1.80	0.62	5.97

Table 13. Self-management of exercise behaviour

	Control		Experimental	
Variable	Pre	Post	Pre	Post
Self-Management	3.42	3.16	3.39	3.29

Table 14. Self-efficacy to self-monitor exercise behaviour

	Control (%)		Experimental (%)	
	Pre	Post	Pre	Post
Self-efficacy to self-monitor	80.70	81.05	83.71	84.69

Table 15. Baseline self-management of exercise behaviour Chronbach's alpha

Variable	Scale Mean if Item Deleted	Scale Variance is Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Chronbach's Alpha if Item Deleted
Pre self-management 1	16.8617	17.660	.576	.438	.881
Pre self-management 2	16.4681	17.994	.651	.537	.869
Pre self-management 3	17.1809	17.081	.664	.497	.866
Pre self-management 4	17.2447	16.096	.760	.651	.850
Pre self-management 5	17.1170	15.622	.759	.738	.850
Pre self-management 6	17.2021	16.898	.759	.747	.852

Table 16. Post-intervention self-management of exercise behaviour Chronbach's alpha

Variable	Scale Mean if Item Deleted	Scale Variance is Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Chronbach's Alpha if Item Deleted
Post self-management 1	171.5500	1415.023	.661	.614	.479
Post self-management 2	92.4750	554.615	.490	.300	.261
Post self-management 3	97.7250	504.820	.568	.679	.161
Post self-management 4	171.3750	1441.984	.391	.560	.493
Post self-management 5	171.6000	1427.067	.629	.673	.485
Post self-management 6	171.4000	1418.451	.708	.717	.480

Table 17. Baseline self-efficacy to self-monitor exercise behaviour Chronbach's alpha

Variable	Scale Mean if Item Deleted	Scale Variance is Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Chronbach's Alpha if Item Deleted
Pre self-efficacy to self-monitor 1	160.1061	913.575	.596	.682	.460
Pre self-efficacy to self-monitor 2	164.4681	829.602	.687	.699	.333
Pre self-efficacy to self-monitor 3	171.8085	999.376	.268	.100	.904

Table 18. Post-intervention self-efficacy to self-monitor exercise behaviour Chronbach's alpha

Variable	Scale Mean if Item Deleted	Scale Variance is Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Chronbach's Alpha if Item Deleted
Post self-efficacy to self-monitor 1	160.2195	1300.976	.660	.460	.665
Post self-efficacy to self-monitor 2	165.8537	1034.878	.543	.297	.756
Post self-efficacy to self-monitor 3	170.9756	934.024	.645	.465	.630

Appendices

Appendix A : Letter of Information

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Letter of Information

UpwardHealth: A Pilot Study to Assess the Utility of a Smartphone Mobile Solution to Promote Self-Monitoring and Exercise Behaviour

Principal Investigator: Dr. [redacted]
Assistant Professor
School of Health and Exercise Sciences
The University of British Columbia, Okanagan Campus
Phone: [redacted]

Introduction:
You are being invited to take part in this research study because you are becoming a member of the [redacted] and fitness centre and can read and speak English.

Your participation in this study is entirely voluntary and it is your decision whether or not to take part in this study. Before you decide, it is important for you to understand what this research will involve. This letter of information will explain the study, why the research is being done, what you will be asked to do and what will happen to you, and the possible benefits, risks and discomforts associated with the study.

If you would like to participate please inform the member services staff member and you will be provided with a space to record your name and phone number in order for a research assistant from UBC to contact you. If you decide to participate in this study you are free to withdraw at any time and without giving any reasons for your decision.

If you do not wish to participate, you do not have to provide any reason for your decision, nor will you face any repercussions. Please take time to read the following information carefully before you decide.

Purpose:
The primary purpose of this study is to determine if the use of the smartphone mobile system aids in the ability of an individual to adhere to a pre-determined goal. The secondary purpose of this study is to assess the usability of a physical activity-tracking smart phone mobile system, and how the system influences the relationship between personal trainers and their clients.

Procedure:

This study will take place at [redacted] fitness facility. After you have provided your name and contact details to the member services representative this information will be passed on to the UBC research assistant. Between 24-48 hours following this you will be contacted by the research assistant. They will be able to answer any additional questions you have regarding the study and if you wish to participant you will arrange a time to meet with the research assistant at the [redacted] fitness facility. This time will be set by yourself at your earliest convenience. During this initial meeting (approximately 1 hour) you will be provided with a letter of consent that, if you agree to terms, you will sign the document and begin work with the research assistant to determine your 8-week exercise goal. Next, you will also be asked to complete a short survey in which you will report information about yourself (i.e., age, sex), as well as questions about your previous physical activity. Following the completion of questionnaires, you will be placed randomly into one of two possible timeline groups. If placed in the group one, you will be introduced immediately to the mobile system to be used throughout the duration of your 8-week study and will meet the personal trainer that you will be working with over the 8-week period. If placed in group two, you will be asked to continue exercising in your regular manner and will be introduced to the mobile system at your follow-up appointment with the research assistant in 8-weeks time. Participants in group two will then have access to the mobile system for 8-weeks and will be supported by a personal trainer during this time. Participation will involve tracking your physical activity through the use of the mobile system. You will be asked to complete progress reports on the system based on your personal goal set at the beginning of the program. All information will be accessible to the designated personal trainer for the study. This personal trainer will be able to view your self-reported data and contact you via the mobile system. For research purposes, at the conclusion of the study, the research assistant will also have access to the information you have provided on the application, which will detail only on which days you have exercised, and if you met your exercise goal. At the end of the 8-week period the research assistant will arrange a final meeting at the [redacted] facility where you will be asked to complete a questionnaire based on your experiences throughout the study, as well as the usability of the application for those individuals that have been using the mobile system (i.e., whether you found the application to be useful and would be interested in using it again). For individuals that have not been using the mobile system you will now be introduced to the mobile system, and your personal trainer following completion of the questionnaires. The time commitment for this final visit is approximately 1 hour.

For tracking purposes, at the conclusion of the 8-week study period, [redacted] will also provide the researcher with a final tally representing the number of times each participant visited the [redacted] adventure and fitness center. This tally will be provided based on the number of times each participant scans his or her member id barcode when entering the facility.

Potential Risks:

The risks that are associated with the exercise bouts are the same as the physical discomfort that you may experience if you did any form of physical activity. These risks include fatigue, fainting, and/or muscle soreness. These risks may be minimized by ensuring that you are working under the supervision of a certified trainer, as well as working towards a safe and attainable goal. There are no physical or health risks associated with the use of the smartphone application.

Emergency Procedures:

In the event of an emergency or injury it is recommended that you alert a staff member of [redacted] fitness immediately. Proper medical and first aid procedures will be followed as is dictated by the [redacted] fitness facility.

Potential Benefits:
The benefits to you that could arise from participation in this research are a) the ability to make use of a new smart phone mobile system created by [redacted] (free of charge) that is not yet available to the public, b) working one-on-one with a certified personal trainer for 8 weeks, and c) the physical health benefits associated with exercising.

Remuneration:
There is no financial compensation for participating in this research study. However, as a participant you will gain access to the [redacted] mobile system and 8-weeks of contact with a personal trainer. Additionally, there is no financial cost associated with the use of this smart phone mobile system.

Confidentiality:
Your confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent to the disclosure. However, research records identifying you may be inspected in the presence of the Investigator or his or her designate by representatives, Health Canada, and the UBC Research Ethics Board for the purpose of monitoring the research. However, no records which identify you by name or initials will be allowed to leave the Investigators' offices. All records will kept for 5 years.

Contact for information about the study:
If you have any questions or desire further information with respect to this study, you may contact Dr. [redacted]

Contact for concerns about the rights of research subjects:
If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Services at 1-877-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832. It is also possible to contact the Research Participant Complaint Line by email (RSIL@ors.ubc.ca)

Appendix B : Consent Form

Faculty of Health and Social Development
School of Health and Exercise Sciences
Reichwald Health Sciences Centre
3333 University Way
Okanagan Campus
Kelowna, B. C., Canada, V1V 1V7

Participant Information and Consent Form

UpwardHealth: A Pilot Study to Assess the Utility of a Mobile Solution Application to Promote Self-Monitoring and Exercise Behaviour

Principal Investigator: Dr. [redacted]
Assistant Professor
School of Health and Exercise Sciences
The University of British Columbia, Okanagan Campus
Phone: [redacted]

Research Assistant: [redacted]
Candidate for Masters of Science
Health and Exercise Psychology Lab
The University of British Columbia, Okanagan Campus
Phone: [redacted]

INVITATION
You are being invited to take part in this research study because you are becoming a member of the [redacted] and can read and speak English.

YOUR PARTICIPATION IS VOLUNTARY
Your participation in this study is entirely voluntary and it is your decision whether or not to take part in this study. Before you decide, it is important for you to understand what this research will involve. This document will explain the study, why the research is being done, what you will be asked to do and what will happen to you, and the possible benefits, risks and discomforts associated with the study.

If you would like to participate please inform the study associated personal trainer and sign your name and provide your phone number in the provided space below for a research assistant from UBC to contact you. If you decide to participate in this study you are free to withdraw at any time and without giving any reasons for your decision.

If you do not wish to participate, you do not have to provide any reason for your decision, nor will you face any repercussions. Please take time to read the following information carefully before you decide.

WHO IS CONDUCTING THE STUDY?
This study will be conducted by Dr. [redacted] at UBC Okanagan and will be run at [redacted] The smartphone mobile solution will be provided by a Kelowna based company called [redacted].

BACKGROUND
[redacted] is in the final development stages of a new mobile application for smart phones ([redacted]). The purpose of the application is to enable individuals involved in exercise and physical activity to set physical goals, track progress towards these goals and record successful completion of these goals on a daily and weekly basis. The mobile system incorporates a self-report tracking system, as well as access to a certified personal trainer. The designated personal trainer is associated with the participant's fitness facility, and has been included in the development of a personalized, attainable physical goal. The proposed study as follows has been developed in conjunction with [redacted], and [redacted] at the University of British Columbia: Okanagan, who will be the primary researcher of the study.

WHAT IS THE PURPOSE OF THE STUDY?
This study is a pilot study. When testing the creation of a new program or system, the use of a "pilot study" is often implemented to first test out this new system. The basic purpose of this pilot study is to test the mobile system to further understand its usability and the likelihood that the mobile system can be usefully implemented into a given environment.

The primary purpose of this study is to determine if the use of the smartphone mobile system aids in the ability of an individual to adhere to a pre-determined goal. The secondary purpose of this study is to assess the usability of a physical activity-tracking smart phone mobile system, and how the system influences the relationship between personal trainers and their clients.

WHO CAN PARTICIPATE IN THIS STUDY?
You may be able to participate in this study if you are between the ages of 19 and 65, are a new member to [redacted] and can read and speak English.

WHO SHOULD NOT PARTICIPATE IN THE STUDY?
There are no exclusion criteria to participation in this study, other than not meeting the inclusion criteria above.

WHAT DOES THE STUDY INVOLVE?
This study will take place at [redacted]. You are receiving this consent form as you expressed interest in participating in this research study, provided your name and contact details to the member services representative, received a letter of information outlining the study and are meeting with the research assistant. If you agree to participate in the study this initial meeting will last approximately 1 hour. During this time you will work with the

research assistant to determine your 8-week exercise goal. Next, you will also be asked to complete a short survey in which you will report information about yourself (i.e., age, sex), as well as questions about your previous physical activity. Following the completion of questionnaires, you will be placed randomly into one of two possible timeline groups. If placed in the group one, you will be introduced immediately to the mobile system to be used throughout the duration of your 8-week study and will meet the personal trainer that you will be working with over the 8-week period.

If placed in group two, you will be asked to continue exercising in your regular manner and will be introduced to the mobile system at your follow-up appointment with the research assistant in 8-weeks time. Participation will involve tracking your physical activity through the use of the mobile system. You will be asked to complete progress reports on the system based on your personal goal set at the beginning of the program. All information will be accessible to the designated personal trainer for the study. This personal trainer will be able to view your self-reported data and contact you via the mobile system. For research purposes, at the conclusion of the study, the research assistant will also have access to the information you have provided on the application, which will detail only on which days you have exercised, and if you met your exercise goal. At the end of the 8-week period the research assistant will arrange a final meeting at the H_20 facility where you will be asked to complete a questionnaire based on your experiences throughout the study, as well as the usability of the application for those individuals that have been using the mobile system (i.e., whether you found the application to be useful and would be interested in using it again). For individuals that have not been using the mobile system you will now be introduced to the mobile system, and your personal trainer following completion of the questionnaires. The time commitment for this final visit is approximately 1 hour.

For tracking purposes, at the conclusion of the 8-week study period, H_20 will also provide the researcher with a final tally representing the number of times each participant visited the H_20 adventure and fitness center. This tally will be provided based on the number of times each participant scans his or her member id barcode when entering the facility.

WHAT ARE THE POSSIBLE HARMS AND DISCOMFORTS?
The risks that are associated with the exercise bouts are the same as the physical discomfort that you may experience if you did any form of physical activity. These risks include fatigue, fainting, and/or muscle soreness. These risks may be minimized by ensuring that you are working under the supervision of a certified trainer, as well as working towards a safe and attainable goal. There are no physical or health risks associated with the use of the smartphone application.

Emergency procedures:
In the event of an emergency or injury it is recommended that you alert a staff member of H_20 fitness immediately. Proper medical and first aid procedures will be followed as is dictated by the H_20 fitness facility.

WHAT ARE THE POTENTIAL BENEFITS OF PARTICIPATING?
The benefits to you that could arise from participation in this research are a) the ability to make use of a new smart phone mobile system created by [redacted] (free of charge) that is not yet

available to the public, b) working one-on-one with a certified personal trainer for 8 weeks, and c) the physical health benefits associated with exercising.

WHAT HAPPENS IF I DECIDE TO WITHDRAW MY CONSENT TO PARTICIPATE?
Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time without any explanation.
If you withdraw from the study your data collected up to the point of withdrawal from the study must be kept for data analysis purposes under strict provisions of confidentiality.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?
Your confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent to the disclosure. However, research records identifying you may be inspected in the presence of the Investigator or his or her designate by representatives, Health Canada, and the UBC Research Ethics Board for the purpose of monitoring the research. However, no records which identify you by name or initials will be allowed to leave the Investigators' offices. All records will kept for 5 years.

WHAT HAPPENS IF SOMETHING GOES WRONG?
Signing this consent form in no way limits your legal rights against the sponsor, investigators, or anyone else, and you do not release the study doctors or participating institutions from their legal and professional responsibilities.

In case of a serious medical event, please report to an emergency room and inform them that you are participating in a clinical study and that the following person can then be contacted for further information: Dr. [redacted] or [redacted] (24 hr mobile)

If you become injured or unexpectedly ill as a consequence of participation in the study due to the administration of the study procedures, your medical condition will be evaluated and medical care will be provided by one of the investigators or you will be referred for appropriate treatment.

REMUNERATION
There is no monetary cost associated with participating in the study as clients will have already become members of the fitness facility under their own will before introduction to the study. Additionally, there is no financial compensation for participating in this research study. However, as a participant you will gain access to the [redacted] mobile system and 8-weeks of contact with a personal trainer. Additionally, there is no financial cost associated with the use of this smart phone mobile system.

WHO DO I CONTACT IF I HAVE QUESTIONS ABOUT THE STUDY DURING MY PARTICIPATION?
If you have any questions or desire further information with respect to this study, you may contact Dr. [redacted].

WHO DO I CONTACT IF I HAVE ANY QUESTIONS OR CONCERNS ABOUT MY RIGHTS AS A SUBJECT?

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Services at 1-877-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832. It is also possible to contact the Research Participant Complaint Line by email (RSIL@ors.ubc.ca)

If you are interested in learning about the results of this research, please provide a mailing address or email address to which we may send you the study findings:

_____

_____

_____

UpwardHealth: A Pilot Study to Assess the Utility of a Smartphone Mobile Solution to Promote Self-Monitoring and Exercise Behaviour

SIGNATURES

Participant Consent:

- I have read and understood the subject information and consent form.
- I have had sufficient time to consider the information provided and to ask for advice if necessary.
- I have had the opportunity to ask questions and have had satisfactory responses to my questions.
- I understand that all of the information collected will be kept confidential and that the result will only be used for scientific objectives.
- I understand that my participation in this study is voluntary and that I am completely free to refuse to participate or to withdraw from this study at any time without jeopardy to my [for example, employment, class standing, access to further services from the community centre, day care, etc.].
- I understand that I am not waiving any of my legal rights as a result of signing this consent form.
- I understand that there is no guarantee that this study will provide any benefits to me.
- I have read this form and I freely consent to participate in this study.
- I have been told that I will receive a dated and signed copy of this form.

I will receive a signed copy of this consent form for my own records.

I consent to participate in this study.

_____	_____	_____
Subject's Signature	Printed name	Date

Investigator Signature

_____	_____	_____
Investigator Signature	Printed name	Date

My signature above signifies that the study has been reviewed with the study subject by me and/or by my delegated staff. My signature may have been added at a later date, as I may not have been present at the time the subject's signature was obtained.

Appendix C : Baseline Questionnaire

THE UNIVERSITY OF BRITISH COLUMBIA

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

School of Health and Exercise Sciences
Health Sciences Building,
3333 University Way
Okanagan Campus
Kelowna, B.C., Canada V1V 1V7
Tel: (250) 807-9670
Fax: (250) 807-8085

THANK YOU FOR YOUR PARTICIPATION!

It will take around 15 minutes to complete the survey. Please answer every question as honestly as possible. Your intuition is the best answer – there is no right or wrong answer and **this is NOT a test.** If you do not want to answer a question you do not have to, simple move on to the next question. If you do not want to do the survey you do not have to. You do not have to give a reason why you do not want to do it. **PLEASE DO NOT PUT YOUR NAME ON THIS SURVEY.**

Are you a new or existing member to Kelowna H_20 adventure and fitness centre?

☐ I am a new member to the centre.
☐ I am an existing member to the centre.

Have you ever worked with a personal trainer?

☐ No, I have never worked with a personal trainer.
☐ Yes, I have previously worked with a personal trainer.

If you have worked with a personal trainer, when was the last time you had a session with him/her?

_____
_____
_____

If you have worked with a personal trainer, how many sessions have you had in the past 5 years?

_____
_____
_____

When working with a personal trainer, what style of communication do you find most beneficial? (tick as many as apply)

☐ Drill Sargent style
☐ Upbeat and motivating.
☐ Quiet, except for providing feedback on form
☐ Caring
☐ Other: _____

The next few questions ask you about your confidence in your ability to self-monitor, or keep track of, certain behaviours. Please **CIRCLE** the **ONE** answer that best describes how you would rate your confidence for each question.

In the next 7 days how confident are you that you can:

Record your exercise bouts?										
0% Not at all Confident	**10 %**	**20 %**	**30 %**	**40 %**	**50 %**	**60 %**	**70 %**	**80 %**	**90 %**	**100% Extremely Confident**
Keep track of how many times you exercise and adjust your behaviour accordingly?										
0% Not at all Confident	**10 %**	**20 %**	**30 %**	**40 %**	**50 %**	**60 %**	**70 %**	**80 %**	**90 %**	**100% Extremely Confident**
Manage your daily schedule to allow time for participation in physical activity/exercise?										
0% Not at all Confident	**10 %**	**20 %**	**30 %**	**40 %**	**50 %**	**60 %**	**70 %**	**80 %**	**90 %**	**100% Extremely Confident**

The following questions ask you about your ability to self-manage your participation in physical activity. Please **CIRCLE** the **ONE** answer that best describes how you feel.

It is difficult for me to find opportunities to participate in physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am able to find or make time to participate in physical activity/exercise				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I succeed in goal setting that I undertake to manage my physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Typically, my plans for participating in physical activity don't work out well.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
No matter how hard I try, my plans to participate in physical activity do not turn out the way I would like.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I'm generally able to accomplish my goals with respect to participating in physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Below is a list of things people (ie. family, friends, physical activity counsellor, etc) might do or say to someone who is trying to be physically active regularly. Please rate how often anyone has said or done what is described during the **past 8 weeks**.

Please write **ONE** number from the following rating scale in each space:

None	Rarely	A Few Times	Often	Very Often	Does Not Apply
1	2	3	4	5	8

During the past 8 weeks, my family, friends, physical activity counsellor:	**Rating**
1. Gave me encouragement to stick to my physical activity program.	
2. Told me how proud they are of me for being physically active.	
3. Were instrumental in helping me attain my physical activity goals.	

Do you currently keep track of your exercise sessions (e.g., record your exercise sessions in a journal, use an online monitoring system, etc.)?

☐ No, I am not currently tracking or recording my exercise sessions in any way.

☐ Yes, I am currently tracking or recording my exercise sessions. If you do keep track of your exercise sessions, how do you do this: _____

If yes, on average, how often do you track your progress per week?

☐	☐	☐	☐	☐	☐	☐	☐
0	1	2	3	4	5	6	7
days	day	days	days	days	days	days	days

The following questions ask you about the frequency that you engage in purposeful physical activity. Please **CHECK** the **ONE** option that best applies to you.

On average, how many times per week do you engage in physical activity?

☐	☐	☐	☐	☐	☐	☐	☐
0	1	2	3	4	5	6	7+
times	times	times	times	times	times	times	times

Have you ever tracked your exercise progress (e.g., using a log or diary, an online tracker, fitbit, or smartphone application device)?

☐ No, I have never tracked my exercise habits.
☐ Yes, I have previously tracked my exercise habits.

If yes, what did you use, and how long did you track your exercise progress for?

What was your reasoning for ending your tracking habits?

You have now completed the survey.
Thank you for your time.
If you have any questions please do not hesitate to ask a research assistant.

Appendix D : Post Study Questionnaire

D.1 Post-Study Questionnaire: Experimental

THE UNIVERSITY OF BRITISH COLUMBIA

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

School of Health and Exercise Sciences
Health Sciences Building,
3333 University Way
Okanagan Campus
Kelowna, B.C., Canada V1V 1V7
Tel: (250) 807-9670
Fax: (250) 807-8085

THANK YOU FOR YOUR PARTICIPATION!
It is people like you that make research possible. It will take around 15 minutes to complete the survey. Please answer every question as honestly as possible. Your intuition is the best answer – there is no right or wrong answer and **this is NOT a test.** If you do not want to answer a question you do not have to, simple move on to the next question. If you do not want to do the survey you do not have to. You do not have to give a reason why you do not want to do it.
PLEASE DO NOT PUT YOUR NAME ON THIS SURVEY.
If you have any questions, please ask. We are here to help!

First, please fill out the following demographic information to the best of your ability.

Sex (please check one):
☐ Male
☐ Female

Year of birth: _____

Height: _____' ___"

Weight: _____ **lbs or** _____ **kgs**

What is the highest level of education you have completed (please check one):
☐ less than high school
☐ high school
☐ apprenticeship or trades certificate or diploma
☐ college
☐ university diploma or degree
☐ post-graduate degree

What is your occupation (please check one):
☐ working full-time
☐ working part-time
☐ working occasionally/contract work
☐ student
☐ retired
☐ other (please specify) _____

The next few questions ask about your confidence in your ability to self-monitor, or keep track of, certain behaviours. Please **CIRCLE** the **ONE** answer that best describes how you would rate your confidence.

In the next 7 days how confident are you that you can:

Record your exercise bouts?										
0% **Not at all Confident**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%** **Extremely Confident**
Keep track of how many times you exercise and adjust your behaviour accordingly?										
0% **Not at all Confident**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%** **Extremely Confident**
Manage your daily schedule to allow time for participation in physical activity/exercise?										
0% **Not at all Confident**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%** **Extremely Confident**

The following questions ask about your ability to self-manage participation in physical activity.

Please **CIRCLE** the **ONE** answer that best describes how you feel.

It is difficult for me to find opportunities to participate in physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am able to manage my time effectively to include time to participate in physical activity/exercise				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I succeed in goal setting that I undertake to manage my physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Typically, my plans for participating in physical activity don't work out well.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

No matter how hard I try, my plans to participate in physical activity do not turn out the way I would like.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I'm generally able to accomplish my goals with respect to participating in physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Below is a list of things people (ie. family, friends, physical activity counsellor, etc) might do or say to someone who is trying to be physically active regularly. Please rate how often anyone has said or done what is described during the **past 8 weeks**.

Please write **ONE** number from the following rating scale in each space:

None	Rarely	A Few Times	Often	Very Often	Does Not Apply
1	2	3	4	5	8

During the past 8 weeks, my family, friends, physical activity counsellor:	**Rating**
1. Gave me encouragement to stick to my physical activity program.	
2. Told me how proud they are of me for being physically active.	
3. Were instrumental in helping me attain my physical activity goals.	

The following questions ask you to report on the frequency that you used the [redacted] Please **CHECK** the **ONE** option that best applies to you.

Did you use the app to report the exercise you did in the past 7 days?

☐ Yes ☐ No

How many times, if at all, did you forget to record your exercise in the past week?

☐	☐	☐	☐	☐	☐	☐	☐
0 times	1 times	2 times	3 times	4 times	5 times	6 times	7+ times

Over the past 8 weeks, how often did you log into the app to track your exercise activities (please circle one answer)?

I never did	I did once and a while	I logged in about half of the times I	I almost always logged my	I always logged my exercise

		exercised	exercise bouts	bouts

Over the past 8 weeks, did you ever record you had completed an exercise session when you actually had not? Or over-reported what you had done? This information will be used by the researchers only. (Please circle one answer)

I never did	I did once or twice	I did about half of the times I reported	I did almost all the time I reported	I always did

The following questions ask you about the support provided to you by the certified personal trainer. Please **CIRCLE** the **ONE** answer that best applies to you personally.

The contact with the personal trainer has helped me.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have trust in the personal trainer's ability to advise me.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The personal trainer understands my goal.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The personal trainer is dedicated to helping me reach my goal.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel comfortable talking to the personal trainer.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The trainer and I agree on my 8-week goal.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel content with the contact I have received from the personal trainer.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I find the personal trainer easily accessible.				
Strongly	Disagree	Neutral	Agree	Strongly Agree

Disagree				

The following questions ask you about the usability of the app. Please **CIRCLE** the **ONE** answer that best describes how you feel.

I found the app easy to navigate.				
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I could easily include the use of the app into my daily routine.				
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I found the number of texts and reminders appropriate.				
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I found the number of texts and reminders motivating and helpful.				
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

The following questions ask you about your intentions to use the app in the future. Please **CIRCLE** the **ONE** answer that best applies to you personally.

In the future, I would continue to use the app.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would pay to use the app.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would continue to use the app, but only if it was free to me.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The use of the app would be a helpful addition to [redacted] centre.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

The following questions ask you about your experience with the personal trainer and future intentions to sign up for sessions. Please **CIRCLE** the **ONE** answer that best describes how you feel.

I enjoyed having access to the personal trainer.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I enjoyed receiving reminders from the personal trainer.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
When the study is complete, I will miss the contact with the personal trainer.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
In the future, I would pay to have sessions with a personal trainer.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would continue sessions with a personal trainer, but only if it was free to me.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
As a member I feel it is important to have access to a personal trainer.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

The following section asks about your time at [redacted].

In the future, do you intend to continue your membership at [redacted]

☐ Yes ☐ No

If yes. What length of membership do you intend to purchase?

_____

_____

If no, is there a specific reason you will not be continuing your membership at [redacted]?

_____

_____

The following section asks about the 8-week goal you set at the beginning of the study. Please answer the questions to the best of your ability.

At the end of the 8-week period your goal was to:

_____
_____
_____
_____

Did you achieve your goal?

☐ Yes ☐ No

Please rate your perceived success in attaining your 8-week goal. (Please circle one answer).				
Not at all successful	Somewhat successful	Very close to succeeding	Definitely successful	N/A (e.g., goal changed)

Is there any additional information you would like to provide based on your success?

_____
_____
_____
_____
_____
_____
_____

What is your current exercise level? Please **CHOOSE** the **ONE** option that best pertains to you (number of days per week).

☐	☐	☐	☐	☐	☐	☐
1 days	2 days	3 days	4 days	5 days	6 days	7 days

The following questions refer to opportunities for further participation in research.

In the event that this research study continues, may we contact you on an infrequent basis to ask follow up questions?

☐ Yes ☐ No

Would you be interested in participating in research studies associated with the University of British Columbia: Okanagan and [redacted] in the future?

☐ Yes ☐ No

If yes, please provide the phone number you prefer to be contacted through.

Phone Number: _____

You have now completed the survey.
Thank you for your time.
If you have any questions please do not hesitate to ask a research assistant.

D.2 Post-Study Questionnaire: Control

THE UNIVERSITY OF BRITISH COLUMBIA

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

School of Health and Exercise Sciences
Health Sciences Building,
3333 University Way
Okanagan Campus
Kelowna, B.C., Canada V1V 1V7
Tel: (250) 807-9670
Fax: (250) 807-8085

THANK YOU FOR YOUR PARTICIPATION!

It is people like you that make research possible. If you have any questions, please ask. We are here to help!

It will take around 15 minutes to complete the survey. Please answer every question as honestly as possible. Your intuition is the best answer – there is no right or wrong answer and **this is NOT a test.** If you do not want to answer a question you do not have to, simple move on to the next question. If you do not want to do the survey you do not have to. You do not have to give a reason why you do not want to do it.

PLEASE DO NOT PUT YOUR NAME ON THIS SURVEY.

First, please fill out the following demographic information to the best of your ability.

Sex (please check one):
☐ Male
☐ Female

Year of birth: _____

Height: _____' ____"

Weight: _____**lbs or** _____ **kgs**

What is the highest level of education you have completed (please check one):
☐ less than high school
☐ high school
☐ apprenticeship or trades certificate or diploma
☐ college
☐ university diploma or degree
☐ post-graduate degree

What is your occupation (please check one):
☐ working full-time
☐ working part-time
☐ working occasionally/contract work
☐ student
☐ retired
☐ other (please specify) _____

The next few questions ask you about your confidence in your ability to self-monitor, or keep track of, certain behaviours. Please **CIRCLE** the **ONE** answer that best describes how you would rate your confidence.

In the next 7 days how confident are you that you can:

Record your exercise bouts?										
0% **Not at all Confident**	**10 %**	**20 %**	**30 %**	**40 %**	**50 %**	**60 %**	**70 %**	**80 %**	**90 %**	**100% Extremely Confident**
Keep track of how many times you exercise and adjust your behaviour accordingly?										
0% **Not at all Confident**	**10 %**	**20 %**	**30 %**	**40 %**	**50 %**	**60 %**	**70 %**	**80 %**	**90 %**	**100% Extremely Confident**
Manage your daily schedule to allow time for participation in physical activity/exercise?										
0% **Not at all Confident**	**10 %**	**20 %**	**30 %**	**40 %**	**50 %**	**60 %**	**70 %**	**80 %**	**90 %**	**100% Extremely Confident**

The following questions ask you about your ability to self-manage participation in physical activity. Please **CIRCLE** the **ONE** answer that best describes how you feel.

It is difficult for me to find opportunities to participate in physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am able to manage my time effectively to include time to participate in physical activity/exercise				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I succeed in goal setting that I undertake to manage my physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Typically, my plans for participating in physical activity don't work out well.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
No matter how hard I try, my plans to participate in physical activity do not turn out the way I would like.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

I'm generally able to accomplish my goals with respect to participating in physical activity/exercise.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Below is a list of things people (ie. family, friends, physical activity counsellor, etc) might do or say to someone who is trying to be physically active regularly. Please rate how often anyone has said or done what is described during the **past 8 weeks**.

Please write **ONE** number from the following rating scale in each space:

None	Rarely	A Few Times	Often	Very Often	Does Not Apply
1	2	3	4	5	8

During the past 8 weeks, my family, friends, physical activity counsellor:	**Rating**
1. Gave me encouragement to stick to my physical activity program.	
2. Told me how proud they are of me for being physically active.	
3. Were instrumental in helping me attain my physical activity goals.	

Do you currently log your exercise sessions (e.g., record your exercise sessions in a journal, use an online monitoring system, etc.)?

☐ No, I am not currently logging or recording my exercise sessions in any way.

☐ Yes, I am currently logging or recording my exercise sessions. If you do keep track of your exercise sessions, how do you do this:

_____

If yes, how often do you track your progress per week?

☐	☐	☐	☐	☐	☐	☐	☐
0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days

The following questions ask you to report on the frequency that you engaged in purposeful physical activity. Please **CHECK** the **ONE** option that best applies to you.

On average, how many times per week do you engage in physical activity?

☐	☐	☐	☐	☐	☐	☐	☐
0 times	1 times	2 times	3 times	4 times	5 times	6 times	7+ times

The following section will ask you questions referring to your time at Kelowna's H_20 fitness facility.

In the future, do you intend to continue your membership at Kelowna's [redacted]?

☐ Yes ☐ No

If yes. What length of membership do you intend to purchase?

_____

_____

If no, is there a specific reason you will not be continuing your membership at [redacted]?

_____

_____

The following section asks about the 8-week goal you set at the beginning of the study. Please answer the questions to the best of your ability.

At the end of the 8-week period your goal was to:

_____

_____

_____

Did you achieve your goal?

☐ Yes ☐ No

Please rate your perceived success in attaining your 8-week goal. (Please circle one answer)				
Not at all successful	Somewhat successful	Very close to succeeding	Definitely successful	N/A (e.g., goal changed)

Is there any additional information you would like to provide based on your success?

_____

_____

_____

_____

_____

What is your current exercise level? Please **CHOOSE** the **ONE** option that best pertains to you (number of days per week).

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

days days days days days days days

The following questions refer to opportunities for further participation in research.

In the event that this research study continues, may we contact you on an infrequent basis to ask follow up questions?

☐ Yes ☐ No

Would you be interested in participating in research studies associated with the University of British Columbia: Okanagan and [redacted] in the future?

☐ Yes ☐ No

If yes, please provide the phone number you prefer to be contacted through.

Phone Number: _____

You have now completed the survey.
Thank you for your time.
If you have any questions please do not hesitate to ask a research assistant.

Appendix E : Godin Leisure Time Exercise Questionnaire

GLTEQ

Godin, G., Shepard, R. J. (1997). Godin Leisure-Time Exercise Questionnaire. Medicine and Science in Sports and Exercise. 29 June Supplement: S36-S38.

Please think back to the **past week** and answer the following questions as honestly as possible. How many times **on average** did you do the following kinds of exercise for **30 minutes continuously or more** during your **free time?** Write the appropriate **number of times** per week on each line.

Times per week

STRENUOUS EXERCISE (heart beats rapidly): _____
(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller-skating, vigorous swimming, vigorous long distance bicycling, skating)

MODERATE EXERCISE (not exhausting): _____
(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, dancing)

MILD EXERCISE (minimal effort): _____
(e.g., yoga, archery, fishing from riverbank, bowling, horseshoes, golf-snow-mobiling, easy walking)

During a typical **7-day period** (a week), in your leisure time, how often do you engage in any regular activity **long enough to work up a sweat** (heat beats rapidly)? Please TICK the box that applies to you.

OFTEN	SOMETIMES	NEVER/RARELY
☐	☐	☐

Appendix F : Goal Setting Handout

TIPS ON EFFECTIVE GOAL-SETTING:

1. **Make them yourself! Nobody should tell you what your goal(s) is.**
2. **Follow SMART principles**
3. **Make your goal moderately challenging, and possible!**
4. **Write goals down and regularly monitor progress**
5. **Use short-term goals to achieve long-term goals**
6. **Avoid setting too many goals – start out with one or two.**
7. **When you've accomplished your short-term goal, write your next short-term goal!**

Let's Develop Your Goal!

Let's develop your goal!

In 8 weeks I would like to accomplish….

Is your goal:

Specific to the outcome you would like to attain? (no "do your best" statements)?

Measurable? (How will you assess, when will you assess, etc)

Attainable? (Based on your current behaviours/health status)

Realistic? (10% improvement in performance is often considered attainable, 40% improvement is not)

Time bound! Remember, this is a 8-week goal!

Appendix G : Barriers to Goal Achievement Handout

Barriers to Goal Achievement

A barrier is something that keeps you from participating in regular physical activity or following through on an exercise plan. People often experience a variety of personal or environmental barriers to engaging in regular physical activity (e.g., boredom with exercise, fear of injury, cost, child care, lack of accessibility to walking paths, cycling trails etc.). Barriers often trigger a lapse in physical activity, making it difficult to be successful.

Barrier that prevents you from exercising	**That barrier occurs..** 1= almost never 2= sometimes 3= about1/week 4= almost daily 5= daily	**How limiting is this barrier to you?** 1= easy to overcome 2= somewhat limiting 3= tough to overcome but I can if I try 4= very hard to overcome 5= insurmountable, out of my control

So far you've developed one primary goal. Let's take another look at that goal.

Now, based on your listed barriers, let's develop two additional goals to help you reach your primary goal! Remember the 5 standards of a S.M.A.R.T goal. Goals number 2 and 3 should also be *specific*, *measurable*, *attainable*, *relevant*, and *time bound* (attainable in 8 weeks).

Example. My biggest barrier to exercise is being too tired, as I often only get 6 hours of sleep each night.
Goal: I am going to show myself how committed I am to exercise, so I am going to go to bed 1 hour earlier each night.

<u>Goal # 2</u>

_____
_____
_____

Goal # 3

_____
_____
_____