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Sedentary Behaviour, Physical Activity, and Mobile Apps Among University Students

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Abstract

Prolonged sedentary behaviour (SB) poses health risks independent of physical activity (PA) levels (Owen et al., 2010). University students in particular are at risk of engaging in prolonged SB due to the demands of school. Due to the pervasiveness of smartphones, and ability of mobile applications (apps) to target SB (Bond et al., 2014), apps may be used to encourage less SB in this population. Apps for PA have been coded for behaviour change techniques (BCTs) (Conroy et al., 2014; Middelweerd et al., 2014; Yang et al., 2015), however, apps for SB have yet to be assessed for BCTs.

The purpose of this study was two-fold. The first aim was review smartphone apps designed to reduce SB for the presence of BCTs. The second aim was to gain an understanding of university students' SB, PA and experiences with apps, and trial an SB app as a pilot intervention in this population.

To address the first aim, systematic searches of the iTunes App and Google Play stores were completed using keyword searches. Two reviewers independently coded free (n=36) and paid (n=14) app descriptions using a taxonomy of 93 BCTs (Michie et al., 2012). A subsample (n=4) of free apps were trialed for one week by the reviewers and coded for the presence of BCTs. In the free and paid app descriptions, only 10 of 93 BCTs were present with a mean of 2.42 BCTs (range 0-6) per app. The BCTs coded most frequently were "prompts/cues" (n=43), "information about health consequences" (n=31), and "self-monitoring of behaviour" (n=17). For the four free apps that were trialed, three additional BCTs were coded that were not coded in the descriptions: "graded tasks", "focus on past successes", and "behaviour substitution". These SB apps have fewer BCTs compared to PA apps (Conroy et al., 2014; Middelweerd et al., 2014;

Yang et al., 2015) and traditional (i.e., non-app) PA and healthy eating interventions (Michie et al., 2009).

To address the second aim, students from WLU (n=177) completed an online survey of questions about self-report levels of PA, SB, and experiences with and perceptions of apps. Following this, participants were asked to participate in a follow-up study and were randomly assigned to a trial group (n=53) or a control group (n=74). The trial group was asked to use the app Rise & Recharge® for two weeks. After two weeks, participants in trial (n=18) and control groups (n=37) completed a second online survey that repeated the self-report PA and SB questions. Participants in the trial group also responded to additional questions about their app experience. A two-way mixed repeated measures ANOVA found no significant difference in PA in either group from 'time 1' to 'time 2' (p>0.05). However, another two-way mixed repeated measures ANOVA for SB determined there was no main effect of time or group (p>0.05), but a significant interaction between group and time ($F(1,33)=6.81$, $p=0.014$, $\eta_p^2= 0.171$), in which the trial group (n=11) decreased in SB from 'time 1' to 'time 2', whereas the control group (n=24) increased in 'time 1' to 'time 2'. Despite this, participants in the trial group rated the app as only 'slightly influential'. Further, students' open-ended responses showed that they perceive a lack of control over their own SB due to the demands of university.

Overall, the present study sheds light on behaviour change potential of SB apps and provides practical insight about coding for BCTs in apps, and provides insight into PA an SB among university students and into the potential of using apps to influence this behaviour.

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Chapter 1: Review of Literature

It has been established that a lifestyle that incorporates regular physical activity (PA) positively contributes to overall health, for example it can reduce the risk of many chronic diseases and improve mood and mental health (CDC, 2015). PA is "any bodily movement produced by skeletal muscles that requires energy expenditure" (Caspersen, Powell, & Christenson, 1985, p. 126) and is classified into light and moderate-to-vigorous categories based on energy expenditure (1.9-2.9 METs, and 3-8 METs respectively) (Ainsworth et al., 2011). Based on the current Canadian guidelines for weekly minutes of moderate-to-vigorous activity (MVPA) (i.e., 150 minutes/week), most Canadians are physically inactive; only 15% of adults (Colley et al., 2011a) and 7% of children in Canada (Colley et al., 2011b) are achieving the recommended amount of PA.

Recently, attention has been drawn to differentiating between sedentary behaviour (SB) and physical inactivity (Owen, Healy, Matthews, & Dunstan, 2010). SB refers to "any waking activity characterized by an energy expenditure ≤ 1.5 metabolic equivalents and a sitting or reclining posture" (SBRN, 2012, p. 540) while physical inactivity "describe(s) those who are performing insufficient amounts of MVPA (i.e., not meeting specified PA guidelines)" (SBRN, 2012, p. 540). Although it is possible to be physically inactive and achieve a high amount of sitting time during the day, it is also possible to meet the PA requirements and still lead a sedentary lifestyle (Owen et al., 2010). This observation has been referred to as the "Active Couch Potato" phenomenon (Owen et al., 2010, p. 4) and it is important to acknowledge as a high amount of sitting time has health risks that are independent of PA levels (Owen et al., 2010; see also Katzmarzyk, Church, Craig, & Bouchard, 2009). Interrupting SB with passive (standing) or active (stepping)

breaks can have a significant effect on acute energy expenditure, with active breaks having a greater influence (Fountaine, Johann, Skalko, & Liguori, 2016). It has been demonstrated that 20 minutes of standing yielded a 9.8% increase in acute metabolic and energy cost (MEC) compared to 20 minutes of sitting. In addition, interspersing 1 minute of light PA (stepping in place) with 9 minutes of sitting twice over 20 minutes yielded a 47.5% increase in MEC **(**Fountaine et al., 2016). With consideration for long-term consequences, a higher number of sitting breaks, irrespective of total sitting time, has been associated with improvements in several health indicators (e.g., body mass index (BMI), and waist circumference) (Healy et al., 2008).

Although guidelines exist for weekly minutes of MVPA, recent research has called for public health recommendations specific to SB (Spence, Rhodes, & Carson, 2017). The current SB recommendations for Canadians are limited to young people (aged 0-17) and the amount of recreational screen time engaged in per day (1-2 hours per day). For children (aged 5-11) and youth (aged 12-17), additional recommendations suggest "limiting sedentary (motorized) transport, extended sitting and time spent indoors" (CSEP, 2016). Unfortunately, the amount of time spent engaged in SBs for Canadian youth (6-19 years) and adults (20-79 years) is quite high, at 8.6 hours/day (Colley et al., 2011a) and 9.5 hours/day respectively (Colley et al., 2011b). Although the SB levels of Canadian youth and adults have been quantified separately, there exists little specific data on emerging adulthood (18-24 years old), an age period that overlaps youth and adult.

Population: University Students

It has been established that the transition from adolescence to early adulthood is associated with a decline in PA (Kwan, Cairney, Faulkner, & Pullenayegum, 2012), an

age period typically associated with entering post-secondary education. Globally, the majority of university/college students are not meeting the PA requirements (Clemente, Nikolaidis, Martins, & Mendes, 2016; Deforche, Van Dyck, Deliens, & De Bourdeaudhuji, 2015; Haase, Steptoe, Sallis, & Wardie, 2004; Weinstock, 2010), and those attending university/college have high potential of long sitting bouts as per the demands of lectures and studying. Rouse and Biddle (2010) demonstrated that in a sample of European university students, the majority of students' sedentary time is spent studying, up to almost 4 hours a day. Other behaviours also contributed to overall sitting time like watching television, sitting and talking, and hanging out (Rouse & Biddle, 2010).

Across the years spent at university/college there is also potential for PA and SB to vary with consideration for other moderating variables. For example, in a longitudinal study over seven semesters of college students in the U.S., daily PA significantly declined from the first semester to the last (Small, Bailey-Davis, Morgan, & Maggs, 2013). Interestingly, living off campus exacerbated this decline. As well, the average number of hours spent in discretionary (i.e., not related to academics or work) SB declined over the semesters, but was not confounded by living on or off campus (Small et al., 2013). However, within Canada the levels of SB and the relationship to PA levels for post-secondary students remains under explored.

Many adult health behaviours are established during this period of late adolescence and early adulthood (Buckworth & Nigg, 2004), making this stage of life crucial for influencing PA and SB habits. In addition to the physical health benefits of disrupting prolonged sitting, Maher, Doerksen, Elavsky, and Conroy **(**2014**)** have

demonstrated that for college students, irrespective of PA, SB was negatively associated with satisfaction with life (SWL), providing further support for distinguishing between SB and physical inactivity.

In addition, a recent qualitative study **(**Deliens, Deforche, De Bourdeaudhuij, & Clarys, 2015) was performed using focus groups with Swedish university students to identify determinants of PA and SB and collect ideas on how to increase PA and decrease SB. The authors found that students often confused SB and physical inactivity. As a consequence, the suggestions for interventions focused on "strategies to be more physically active, whereas little to no specific recommendations were made to target actual SB" (Deliens et al., 2015, p. 17). However, the students did highlight a connection between PA and SB, believing that "the lack of PA may increase the likelihood of spending more time in sedentary mode" (Deliens et al., 2015, p. 17). They concluded that SB was still a relatively misunderstood concept among university students.

Mobile Apps Intervention Strategies

As previously discussed, time spent engaged in SB contributes to a reduction in energy expenditure (Owen et al., 2010), however, as SB is not the absence of MVPA, interventions and promotion tactics designed to increase PA will not necessarily result in a reduction of time spent sitting. In support of this notion, a recent meta-analysis (Prince, Saunders, Gretsy, & Reid, 2014) that reviewed 33 controlled trials (quasi-experimental or randomized control trials) compared the effectiveness of a variety of interventions focusing on PA and/or SB for reducing sedentary time in adults (18-94 years old). The authors concluded that interventions focusing on only SB resulted in greater reduction of sedentary time, compared to interventions with a goal of increasing PA levels or a

combined goal to increase PA levels and decrease sedentary time. Therefore, to have a larger impact on SB, interventions that specifically target SB are required. However, using the same techniques that have been successful in influencing PA may not result in a positive influence on SB. For example, action planning, an established technique for bridging intention and behaviour for PA was found to have no impact on changing SB (Maher & Conroy, 2015). Thus, addressing SB independently and exploring novel ways to influence SB is imperative.

Mobile apps and other forms of mHealth (mobile-Health) are increasingly being utilized in interventions for a variety of health behaviours (Iacoviello, et al., 2017; Puszkiewicz, Roberts, Smith, Wardel, & Fisher, 2016; Turner & Hingle, 2017), and are already being used by smartphone owners under their own volition. In fact, 19% of smartphone owners have at least one health app and 38% of health app users track their exercise (Fox & Duggan, 2012). A recent systematic review evaluated 52 articles that were smart-phone based (including SMS text messaging, apps, etc.) and involved PA promotion and/or assessment to determine practicality and effectiveness of PA apps among a variety of populations of adolescents and adults (Monroe, Thompson, Bassett, Fitzhurg, & Raynor, 2015). The findings indicated "out of 26 studies that reported a PA behaviour change outcome, 13 observed favourable PA changes…" (Monroe et al., p. 196). In addition, "10 studies examined the validity of mobile phones for PA assessment, and 9 reported favourable outcomes [and] participants found mobile phones to be highly acceptable" (Monroe et al., p. 196). Overall, this review demonstrates that apps are highly acceptable, valid measurement tools, and have the potential to improve PA (Monroe et al., 2015).

With respect to SB, Bond et al. (2014) outlined several advantages of smartphone-based interventions specifically for SB including the ability to target SB, monitor SB using the built-in accelerometer, prompt users to take PA breaks, and provide feedback in real-time. However, research on the behaviour change effectiveness of apps for health has been limited, and even fewer studies have examined apps specific to disrupting SB. However, two such exceptions have demonstrated encouraging preliminary results for SB apps (van Dantzig, Geleijnse, & van Halteren, 2012; Bond et al., 2014). van Dantzig et al. (2012) performed a smart-phone intervention with 40 office workers that utilized text messaging. A text was sent to participants after 30 minutes of designed uninterrupted computer activity (indicating sitting time) to encourage sitting breaks. The intervention resulted in significant increases in PA and decreases in computer activity compared to a control group. Eight of those office workers used a prototype app called "SitCoach" for 1 day. Although these participants reported little awareness of the harmful effects of prolonged sitting, and poor perceived internal control over SB, overall, participants reported that "SitCoach" was perceived as a helpful tool to reduce SB. Similarly, Bond et al. (2014) found that for 40 overweight/obese individuals, using a SB app called "B-MOBILE" resulted in reduced sedentary time and increased PA. In addition, 3-min breaks after 30 sedentary minutes saw the greatest reduction in sedentary time and increase in PA (compared to 6-min breaks after 60 minutes sitting or 12-min breaks after 120 minutes sitting). Overall, these two preliminary studies highlight the potential of SB apps to influence SB and PA, and possibly the optimal frequency of interrupting sitting.

College and university students are popular smart-phone/app users, 96% of undergraduate students have a cellphone (Smith, Rainie, & Zickhur, 2011). However,

some concerning findings have demonstrated that within college students, cellphone use has been found to be associated with lower GPA (Lepp, Barkley, & Karpinski, 2015) and lower cardiorespiratory fitness (Lepp, Barkley, Sanders, Rebold, & Gates, 2013). Despite the irony, given the pervasiveness and potential to influence behaviour, smartphone technology remains a promising area to explore**.** Although there exists limited research on the behaviour change effectiveness of mobile apps for health for university students (Miller, Chandler, & Mouttapa, 2015), exploratory investigations have begun to address foundational considerations for PA apps among university students including app use and feature preferences. As such, 81.8% of college students have expressed interest in receiving PA and fitness via a health/wellness app specific for their campus (Miller et al., 2015), and students who use health/fitness apps do so to either support an established behaviour or adopt a new behaviour (Gowin, Cheney, Gwin, & Wann, 2015). Middelweerd et al. (2015) recently provided a group of 30 Dutch university students with a prototype app designed to support PA participation. After 3 weeks of using the app, focus groups were conducted to assess participants' experience with apps in general, and with the prototype app. Participants reported that they prefer PA apps that coach and motivate them, that provide tailored feedback toward personally set goals, and that allow competition with friends (Middelweerd et al., 2015). In addition, Miller et al. (2015) indicated that students wanted an app that had interactive features (e.g. monitoring and tracking health behaviour). Gowin et al. (2015) indicated that students reported that acceptable apps were free, easy to use, provided visual/auditory cues, and had game-like rewards. Taken together, these investigations (Gowin et al., 2015; Middelweerd et al., 2015; Miller et al., 2015) contribute to our understanding of how students currently use

PA apps, and key features they perceive as important. However, most of these investigations have centered on PA as opposed to SB for students. There seems to be lack of research focused on university students' use of SB apps.

Behaviour Change Techniques and Mobile Apps

It has been established that interventions for health behaviour change are more likely to be effective if they are based in behaviour change theory (Webb, Joseph, Yadley, & Michie, 2010). iPhone apps for PA that have been assessed for the presence of health behaviour change theory constructs display limited theoretical content (Cowan et al., 2010). Apps for PA have also been coded for the presence of specific behaviour change techniques (BCTs) (Conroy, Yang, & Maher, 2014; Middelweerd, Mollee, van der Wal, & te Velde, 2014; Yang, Maher, & Conroy, 2015). BCTs are the "observable and replicable components of behaviour change interventions" (Michie & Johnston, 2012, p. 3), or the "active ingredients" in interventions. Coding interventions for BCTs identifies the components of an intervention that may lead to behaviour change. Coding apps for BCTs can inform users, researchers, and developers about the behaviour change potential in apps.

These three studies that coded PA apps for BCTs had varied methods. Middelweerd et al. (2014) utilized a systematic search of the iTunes and Google Play app stores and coded apps by downloading and using the apps. Yang et al. (2015) and Conroy et al. (2014) reviewed top PA apps in the "health and fitness" categories and both coded for the presence of BCTs using the app description. Despite utilizing different BCT taxonomies for coding, each found a low average number of BCTs for each app: Middelweerd et al. (2014) found an average of 5 BCTs with a range from 2 to 8 BCTs,

Yang et al. (2015) found an average of 6.6 and a range from 1 to 21, and Conroy et al. (2014) found an average of 4.2 and a range from 1 to 13. These studies have also made comparisons between free and paid apps and apps from the iTunes and Google Play stores. Yang et al. (2015) and Middelweerd et al. (2014) found no difference in the number of BCTs in each app between paid or free apps, but Conroy et al. (2014) did find some differences between BCTs coded. Middelweerd et al. (2014) also found no difference in BCTs between apps from the iTunes and Google Play stores.

Although these reviews provided important insight into the behaviour change capacity of apps designed to increase PA, apps designed specifically to decrease SB have not been examined (i.e., coded) for the presence of BCTs. Thus, we do not yet know which BCTs are typically utilized and the subsequent behaviour change potential in apps for SB.

Caveat

Collectively, despite preliminary investigations, there remains a scarcity of research devoted to SB for Canadian university students. However, as SB poses a health threat independent of the levels of PA, developing an understanding SB within this meaningful age period is imperative. In addition, as a result of the prevalent use of smartphones among university students and the ability to incorporate BCTs into apps, there is a large potential benefit of incorporating an app that encourages less SB. Yet, it is also important to understand the underlying behaviour change potential in SB apps as they exist currently.

Purpose and Research Questions

The purpose of this study was two-fold. The first aim was review smartphone apps designed to reduce sedentary/sitting time for the presence of BCTs. Specifically, we aimed to compare BCTs coded as present: 1) between apps from the iTunes (i.e., for iPhones) and Google Play (i.e., for Androids) store, 2) between free and paid apps, and 3) with different coding strategies (i.e., coding 'by description' and coding 'by use'). The second aim was to gain an understanding of university students' SB, PA and experiences with apps, and trial an SB app as a pilot intervention in this population. The specific research questions were: (1) what are the levels of university students' SB and PA and is there a relationship between levels of SB and PA?, (2) What is students' knowledge of SB and PA, as distinct but related behaviours?, (3) What have students' experiences been with SB or PA apps?, (4) What are students' perceptions of features (BCTs) that would be critical for them in a SB app? (5) What is the impact of using (trialing) a SB app? The first purpose is addressed in Part 1 (Chapter 2), and the second purpose and specific research questions are addressed in Part 2 (Chapter 3).

Chapter 2: Behaviour Change Techniques in Mobile Apps for Sedentary Behaviour (Part 1)[1]

Purpose

The purpose of Part 1 was to review mobile apps designed to reduce sedentary/sitting time for the presence of BCTs. Specifically, we aimed to compare BCTs coded as present: 1) between apps from the iTunes (i.e., for iPhones) and Google Play (i.e., for Androids) store, 2) between free and paid apps, and 3) with different coding strategies (i.e., coding 'by description' and coding 'by use').

Methods

Search strategy.

Systematic searches of the iTunes App store for iPhone apps and Google Play Marketplace for Android apps were completed using 10 keyword searches. Search terms included "sitting", "sit", "stand", "standing", "stand up", "sedentary", "break", "exercise break", "PA break", and "move". Although the search terms were consistent between the iTunes App store and Google Play Marketplace, the search strategy was slightly different for the iTunes and Google Play as they employed different search algorithms as previously noted by Middelweerd et al. (2014). The iTunes store displays a maximum of 100 apps for each search. A total of 815 iPhone apps were obtained with the keyword searches in iTunes. For Google Play, more search results are obtained, therefore, as per the search performed by Middelweerd et al. (2014), the first 100 apps were screened for inclusion. If at least five of those 100 apps met the criteria, the next 100 apps were also

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screened. If one app met the criteria within these second 100 apps, then the next 100 apps were also screened. This continued until no additional apps were selected in a group of 100 apps. A total of 1400 Android apps were obtained with all the keyword searches in Google Play. Following the search, all apps (n=2215) were screened in one step for inclusion criteria by title, picture, and description by the researcher (ED). A total of 2165 apps were removed, and thus a total of 50 apps remained to be coded (see Figure 2.1).

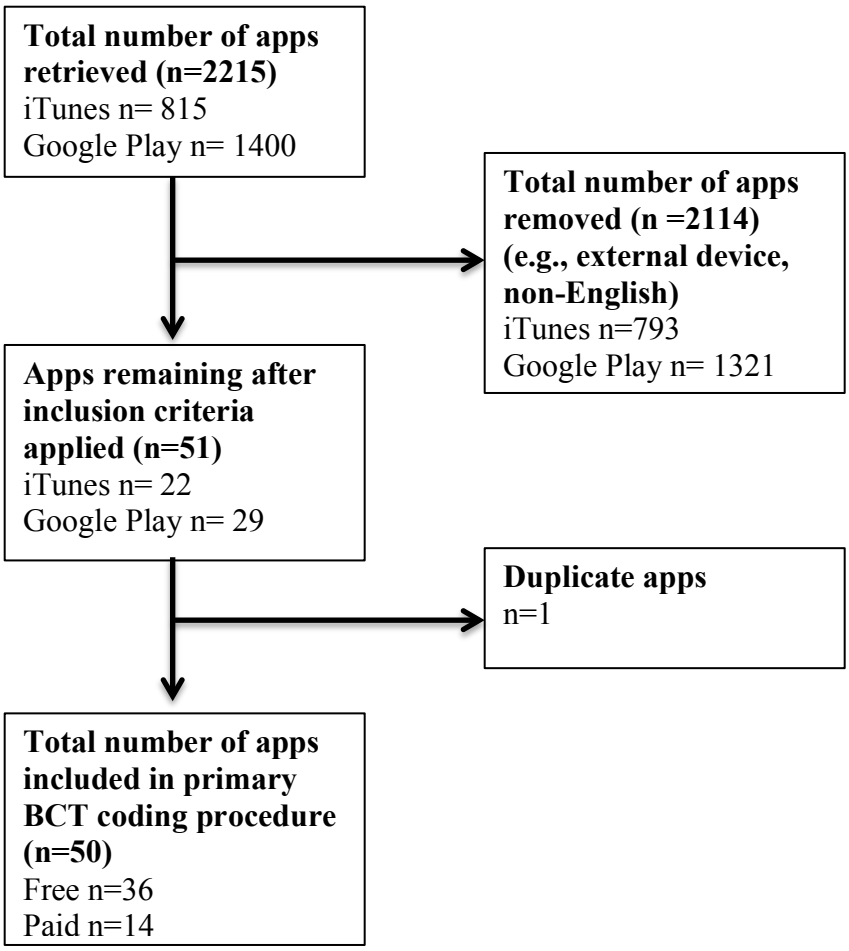


Figure 2.1. Flow chart of systematic search of the app stores

Inclusion criteria.

To be included, the app must have been: 1) related to SB with a goal of disrupting sitting time, with or without providing suggestions of what to do during these interruptions, 2) compatible for mobile smartphones (i.e., not exclusively for iPads or desktops), 3) available in English, and 4) not associated with an external device (e.g., Fitbit® device).

Primary coding process.

The taxonomy that was used to code the apps distinguishes between 93 BCTs (BCTTv1) (Michie et al., 2013). The apps identified in the search that meet the inclusion criteria were scored as present or not present for each of the 93 BCTs independently by two reviewers (ED, JRW). Both reviewers completed online certifications for BCT coding using the BCTTv1 training. Apps were only coded for the presence of BCTs related to SB. The app could have had other features not related to SB (e.g., water intake) that were not coded.

Two reviewers first coded all the free apps (n=36) based on their descriptions. A third reviewer who is a trained, experienced coder (HG) was consulted to address the app coding issues that arose between the two reviewers. A set of coding rules was developed to address these issues (see Table A1 in Appendix A). The two initial reviewers then re-coded the apps in question, implementing the set of coding rules and any remaining coding issues were resolved through discussion between the three reviewers.

Paid apps (n=14) were then coded by description, implementing the developed set of rules as well. The third reviewer was again consulted with to resolve disagreements. There were four apps that had a free and paid version.

Secondary coding process.

Based on the primary coding process for free and paid apps (described above), a subsample (n=4) of free iTunes apps with the greatest number of BCTs coded in the description were downloaded and used for one week (February 8th to the 15th, 2017) by two reviewers (ED, JRW). These apps were Rise & Recharge®, Standland®, Sitting®, and Stand Up®. After the week, the apps were coded for the presence of BCTs. Reviewers took screenshots of the apps as evidence for identifying the BCT. New issues with coding 'by use' arose and the third reviewer (HG) was consulted again. The two reviewers then recoded the apps in question and any remaining issues were resolved through discussion.

Statistical Analysis

A Cohen's kappa statistic (Landis & Koch, 1977) and PABAK (Byrt, Bishop, & Carlin, 1993) statistic were calculated as a measure of inter-rater reliability for the initial round of coding (i.e., before the third reviewer was consulted) for apps coded 'by description' and 'by use'. PABAK was used to adjust for bias and high prevalence of negative cases between reviewers (i.e., both coded 'not present') (Byrt et al., 1993). The PABAK has been previously used to describe agreement between reviewers using the BCTTv1 to code interventions (Cradock et al., 2017; Wood et al., 2006). Inter-rater reliability values of .61–.80 indicate 'substantial' reliability, and those above .80 would be considered 'outstanding' (Landis & Koch, 1977; Cradock et al., 2017).

Descriptive and frequency statistics were performed to describe the BCTs coded, obtain mean BCTs coded, mean price for paid apps, and mean Cohen's kappa and PABAK scores. Independent t-tests were performed to compare mean BCTs and mean

word count between free and paid apps and between iPhone and Android apps. Since there was only one duplicate between app stores, a t-test was performed to examine if users who have iPhones or Androids are exposed to apps with different BCTs. Statistical analyses were performed on SPSS Version 24.

Results

Inter-rater agreement.

The overall average kappa score across both primary (free n=34; paid n=14) and secondary coding (n=4) was 0.60 and PABAK score was 0.96. These scores indicate substantial and outstanding agreement, respectively (Landis & Koch, 1977).

BCTs.

See Table A2 in Appendix A for a comprehensive list of BCTs present in each free and paid app in the iTunes and Google Play stores. In the descriptions, only 10 of a potential 93 BCTs were present. A mean of 2.42 BCTs (range 0-6) were present in each app description. The three BCTs that were coded the most frequently include "prompts/cues" (n=43), "information about health consequences" (n=31), and "self-monitoring of behaviour" (n=17) (see Table 2.1 and Figure 2.2).

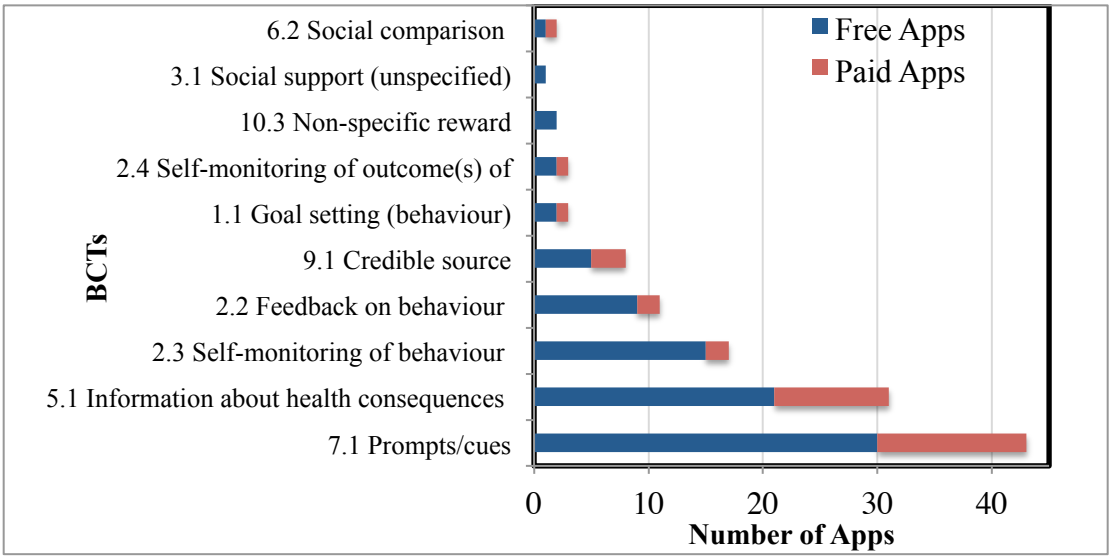


Figure 2.2. Number of apps with BCT present

Table 2.1. Frequency of BCTs Coded as Present in Description

BCT	Free Apps	Paid Apps	Total
Prompts/cues	30	13	43
Information about health consequences	21	10	31
Self-monitoring of behaviour	15	2	17
Feedback on behaviour	9	2	11
Credible source	5	3	8
Goal setting (behaviour)	2	1	3
Self-monitoring of outcome(s) of behaviour	2	1	3
Non-specific reward	2	0	2
Social support (unspecified)	1	0	1
Social comparison	1	1	2

There was a difference in number of BCTs present between apps for iPhones and Androids (t(48)=2.67, p=0.01), where iPhones apps (n=22) had an average of 3 BCTs per apps and Android apps (n=28) had an average of 1.96 BCTs. However, there was no difference in number of BCTs present in free (M=2.44, SD=1.42) and paid app (M=2.36, SD=1.55) descriptions (t(48)=0.19, p=0.85). The average price of the paid apps was $1.90 (SD=0.980). The average word count of the descriptions was 226.36 words (SD=133.70). There was no statistically significant difference in word count between

apps for iPhones and Androids (t(48)=1.466, *p*=0.149), where iPhone apps (n=22) had an average of 257.27 words per description and Android apps (n=28) had an average of 202.07 words per descriptions. There was also no statistically significant difference in word count between free and paid apps (t(48)=-1.890, *p*=0.065), where free apps (n=36) had an average of 204.64 words per description and paid apps (n=14) had an average of 282.21 words per description.

Several differences emerged in the actual BCTs coded 'by use' (see Table 2.2). Specifically, there were 3 BCTs coded that were previously not coded in the descriptions: "graded tasks", "focus on past successes", and "behaviour substitution". Thus by coding 'by use', there were 13 out a potential 93 BCTs identified. The BCTs "information on health consequences", "credible source", and "self-monitoring of outcome of behaviour" were present in descriptions, but not in 'by use' coding.

Table 2.2. Apps Coded 'By Description' and 'By Use'

App	BCTs by Description	BCTs by Use
Stand Land (App 9)	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 3.1 Social support (unspecified) **5.1 Information about health consequences** 10.3 Non-specific reward	**1.1 Goal-Setting (behaviour)/ "stands"** 2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 3.1 Social support (unspecified) **8.7 Graded tasks** 10.3 Non-specific reward **15.3 Focus on past successes**
Rise & Recharge (App 10)	1.1 Goal setting (behaviour) 2.3 Self-monitoring of behaviour 5.1 Information on health consequences 7.1 Prompts/cues **9.1 Credible source** 10.3 Non-specific reward	1.1 Goal-Setting (behaviour) **2.2 Feedback on behaviour** 2.3 Self-monitoring of behaviour 5.1 Info on health consequences 7.1 Prompts/cues **8.2 Behaviour substitution** 10.3 Non-specific reward

Sitting (App 3)	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour **5.1 Information about health consequences** 7.1 Prompts/cues	**1.1 Goal-Setting (behaviour)** 2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 7.1 Prompts/cues
Stand Up (App 8)	1.1 Goal setting (behaviour) 2.3 Self-monitoring of behaviour **2.4 Self-monitoring of outcome(s) of behaviour** 5.1 Information about health consequences 7.1 Prompts/cues 9.1 Credible source	1.1 Goal-setting (behaviour) **2.2 Feedback behaviour** 2.3 Self-monitoring of behaviour 5.1 Information about health consequences 7.1 Prompts/cue 9.1 Credible source

[a] Bolded BCTs indicate discrepancies between coding 'by description' and 'by use'

Discussion

The purpose of the current study was to code and compare mobile apps designed to reduce sedentary/sitting time for the presence of BCTs. Compared to PA apps coded previously (Conroy et al., 2014; Middelweerd et al., 2014; Yang et al., 2015), there were substantial differences in the BCTs coded for apps for SB presently. Overall, the SB apps in this review contained fewer BCTs on average, a smaller range of BCTs per app, and fewer BCTs were identified overall. As well, the most prevalent BCT coded in this review was "prompts/cues", whereas the most prevalent BCTs coded in Yang et al.'s (2015), Conroy et al.'s (2014), and Middelweerd et al.'s (2014) reviews were "social support (unspecified)", "provide instruction on how to provide behaviour", and "provide feedback on performance", respectively.

One reason for these discrepancies could be due to the differences in taxonomies used by Conroy et al. (2014) and Middelweerd et al. (2014). However, Yang et al. (2015) used the same 93-BCT taxonomy implemented here and coded 39 BCTs present in 100

PA apps. A second reason for these discrepancies reflects different strategies employed by app developers for PA compared to SB apps. Explicitly, apps for PA appear to employ more behaviour change strategies compared to apps for SB. In addition, the SB apps reviewed here also contained fewer BCTs compared to traditional (i.e., non-app) PA and healthy eating interventions coded previously (Michie, Abraham, Whittington, McAteer, & Gupta,, 2009). At this time, interventions would benefit from using SB apps in conjunction with other behaviour change methods (i.e., as part of a multi-component, theory-based intervention). As preliminary findings from Schoeppe et al. (2016) suggests, apps that are used in multi-component interventions for PA appear to result in better behavioural and health outcomes than stand-alone app interventions. Although determining the stand-alone impact of apps in multi-component studies is challenging, based on the lack of BCTs, SB apps in their current form may be insufficient for changing behaviour on their own. In order to implement SB apps as independent interventions, and as per recent recommendations from Schoeppe et al. (2016), further investigation is warranted to "determine the optimal number and combination of app features, BCTs, and level of participant contact needed to maximize user engagement and ultimately intervention efficacy" (p.23). As well, as suggested by Direito et al. (2014), to maximize the effectiveness of apps, app developers should be provided with guidance in incorporating BCTs to include in their apps.

Coding challenges.

The challenges of the present study mirror the current debate about how PA, physical inactivity, and SB fit together and how they should be approached through intervention (Spence et al., 2017). An issue that arose frequently in the coding process

was appropriate coding for the behaviour of interest (i.e., sitting). For example, in the apps coded 'by use', all four apps had "goal-setting (behaviour)" present but the actual goal varied from number of stands, breaks (consisting of 15 steps), sitting minutes, or standing minutes. Most of these goals are not specific to sitting, but involve the opposite behaviour (i.e., not sitting). However, "not sitting" can involve PA behaviours ranging in intensity from light (e.g., standing, slow walking) to moderate-to-vigorous (e.g., running, squats, push-ups) (Spence et al., 2017). Thus, in order to keep the BCTs centered around sitting, we chose to clarify that in order to code "goal-setting (behaviour)" the app could have had a goal opposite of sitting (e.g., minutes spent standing) but not a goal that specified moderate-to-vigorous PA (MVPA).

These challenges reflect current consideration of what is called the "dual-hinge approach" which Spence et al. (2017) describe as substituting SB with MVPA. As seen with the "goal-setting (behaviour)" BCT, some of these apps employ the dual-hinge approach, which makes coding challenging because the BCTs are supposed to be specific to the behaviour of interest (i.e., sitting) and not PA. Along with recommendations from Spence et al. (2017) for SB interventions, this should also be taken into consideration for coding apps. Although MVPA substitution-based interventions may result in more significant health outcome benefits (Spence et al., 2017), interventions specific to SB are more effective for decreasing sitting time (Prince et al., 2014).

As well, the discrepancies that existed between coding 'by description' and coding 'by use' were the result of inaccurate app descriptions or app functions not working. Therefore, just because a BCT is present in the app description, it may not actually be present as a BCT for use. As previously noted by Cowan et al. (2012), since

apps developers are using app descriptions as a marketing platform to sell their apps, the app descriptions alone might not adequately represent the content and functionality of the app. These challenges are important to consider for future app coding projects.

Limitations.

The findings presented here should be considered within the context of several limitations. Most importantly, as noted by Middelweerd et al. (2014), BCT taxonomies were not designed to score app-based interventions, and therefore interpreting BCTs as app functionalities may result in biases while coding, which potentially complicates comparing to other studies that coded apps with BCT taxonomies. As well, each previous app coding study has used a different taxonomy for coding which further complicates comparing the BCTs coded between studies. Despite the comprehensiveness of the systematic search of the app stores, some apps may still have not been identified because they were missed in the search process or had a poor description. As well, missing are a small subset of apps that are designed to support external devices (e.g., Fitibit®). Furthermore, only four apps were coded by trialing, therefore the majority of coding presented here reflects the app descriptions only.

Implications and future research.

Overall, the present study contributes to understanding the behaviour change potential in mobile apps for SB, which can inform researchers designing SB interventions that utilize apps and developers in app design. Most importantly, the SB apps in this present study have fewer BCTs than PA apps and traditional interventions. Despite this, due to the pervasiveness of mobile phones, apps can still be a useful way to influence the habitual nature of SB.

Moving forward, in line with previous recommendations (Cowan et al., 2012), health behaviour change specialists should look to work with app developers in creating apps based in theory. Based on the present review, some suggestions to consider in future collaborative investigations are that SB apps should look to incorporate more BCTs, or, in their current form, sedentary apps could be utilized in multi-component interventions to increase effectiveness. As well, apps should avoid promoting the replacement of SB with MVPA (the dual-hinge approach), and focus on strategies that relate specifically to SB.

Chapter 3: Sedentary Behaviour, Physical Activity, and Mobile Apps in University Students (Part 2)

Purpose

The purpose of this study was to gain an understanding of university students' SB, PA and experiences with apps, and trial an SB app as a pilot intervention in this population. The specific research questions are: (1) what are the levels of university students' SB and PA and is there a relationship between levels of SB and PA?; (2) What is students' knowledge of SB and PA, as distinct but related behaviours?; (3) What have students' experiences been with SB or PA apps?; (4) What are students' perceptions of features (BCTs) that would be critical for them in a SB app?; (5) What is the impact of using (trialing) a SB app? The first purpose is addressed in Part 1, and the second purpose and specific research questions are addressed in Part 2.

Methods

Part 2A. Survey.

Population and recruitment.

Participants were undergraduate university students from Wilfrid Laurier University (WLU) aged 17-24 years, who owned and used a smartphone, and did not have a mobility impairment that would limit standing and walking. Participants were recruited through posters displayed on campus, online posts in Facebook® groups for undergraduate students, and brief presentations by the primary investigator in undergraduate classes. Students were informed that after completing the survey, they would be entered into a draw to win a $25 gift certificate to the WLU bookstore.

Ethics.

This study was approved by the review ethics board at Wilfrid Laurier University (REB#5086). Participants provided consent by selecting an option to the first multiple-choice question in the survey (see Appendix B). Participants were granted access to the survey if they selected option 1 (consent to participate and have quotes used) or option 2 (consent to participate but not have quotes used). If participants did not answer this question, or selected option 3 (decline to participate) they were not granted access to the survey. Participants were asked to create an ID code and this was used to match their survey response from Part 2A to Part 2B (see below).

Protocol.

The initial survey was administered online via SurveyMonkey® and was composed of three parts: 1) demographic questions (e.g., sex, age, year of study), 2) the short-version of the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003) a modified version the Sedentary Behavior Questionnaire (SBQ) (Prapavessis, Gaston, & DeJesus, 2015), and 4) questions about students' knowledge of PA and SB, experiences with PA/SB apps, and perceptions of what features (BCTs) would be vital in a SB app.

The short version of the IPAQ was used to address levels of PA. This version included two items, frequency (number of days) and duration (minutes per day), for three different physical activity intensities: walking, moderate-intensity activities and vigorous intensity activities. The IPAQ also included a question of time spent sitting, but since it only addressed sitting time for a weekday (i.e., during the last 7 days, how much time did you spend sitting on a week day), one additional question was added from the long

version of the IPAQ that addressed estimated sitting time on a weekend day (i.e., during the last 7 days, how much time did you spend sitting on a weekend day (i.e., Saturday or Sunday). The IPAQ responses were computed into a composite, continuous score. For the IPAQ, a composite score for walking, moderate-intensity, and vigorous-intensity activity was computed as a measure of metabolic equivalents (MET)-minutes per week, as well as a total leisure time MET-minutes per week. The equations are the following (1) walking MET-minutes/week leisure = (3.3 x walking minutes x walking days in leisure) (2) moderate MET-minutes/week leisure = (4.0 x moderate-intensity activity minutes x moderate-intensity days in leisure) (3) vigorous MET-minutes/week leisure = (8.0 x vigorous-intensity activity minutes x vigorous-intensity days in leisure) and (4) total Leisure-Time MET-minutes/week = ∑Walking + Moderate + Vigorous MET-minutes/week scores in leisure.

The results from the IPAQ were also used to categorize respondents into categories of 'health-enhancing physically active' ('HEPA active'), 'minimally' or 'sufficiently' active, and 'inactive' (IPAQ, 2004). To be classified as 'HEPA active', participants must have reported "vigorous-intensity activity on at least 3 days achieving a minimum of at least 1500 MET-minutes/week OR 7 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week". To be classified as 'minimally active' participants must have reported "3 or more days of vigorous activity of at least 20 minutes per day OR 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day OR 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 600 MET-min/week." Finally, if a participant

did not qualify for either 'HEPA active' or 'minimally active', they are were considered 'inactive' (IPAQ, 2004).

The IPAQ-short has demonstrated acceptable test-retest reliability (Craig, et al., 2003), however, validation studies demonstrated "negligible to small correlations in total PA level with objective measuring devices (correlation range of ρ=0.09 to 0.39)" (Lee, Macfarlane, Lam, & Stewart, 2011, p. 4). Despite the poor concurrent validity of the IPAQ short-form, all self-report tools are flawed in accuracy compared to objective measures (Welk, 2002; Atkin et al., 2014). The IPAQ best met the goal of the present study as it provided concise information on the intensities of PA and continuous and categorical measures.

To address domain-related information for SB, a modified version SBQ, used by Prapavessis et al. (2015) in a sample of university students was adopted for this study. There were 12 domain specific sedentary pursuits (e.g., sitting for work, watching TV) that participants selected a fixed duration of time for each (e.g., none, 15 min or less, 30 min, 1 hour, 2 hours). This was done separately for weekdays and weekend days. In comparison to the original, Prapavessis et al. (2015) modified the SBQ by adding 2 more sedentary pursuits (i.e., eating and sitting for religious or spiritual pursuits) and additional duration response options (i.e. 7 h, 8 h, or 9 h or more). The SBQ responses were also computed into a composite, continuous score. The SBQ average daily score is reported in hours and was calculated using the following: $[(\sum 12 \text{ weekday items} \times 5) + (\sum 12 \text{ weekend items} \times 2)]/7$. Weekday and weekend totals were also calculated separately.

The original SBQ has demonstrated acceptable test-retest reliability (Rosenberg, et al., 2010). The validity has been shown to being low when compared to objective

accelerometer measures and other subjective measures of SB (criterion validity), but there is high construct validity with association with BMI (Rosenberg et al., 2010). As the IPAQ, the SBQ best met the goal of the present study, with its confines.

Refer to the Appendix B for the complete survey including demographic questions, IPAQ, SBQ, questions relating to knowledge of PA and SB, and app experiences and preferences.

Data cleaning.

i. Participants.

There were 270 eligible responses to the survey, however 93 respondents were excluded for failing to provide adequate information. Participants were excluded if their survey responses were incomplete beyond informed consent (n=57), demographic information (n=14), the IPAQ (n=17), or the SBQ (n=5). There were 177 participants who provided complete responses. See Figure C1 Appendix C for completion flow chart.

ii. IPAQ.

Four participants were removed from the IPAQ analysis for composite scores of 0 or incomplete data. Two more participants were removed as they were identified as outliers, as the IPAQ composite z-score fell outside of three standard deviations from the mean (Field, 2009). Thus there were 171 participants included in the analysis of IPAQ composite scores. The distribution of IPAQ composite scores was highly positively skewed (1.60) and leptokurtic (2.73). The skewness and kurtosis, divided by the standard error of each respectively, were above 1.96, indicating that the data were non-normal (Rose, Spinks, Canhoto, 2015). The IPAQ composite scores were transformed using the logarithmic, square root, and reciprocal methods. However, none of the transformations

were able to correct the non-normal distribution, and thus the original data were used. As per recommendations, given that a non-normal distribution of energy-expenditure is typical in many populations, the median values are reported as the measure of central tendency (IPAQ, 2004).

iii. SBQ.

Eleven participants were removed from the SBQ analysis for composite scores above 24 hours. There were no identified outliers based on transformed z-scores. For 18 participants the SBQ composite was not calculated due to incomplete data. The distribution of SBQ composite scores was only slightly positively skewed (.339) and platykurtic (-.710). The skewness and kurtosis, divided by the standard error of each respectively, were below 1.96, indicating that the departure from normality was not extreme (Rose et al., 2015).

iv. Weekday and weekend.

For the analysis between the IPAQ sitting questions and SBQ, separate data cleaning was also performed for the weekday and weekend values. One participant's data were removed from the IPAQ weekend for a score above 24 hours. Two outliers in each the weekday and weekend distributions were identified via z-score transformations and removed. The weekday and weekend distributions were both not normally distributed based on skewness and kurtosis (i.e., values above 1.96 when divided by standard error). Square root transformations were able to correct the distributions (i.e., skewness and kurtosis values below 1.96 when divided by standard error).

Twelve participants were removed from the SBQ weekday composite and 21 from the weekend composite for scores above 24 hours. There were no outliers identified

based on z-score transformations. Again, the weekday and weekend distributions were both not normally distributed based on skewness and kurtosis (i.e., values above 1.96 when divided by standard error), but square root transformations were able to correct the distributions (i.e., values below 1.96 when divided by standard error).

Statistical analysis.

To compare demographic information between those who did not provide information beyond demographics (n=36) and those who had compete responses (n=177), independent t-tests were performed for age, BMI, and hours of class. Chi square analyses were performed for gender, year of study, full-time/part-time, and on/off campus living.

To address the first research question, descriptive statistics were performed to describe the participants demographically, as well as by the level of PA (IPAQ) and SB (SBQ). The IPAQ data were used to determine if the participant met the Canadian PA guidelines (i.e., 150 minutes of MVPA/week). This was computed using the following equation=(vigorous days x vigorous-intensity activity minutes) + (moderate days x moderate-intensity activity minutes). A one-way ANOVA was performed to compare three IPAQ categories (‘HEPA active’, ‘minimally active’ and ‘inactive’) on the continuous score of SBQ. Correlational statistics were used to assess the relationship between the composite scores of PA (IPAQ) and SB (SB). Due to the non-normal distribution of the IPAQ data, the non-parametric alternative (Spearman’s rank correlation) was also performed. Correlational statistics were also used to assess the relationship between composite scores of SBQ and IPAQ sitting questions for the weekday and weekend respectively. Since the distributions could be corrected via square root transformations, the parametric correlation (Pearson’s test) was performed.

However, for as a comparative measure the non-parametric alternative (Spearman's rank-order) was also performed using the non-transformed data.

To address the second, third, and fourth research questions, a content analysis of open-ended questions and descriptive statistics (e.g., multiple choice, Likert-scale questions) were performed for questions regarding app experiences and feature preferences.

Part 2B. App Trial.

Population and recruitment.

Upon completing the initial survey, participants were recruited to participate in the app trial. Participants must have had an iPhone or Android smartphone that supported the selected app. Students were informed that in addition to being entered into the original gift certificate draw, if they participated in Part 2B, they would be entered into another draw to win a $50 gift certificate to the WLU bookstore. Participants must have provided an email address to which the primary researcher could send another survey to. The email addresses were removed from the data file after the survey had closed. The participant created ID was used to match their survey response from Part 2A to Part 2B. Upon obtaining consent, participants were randomly assigned to the trial group or the control group.

Protocol.

Students assigned to the trial group were asked to download and use the app Rise & Recharge® for 2 weeks. This app was selected based on the results from Part 1. This app had the most BCTs based on 'by description coding' and was available for free on both the iTunes (iPhones) and Google Play (Android) stores (see Chapter 2). The app

utilizes the accelerometer on a smartphone via the Health app for iTunes and Google Fit apps for Android. It sends notifications at user-defined time intervals and tracks when the user has taken a break (i.e., 15 steps). The default time interval for a break is 30 minutes. There were no specific instructions given on how they should use the app; participants were told to use the app as best fits their lifestyle. After the 2-week trial, participants were emailed another online survey via Survey Monkey® that consisted of the IPAQ and SBQ again, as well as 13 additional questions assessing their experience with the app. Since it has been noted that there exists limited research on the behaviour change effectiveness of apps (Miller et al., 2015), the survey addressed an individual's perceptions of the influence the app had on his or her behaviour. As well, questions with respect to preferences about the app including ease of use, frequency of use, and acceptability of the app were included. Refer to the Appendix B for the Exit Survey.

Participants randomized to the control group were not informed of the trial group. They were told they would be sent another survey in 2 weeks with additional questions about their PA, SB, and use of mobile apps. After 2 weeks, participants in the control group were emailed another online survey via Survey Monkey® that only consisted of the IPAQ and SBQ.

Timeline.

The initial survey was available on SurveyMonkey® for 4 weeks from November 1st for to November 29th, 2016. Randomization and app trialing occurred in a rolling fashion. Thus, after completing the initial survey, consenting participants were immediately randomly assigned into the app trial group or into the control group. Refer to Figure 3.1 below for a flow chart of both components of Part 2.

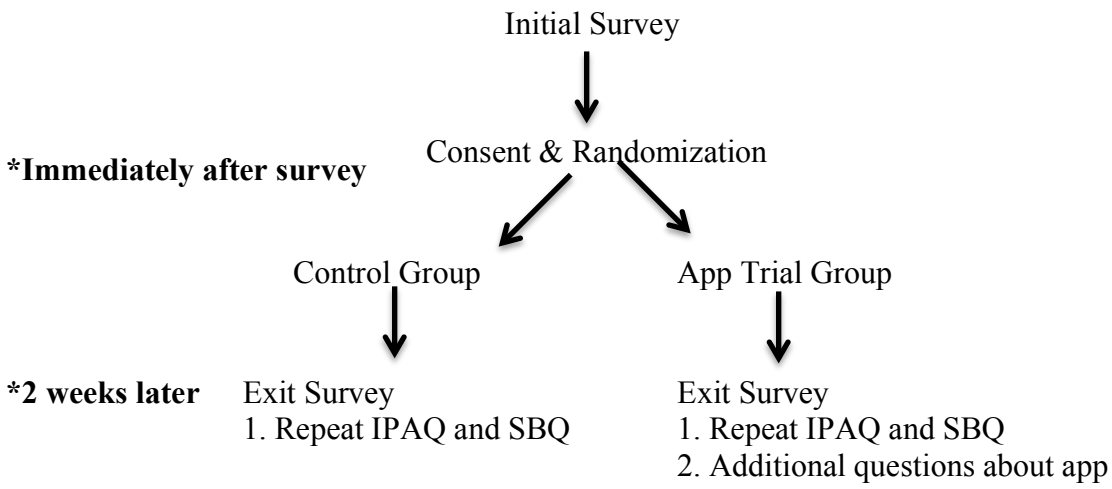


Figure 3.1. Flow Chart of Study Sequence

Data cleaning.

i. Participants.

Of the participants who completed the first survey, 140 chose to participate in part 2 and were randomized into either the trial group (n=65) or control group (n=75). After randomization, 12 participants randomized to the trial group declined to participate and 1 participant randomized to the control did not provide an email address. Thus, at 'time 1' there were 53 participants in the trial group and 73 in the control group. For 'time 2', 21 participants in the trial group and 40 in the control group completed the second survey. Three participants from the trial group and three from the control group were removed because the participant created ID's could not be matched from the initial survey and they did not answer the open-ended questions about the app experience. Thus, 18 participants were kept in the analysis for the trial group and 37 for the control group. There were two participants in the trial group and two in the control group that answered the IPAQ and/or SBQ but not the additional questions but were kept in the analysis for the repeated measure ANOVA. Additionally, there was one participant in the trial group and three in

the control group whose ID could not be matched, but provided answers to the additional questions and thus, was kept in the analysis for content analysis of those questions. See Appendix C for completion flow chart.

ii. IPAQ.

'Time 1' and 'time 2' IPAQ data were available for 16 participants in the trial group and 35 in the control group. Based on visual inspection and skewness and kurtosis statistics, the respective trial and control groups' data for 'time 1' and 'time 2' were not normally distributed. Based on a z-score transformation, there were 2 outliers removed from the control group for being 3 standard deviations above the mean. In an attempt to make the distribution normal, the IPAQ composite-scores were transformed via logarithmic, square root, and reciprocal methods. The resulting square root and reciprocal distributions were still considered non-normal based on skewness and kurtosis statistics. The logarithmic transformation was able to make the distribution normal based on the skewness and kurtosis statistics, with the exception of the kurtosis within the trial group for 'time 2' (i.e., kurtosis divided by standard error or kurtosis was greater than 1.96). As such, the results should be interpreted with caution as the assumption of normality was violated for this one group.

iii. SBQ.

There was 'time 1' and 'time 2' SBQ data for 11 participants in the trial group and 24 in the control group. 'Time 1' and 'time 2' data for the respective trial and control groups were considered normally distributed based on visual inspection, and skewness and kurtosis statistics. There were no outliers identified based on z-score transformations.

Statistical analysis.

To compare demographic information between those in the trial group and those in the control group, independent t-tests were performed for age, BMI, and hours of class, and chi square analyses were performed for gender, year of study, full-time/part-time, and on/off campus living.

To address changes in the IPAQ and SBQ composite scores, respective two-way mixed repeated measures ANOVAs were performed. An additional two-way mixed repeated measures ANOVA was performed using the log-transformed IPAQ composite scores. The questions regarding the app experience in the exit survey were analyzed via a content analysis of open-ended questions and descriptive statistics (e.g., multiple choice, Likert-scale questions).

Finally, a content analysis of open-ended questions and descriptive statistics (e.g., multiple choice, Likert-scale questions) were performed for the additional questions in the exit survey for the trial group about ease of use, frequency of use, and acceptability of the app were included.

Results

Part 2A. Survey.

Demographics.

Participants were mostly female (n=132, 75%), full time students (n= 173, 97.7%), and in first year (n=105, 59.3%). The mean age was 18.86 (SD=1.38), mean BMI was 22.73 (SD=3.48), and mean hours of class per week was 16.45 (SD=5.07). The majority of participants were from the departments housed in Science (n=74, 41.8%), Business and Economics (n=59, 33.33%), or Arts (n=41, 23.2%). Most participants lived

off-campus (n=113, 63.8%), and the most frequent method of transportation to campus was walking (n=90, 63.4%). For those who most frequently walked (n=90), the average length of walk to campus was 7.62 minutes (SD= 4.73). See Table 3.1 for a demographic summary.

There were no significant differences (p>.05) found between the groups for any of demographic variables. See Table C1 in Appendix C for test-statistics. The department of study was not analyzed, as there was several cell counts below 5 due to some departments having only 1 participant.

Table 3.1. Demographic Summary (n=177)

Age (n=177)	*M*=18.86, SD= 1.375 Range 17-24
Gender (n=176)	Female n=132 Male n= 44
BMI (n=170)	*M*= 22.73, SD= 3.48 Range= 15.93-36.83 Underweight (<18.5)- n=11 Normal weight (18.5-24.9)- n=120 Overweight (25.0-29.9)- n=33 Obese (30-34.9)- n=6
Year of study (n=177)	1- n=105, 59.3% 2- n=33, 18.6% 3- n=13, 7.3% 4- n=23, 13.0% 5- n=3, 1.7%
Full time/part time (n=176)	Full time n=173, 97.7% Part time n=3, 1.7%
Department (n=177)	Science n=74, 41.8% Business & Economics n=59, 33.33% Arts n=41, 23.2% Social Work n=1, 0.6% Music n=1, 0.6% Seminary n=1, 0.6%
On/Off campus (n=177)	On n=64, 36.2% Off n= 113, 63.8%
Most frequent mode of transportation (n=142)	Walk n=90, 63.4% Public Transit n=26, 18.3% Drive n=15, 10.6%

	Bike n=2, 1.4% 'Tied' (e.g., walk/bike equal # of days to campus) n=9, 6.3%
Minutes to campus for students whose most frequent mode of transportation is walking (n=90)	*M*= 7.62, SD=4.73 Range 0-20
Hours of class (n= 148)	*M*= 16.45, SD= 5.07 Range 0-40

IPAQ & SBQ.

The median IPAQ score was 1506.0 MET-minutes/week (SD=1722.52, minimum=66.0, maximum=8532.0). Based on the IPAQ categorical definitions, 32.2% were 'HEPA active' (n=57), 51.4% were 'minimally active' (n=91), and 16.4% were 'inactive' (n=29). Based on the Canadian guidelines for adults (150 min/week of MVPA), 46.3% (n=82) met the guidelines and 52.5% (n=93) did not.

The mean SBQ composite score was 14.12 hours/day (SD=4.23, minimum=5.82, maximum=24.00). The weekday domains that had the highest report hours were 'sitting for work of school' (*M*=5.13, SD=1.9), 'using the computer for recreational purposes' (*M*=1.79, SD=1.33), and 'socializing' (*M*=1.69, SD=2.20). The weekend domains that had the highest report hours were 'sitting for work or school' (*M*=3.54, SD=2.20), 'socializing' (*M*=2.52, SD=1.83), and 'using the computer for recreational purposes' (*M*=2.46, SD=1.80). See Table C2 Appendix C for descriptive statistics of all domains for the weekday and weekend. The IPAQ composite and SBQ composite scores were not significantly correlated (r_S=0.048, *p*=0.567) based on Spearman's rank correlation of 143 observations. There was no statistically significant relationship between IPAQ categories 'HEPA active', 'minimally active', or 'inactive', and the SBQ composite score (F(2,145)=0.02, *p*=0.99).

Pearson's correlation determined a small positive correlation between SBQ weekday composite and IPAQ sitting questions for weekday (r=0.186, p=0.02, n=150) and a small positive correlation between SBQ weekend composite and IPAQ sitting question for weekend (r=0.252, p=0.003, n=141). Spearman's rank-order correlations determined the small significant correlations for weekday (r_S=0.200, p=0.014) and weekend (r_S= 0.227, p=0.007). The mean SBQ weekday was 13.62 hours/day and IPAQ weekday 6.93 hours/day, and the mean SBQ weekend was 14.48 hours/day and IPAQ weekend was 6.61 hours/day.

Knowledge.

Based on open-ended responses, the majority of participants (n=117, 66.1%) did not know, or were unsure what the PA guidelines were for their age group. The true or false questions (see Appendix B, Primary Survey, Question 24) addressed the knowledge of participants on the relationship between SB and PA. Nine participants' responses were removed from the analysis for selecting either all 'true' or 'false' responses, as it indicated that the respondent has contradictory answers. Most participants responded true to the statement "if I meet the PA guidelines, should still try to limit my sitting time during the day" (n=135, 83.9%) and "if I don't meet the PA guidelines, I should try to limit my sitting time during the day" (n=142, 89.31%). Fewer participants responded true to "if I meet the PA guidelines, I can sit for most of the day" (n=28, 17.83%) and "if I don't meet the PA guidelines, I can still sit for most the day" (n=22, 14.19%). See Table 3.2 for frequency of true/false for each statement.

Table 3.2. Frequency of Responses to True/False Knowledge Question

Statement	True	False
If I meet the physical activity guidelines, I can sit for most the day (n=157)	n=28	n=129
If I meet the physical activity guidelines, I should still try to limit my sitting time during the day (n=161)	n=135	n=16
If I don't meet the physical activity guidelines, I should try to limit my sitting time during the day (n=159)	n=142	n=17
If I don't meet the physical activity guidelines, I can still sit for most of the day (n=155)	n=22	n=133

App experiences.

Seventy-two participants (40.9%) reported a previous experience with a SB or PA app. The most frequently reported apps used were the Fitbit® app (n=18), MyFitnessPal (n=14), and a Nike+ app (n=12). The most popular features that participants reported liking (open-ended response, question 27) were tracking of PA (e.g., steps, distance traveled) (n=41), tracking calories and/or food intake (n=24), and providing workouts/exercises (n=18). The most common reasons reported for starting to use the app (open ended response, question 28) were that it was app associated to an external device/equipment (e.g., Fitbit® device) (n=8), it was already installed on their smartphone (e.g., Apple Health) (n= 8), and they wanted to lose weight/achieve a weight goal (n=7). Thirty-five of these participants have since ceased use of the app, for the following most common reasons (open ended response, question 29): forgot about it/lost interest (n=14), lack of time (n=6), and lost/broken associated external device (n=4). See Table C3-7 in Appendix C for a comprehensive list of all apps used, features liked, reasons for starting, and reasons for ending use.

App perceptions.

The most common features that participants selected (multiple choice response, question 30) would like in a SB app was 'tracking of behaviour' (n=131), followed by 'goal-setting (n=138), 'feedback on behaviour' (n=104), 'rewards' (n=101), 'notifications' (n=87), and 'linking to social media' (n=34).

Part 2B. App trial.

Demographics.

There were no significant differences (p>0.05) found between the groups for any of demographic variables. See Table 3.3 for a summary of demographics for both groups. See Table C7 in Appendix C for test statistics.

Table 3.3. Demographic Summary of App and Control Groups

	Trial group	**Control Group**
Age	*M*= 18.67, SD= 1.46 (n=18)	*M*=19.08, SD=1.36 (n=38)
BMI	*M*= 21.70, SD= 2.92 (n=17) Range=15.93-26.41 Underweight (<18.5)- n=3 Normal weight (18.5-24.9)- n=13 Overweight (25.0-29.9)- n=1 Obese (30-34.9)- n=0	*M*= 22.82, SD= 2.82 (n=38) Range=17.75-31.35 Underweight (<18.5)- n=1 Normal weight (18.5-24.9)- n=28 Overweight (25.0-29.9)- n=8 Obese (30-34.9)- n=1
Hours of Class	*M*= 16.82, SD= 2.62 (n=16)	*M*=17.03, SD= 3.46 (n=33)
Gender	Female= 13, Male =5 (n=18)	Female= 32, Male= 6 (n=38)
Year of Study	n= 18 1: n=11 2: n=2 3: n=2 4: n= 3 5: n=0	n= 38 1: n=21 2: n=7 3: n=4 4: n= 5 5: n=1
Full/part time student	n= 17 Full time: n= 17 Part time: n=0	n= 38 Full time: n= 37 Part time: n=1
On/Off Campus	n= 18 On: n= 7 Off-: n= 11	n= 38 On: n= 16 Off-: n=22

IPAQ.

The results of the two-way mixed repeated measures ANOVA showed that there was no significant main effect of group ($F(1,47)=2.817$, $p=0.100$, $n_p^2=0.057$), time ($F(1,47)=0.501$, $p=0.483$, $n_p^2=0.011$), or significant interaction effect between time and group ($F(1,47)=0.019$, $p=0.891$, $n_p^2<0.000$). Using the log transformed IPAQ composite scores, the results of the ANOVA were all non-significant as well. Levene's test of equality of variance were non-significant for 'time 1' and 'time 2' ($p>0.05$) indicating that the variances were equal across the groups, and the homogeneity of variance assumption was not violated.

SBQ.

The results of the two-way mixed repeated measures ANOVA showed that there was no significant main effect of time ($F(1,33)=0.92$, $p=0.764$, $n_p^2=0.003$), where 'time 1' and ($M=13.83$) 'time 2' ($M=14.64$) had similar averages. There was also no significant main effect of group ($F(1,33)=0.054$, $p=0.817$, $n_p^2=0.002$), where the trial group ($M=13.98$) and control group ($M=14.36$) had similar averages. However, there was a significant main interaction effect between group and time ($F(1,33)=6.81$, $p=0.014$, $n_p^2=0.171$). Descriptive statistics show that the trial group decreased in SB from 'time 1' to 'time 2' by 1.47 hours/day, whereas the control group increased in SB from 'time 1' to 'time 2' by 1.86 hours/day. See Figure 3.1. Levene's test of equality of variance was significant for 'time 2' ($p=0.03$), indicating that the variances were unequal between the app and control group, and the homogeneity of variance assumption was violated.

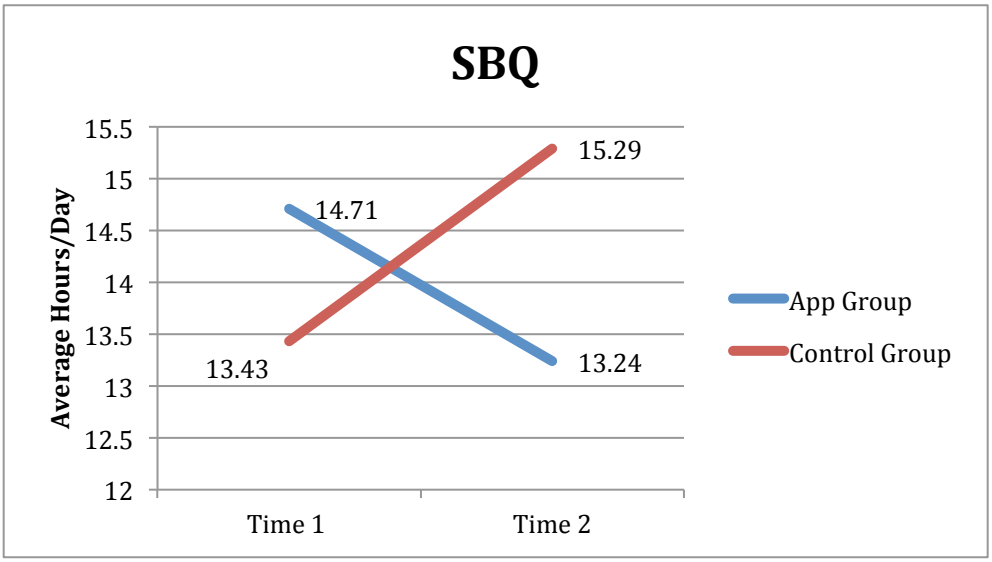


Figure 3.1. Two Way Mixed Repeated-Measures ANOVA for SBQ

Exit survey.

The exit survey included questions about the individual's experience with the Rise & Recharge® app. These include questions about: usage, influence, lifestyle, ease of use, favourable features, suggestions for changes, future use, and willingness to pay. See Table C8 in Appendix C for comprehensive frequencies of all Likert question responses, and Table C9-11 in Appendix C for a comprehensive content grouping for open-ended questions including influence, lifestyle, and ease of use.

i. Usage.

On average, participants reported using the app only 'sometimes' (*M*=2.8, SD=1.26). More specifically, the average number of days a week of use was 4.15 (SD=2.30).

ii. Influence.

On average, participants reported the app as being 'slightly influential' (*M*=2.20, SD=0.94). In response to question 14 (i.e., describe how or how not the app was influential; open ended), participants described how it was influential (n=8), or not influential (n=3) responses. An example of how it was influential was "the reminders on my phone influenced me to get up and walk around". An example how it was not influential was, "it would tell me to take breaks when it wasn't convenient so then I would forget".

iii. Lifestyle.

In response to question 15, (i.e., 'how, if at all, did the app fit into your lifestyle?'; open-ended), few participants (n=2) reported it as a good fit, and the majority of respondents (n=9) described it as not a good fit. Most of the respondents (n=7) highlighted concerns with actually using the app. Specifically, the most frequent concern (n=3) was that the users did not keep their phones on their person all the time to track movement (e.g., "It didn't really fit into my lifestyle because I'd often leave my phone at my desk as I move around. It measures my movement through my phone, but it was too hard to keep track of when I had moved or not"). Two respondents highlighted concerns with taking standing breaks (e.g., "[to be honest] it was more of a nuisance than anything else. My lifestyle is such that I spend a chunk of my time exercising moderately and then another chunk sitting. I don't tend to take breaks from sitting besides getting up for food/bathroom etc. so that was a bit of a change.").

iv. Ease of use.

On average, participants reported the app as being 'mostly easy' to use (*M*=3.67, SD=0.98). In response to question 19 (i.e., describe why or why not the app was easy to use; open-ended), the responses were varied. Several participants (n=6) described the app as simple to use (e.g., "It has a simple (but creative) design that makes it easy to see where in your day you are being the most sedentary."), however others (n=4) highlighted as not simple (e.g., "I didn't understand the stars or what the circle was").

v. Favourable features.

In response to question 20 (i.e., 'what did you like about this app?'), the features or qualities that were most frequently reported were the notifications/reminders (n=3), the logging of activity/feedback (n=3), the ease of use (n=3), and that it encouraged a less sedentary lifestyle (n=3). See Table 3.4 for frequencies of all features described.

Table 3.4. Frequency of App Features Liked (n=14)

Features	**Frequency of responses**
Notifications/Reminders	3
Encouraging a less sed. lifestyle	3
Logged activity/feedback	3
Easy to Use	3
Goals	1
Monitoring	1
Rewards (i.e. stars)	1
Health information about SB	1
Break suggestions	1
Other	2

vi. Suggestions for changes.

In response to question 21 (i.e., 'if you could, what would you change about this app?), the changes most frequently suggested were making the reminders more

personalized (n=2) and changing the layout (n=2). See Table 3.5 for frequencies of all suggestion made.

Table 3.5. Frequency of Suggestions for Changes (n=9)

Suggestions	**Frequency of responses**
Reminders more personalized	2
Layout	2
Google Fit app not mandatory	1
More interesting	1
More health information	1
Improve functionality	1
Unclear recommendation	1

vii. Future use.

On average, participants selected that they 'might use' this app in the future (*M*=2.33, SD=1.35). In response to question 23 (i.e., describe why or why not you see yourself using the app in the future), the most frequent reason why respondents would continue to use it was as inspiration to move/be active (n=3). A non-exhaustive list of reasons why respondents would not continue to use it include; it was annoying (n=1), they didn't like it (n=1), and they don't like to rely on apps (n=1). See Table 3.6 for frequencies of reasons about future use.

Table 3.6. Frequency of Responses About Future Use (n=12)

	Reasons	**Frequency of responses**
Why	Inspiration to move/be active	3
	Helps track breaks	1
Why Not	Did not work	1
	Annoying	1
	Did not like	1
	Do not like to rely on apps	1
	Do not need	1
	No interest	1

viii. Willingness to pay.

Most of the participants (n=9) said they would not be willing to pay for this app, or a similar app. Of the participants who said they would be willing (n=4), the range of price reported that they would pay was $0.99 to $2.

ix. Student lifestyle.

Participants in both the app and control groups were asked the question about SB and lifestyle in the second survey (i.e., as a student, how is SB a part of your lifestyle?; open-ended). The majority of responses (n=35) highlighted school in general, or some specific aspects of school (e.g., lectures, studying), as large contributors to personal SB. For example, "I am engaged in sedentary behaviour for long lengths of time when sitting in class, and also when completing homework". Of these responses, most participants (n=16) used language that described SB as necessary or unavoidable for school-related pursuits (e.g., "I have to sit in classes. I sit when I get home to work on the computer. My required daily tasks don't involve much movement."), even for peripheral school-related pursuits (e.g., sedentary commute to campus). In addition, several participants (n=5) cited the SB requirements of school as interfering with time or opportunity to be physically active (e.g., "we sit and study/listen in class for a lot. I wish I had more time to go to the gym or take walks outside"). Beyond school, participants cited other contributors to SB, including engaging in SB to relax (n=5), and for health reasons (n=1). See Table C12 -13 in Appendix C for all of the open-ended responses categorized.

Discussion

The aim of this study was to gain an understanding of university students' SB, PA and experiences with apps, and trial an SB app as a pilot intervention in this population. To reiterate, the specific research questions were: (1) what are the levels of university students' SB and PA and is there a relationship between levels of SB and PA? (2) What is students' knowledge of SB and PA, as distinct but related behaviours? (3) What have students' experiences been with SB or PA apps? (4) What are students' perceptions of features (BCTs) that would be critical for them in a SB app? (5) And what is the impact of using (trialing) a SB app?

PA and SB.

Based on the classification of IPAQ scores, over half of the participants were at least minimally active. As well, based on the Canadians guidelines, just under half of the participants were achieving the recommended amount of PA. This is more than the percentage of Canadian children (8%) and adults (15%) who achieve these levels (Colley et al., 2011a, Colley et al., 2011b). However, this still means that about half of students are not active enough. This is in concordance with previous reports that have determined that more than half of Canadian university students are not active enough to gain health benefits (Irwin, 2004). However, the average levels of reported SB in the SBQ (14.12 hours/day) are considerably higher than the national average for children (8.6 hours/day) and adults (9.5 hours/day) (Colley et al., 2011a, Colley et al., 2011b). Unsurprisingly, students are spending the most amount of their sitting time sitting for school or work (5.13 hours/weekday and 3.54 hours/weekend day). Although not accounting for time spent in class, this is more than up 4 hours a day studying in a sample of European

university students previously reported by Rouse and Biddle (2010). As such, sitting for school remains an important area in which SB intervention is critical.

There was neither a positive or negative correlation for PA and SB composite scores. Although a crude indicator, this supports the notion that PA does not necessarily displace time in SB (i.e., low SB does not correlate to high PA) (Owen et al., 2010). As well, individuals who could be considered "Active Couch Potatoes" (Owen et al., 2010, p. 4) (i.e., high SB and high PA) might exist in this population. This is further supported by the result that there was no difference in SB based the IPAQ category in which the participants belonged. Therefore, people might be able to be categorized into one of four categories; i) high PA and high SB, ii) high PA and low SB, iii) low PA and high SB, or iv) low PA and low SB. To determine 'high' and 'low' PA, meeting the recommended guidelines can be used as a simple categorization. However, at the current time there are no valid cut-offs for SB to determine whether 'low' or 'high'.

Despite differences in weekday and weekend SB as determined by the SBQ and IPAQ, there were significant, yet small, positive correlations for the IPAQ sitting question and SBQ average for weekdays and weekends. In a sample of overweight adults, these measures have previously been modestly correlated (Rosenberg et al., 2010). Despite the positive correlation, the large differences in the means of total sitting time between the two methods indicate that the participants were inconsistent at self-reporting time spent sitting. This is likely due to the different methods of evaluation. Single-item questions, like the IPAQ sitting question, have been shown to significantly underestimate sitting time, whereas multiple-item domain specific questions, like the SBQ, more accurately assess sitting time (Clemes, David, Zhao, Han, & Brown, 2012). The SBQ

specifically has been promoted over the IPAQ as "inquiring about specific sedentary behaviours (as the SBQ does) may have an advantage of being easier to recall than all SBs at once" (Rosenberg et al., 2010, p. 702). However, there were still several participants who reported over 24 hours of SB, which could be because the SBQ contains SBs that may not be mutually exclusive (e.g., 'eating' and 'socializing'), but also "reflect the limited accuracy inherent in self-report measures" (Rosenberg et al., 2010, p. 703).

Knowledge.

Despite the high levels of SB reported, with respect to the true/false responses, most students were aware that they should not be sitting all day even if they have been physically active (i.e., met the physical activity guidelines). However, there was still a portion of participants who said it was fine to sit all day, regardless of whether they have been physically active or not. Thus, it seems that educating about how PA and SB contribute independently to health is still required at least for some university students. Deliens et al. (2015) have made similar recommendations that "researchers along with policy makers still need to work on familiarizing students with this concept and its association with overall health" (p. 7). As described in Chapter 1, in their qualitative study with Swedish university students, they observed that when asked about factors that influenced their SB, students tended to deviate and discuss physical inactivity. They concluded that SB is relatively misunderstood concept among university students. Similarly, in the pilot app trial of 'SitCoach' completed by van Dantzig et al. (2012), there was low awareness of the harmful effects of SB in their sample of office workers. As a result, they concluded that "persuasive strategies to stimulate the user to take sitting breaks are likely to be more successful after having established awareness of the adverse

health effects of sitting behaviour" (van Dantzig et al., 2012, p. 8). Thus, it is necessary for education to come before intervention. However, since most students in this sample seemed to be aware, it is unlikely that it is the lack of knowledge of risks of SB that is solely impeding university students' adoption of a less sedentary lifestyle. Thus, future research among university students should look to avoid an educational-only focus and incorporate persuasive methods of behaviour change.

App experiences and perceptions.

As evidenced by almost half of participants reporting previous experience using a PA/SB app under their own volition, apps remain pervasive intervention tools. The most frequent reason participants cited for using a PA/SB app previously was because the app was associated with an external device (e.g., Fitbit ®). Wearable devices for PA have been shown to incorporate several BCTs for PA (Lyons et al., 2014), and devices like Fitbit® do already include a sedentary reminder. If devices as such, or their accompanying app, were to incorporate more BCTs specific to SB, we might be able to utilize the popularity of wearable devices to influence SB in the general population. The most popular feature that participants reported liking in apps they've used previously, was tracking of PA (e.g., steps, distance traveled). This is similar to Miller et al. (2015), who found that students wanted an app that had interactive features (e.g., monitoring and tracking health behaviour). Some features that did not present themselves in the current study that have been previously reported as preferred features for PA apps are coaching or motivating, and competition with friends (Middelweerd et al., 2015).

With respect to SB apps, the BCTs that were most frequently selected by participants as features they would like in a SB app were 'tracking of behaviour' (i.e.,

self-monitoring), ‘goal-setting’, ‘feedback on behaviour’, and ‘rewards’. However, as shown in Part 1 (refer to Chapter 2), these BCTs are not frequently incorporated into SB apps in their current form. Thus, SB apps should look to include these BCTs as they are not only chosen by these participants, but also because they have shown to be effective in PA interventions (Michie et al., 2009).

App trial.

The trial group declined in SB over a two-week period of about an hour and a half/day. Although these results suggest that with the use of Rise & Recharge®, participants have decreased their SB, most of the participants reported that they only used the app sometimes (n=4), rarely (n=3), or never (n=3). Furthermore, there was an increase in SB in the control group by an average of almost two hours/day that might suggest that not using the app led to an increase SB, which is misleading. These perplexing findings may be partially explained by factors beyond the control of the study including natural week-to-week variability of SB in students. In the longitudinal study of college students in the US by Small et al. (2013), there were differences in SB based on semester of study. Therefore, as the amount of students’ SB is subject to fluctuate over time, and since the study was carried out in a rolling fashion (i.e., time was not controlled for) we cannot confidently attribute the changes in SB reported in the present study to using or not using the app. In addition, statistically, unequal sample sizes between groups and violations of the assumptions of normality and homogeneity of variance suggest caution in interpreting study findings. It was not surprising that there was no significant change in PA over the two weeks. This is likely because the app was not designed to address PA, and the IPAQ was not sensitive enough to detect increases in PA with use of

the app. The results for both the IPAQ and SBQ may also be due to the issues with reliability and/or validity with these self-report measures, especially with the small sample size in this study.

With respect to the use of Rise & Recharge ®, how participants described being influenced by the app varied. Some participants felt the notifications influenced them to break from sitting, while others did not change their behaviour. Similarly, some participants found the same features of the app to be easy to use, while others did not. More clarification would have been beneficial in determining what specifically influenced behaviour and what was not understood. Ease of use has been shown to be a quality that contributes to the acceptability of PA apps in university students (Gowin et al., 2015), and thus, should be considered in future app interventions. As such, some participants in this study might have benefitted from an initial app tutorial to explain and clarify app features.

A prominent concern that participants raised about integrating the app into their lifestyle was that they do not always have their phone on their person. As such, apps might not be ideal for tracking SB. For example, if an individual receives a prompt from the app to break from sitting, then subsequently breaks to stand and/or walk around but does not bring their phone with them, the accelerometer will not detect movement and the app will assume the person is still sitting. This is an important consideration as it can lead to over-reporting of sitting time. As seen in Chapter 2, apps still have the potential to incorporate other features or BCTs not related to tracking SB that would be useful to changing SB (e.g., information on health consequences, goal-setting), but more accurate measures of tracking SB for individual and research purposes are necessary.

Another consideration that was raised was that despite some participants liking the notifications, a suggestion for change was that the notifications could be more personalized. In an app-based intervention to reduce screen-time and promote PA in adolescent boys, tailored informational and motivational messages were sent via notifications (Lubans, Smith, Skinner, & Morgan, 2014). The messages were based on outcome expectations that were personally important to the user (i.e., appearance, health and well-being, school performance, and social interaction). However, these messages were considered too frequent and repetitive, or were received at inappropriate times. As such, despite the message being personalized, they were still not well received. As the notification feature is the major component of SB apps as determined in Part 1 (i.e., the BCT "prompts/cues" was coded the most frequently in the SB apps), this feature should be experimented with to determine optimal personalization, frequency, and timing.

Student lifestyle.

A large majority of participants described in the open-ended responses about SB in the student lifestyle that sitting for school is necessary. These descriptions suggest that participants perceived a lack of control over their sitting time due to the demands of being a student. Similar results were also seen in the pilot app trial by van Dantzig et al. (2012). Albeit in office workers, participants believed that they have little internal control over their own sitting behaviour. van Dantzig et al. (2012) called for solutions to support autonomy for SB. Specifically, with respect to app notifications, reminders might be considered annoying and "undermine autonomy because they disturb people at untimely moments" (van Dantzig et al., 2012, p. 8).

As several psychological factors were found to influence SB and PA (i.e., "…perceived enjoyment, self-discipline, values, norms and beliefs, and time-management…" (p. 6) among university students in the study by Deliens et el. (2015), they suggested that self-regulation skills should be addressed when aiming to decrease SB in university students. They stated that their findings support LaCaille, Dauner, Krambee, and Pederson's (2011) recommendation to strengthen students' self-regulation skills (e.g., self-discipline, time management) for PA around the transition from secondary school to university. The findings also support McArthur and Raedeke's (2009) findings that self-management strategies are strongly associated with PA level among college students.

A recent SB smartphone intervention has shown promise in positively influencing important psychological aspects of behaviour change. Cotton and Prapavessis (2017) used text-messaging with Canadian university students to prompt non-sedentary breaks, which not only resulted in reduced sitting time overall, but also improved self-efficacy beliefs about taking more breaks (Cotton & Prapavessis, 2017).

Based on the perceived lack of control, not only should we look to self-regulatory skills and psychological aspects of SB, but we should also look to the environment as an area for future intervention. University students have reported the social and physical environment as having a meaningful influence on PA and SB (Deliens et al., 2015). With respect to the physical environment, recent research has found preliminary success in adding active workstations to the work or learning environment. For example, standing workstations have been shown to be successfully integrated into elementary classrooms, decreasing SB and offering flexibility in classrooms (Hinckson et al., 2013).

Additionally, sit-stand desks in the workplace have shown to reduced sitting time at work and have high usability and acceptability (Grunseit, Chau, van der Ploeg, & Bauman, 2013). Within a university setting, an initial needs assessment about acceptability and feasibility of introducing standing desks, found the vast majority of both instructors and students to be in favour of incorporating standing desks into the classroom (Benzo, Gremaud, Jerome, & Carr, 2016). However, there has yet to be any research, known to the primary investigator, of actually introducing active workstations in classrooms or study spaces on campuses.

Furthermore, collectively addressing psychological factors, self-regulation skills and the physical and social environment via a multicomponent intervention might improve the likelihood of changing decreasing SB. A review of interventions for workplace sitting by Chu et al. (2016), found that environmental and multicomponent (environmental and educational) interventions had more substantial improvements in sitting compared to educational interventions alone. Within a smartphone-based intervention, there is potential to incorporate BCTs that address all of these components. A recent review by Gardner, Smith, Lorencatto, Hamer, and Biddle (2016) of behaviour change methods in SB interventions for adults identified several BCTs associated with promising interventions for decreasing SB. These not only included modifying social and physical environments and providing information on the health impact of sitting, but also BCTs that relate to the individual including self-monitoring behaviour and problem solving (Gardner et al., 2016).

Limitations.

The results from this study should be interpreted in the context of several limitations. First, the self-report methods used were subject to recall and reporting biases (Atkin et al., 2012), and the IPAQ and SBQ have displayed poor validity. As such, the levels of PA and SB reported are likely to be inaccurate compared to the true levels. Thus, despite the statistical significance, in addition to the considerations mentioned previously, it is unlikely we can attribute the decline in SB solely to use of the app. What is possible is that by being exposed to questions about SB and PA in the initial survey might have primed participants to be more conscious of their behaviour, or that being the trial group itself might have led participants to underreport SB. Additionally, due to large dropout with the trial portion (Part 2B), the sample sizes were small and unequal across the groups. Collectively, these might have all influenced the PA and SB data, and such the significant results should be interpreted with caution. Second, these participants are a convenience sample, and thus, might not accurately represent the student body at WLU or Canadian university students generally. Third, the online survey method prevented the option for clarification of responses, and thus there were open-ended responses that were unclear. Lastly, although there was no strict implementation of the app, there were students who simply did not use the app despite being asked to.

Implications and future research.

With respect to data collection, future researchers should look to incorporate objective methods, or a combination of subjective and objective methods, of recording SB and PA, and might consider using in-person focus groups to obtain more in-depth app feedback responses. Additionally, equal sample sizes in trial and control groups, and

control of individual schedules will hopefully assist in determining the true change in SB with use of Rise & Recharge®, or other SB apps.

With respect to the understanding of SB, critical areas of further exploration include perceived control of SB, self-regulation, environmental considerations, and how these interact to influence SB. Overall, this study contributes to the understanding of PA and SB in university students. Specifically, it provides insight into the levels, relationship, and knowledge of PA and SB, and the potential of using apps to influence SB. Specific to apps, some important considerations for this population include: tracking of SB via apps, personalizing notifications, and incorporating BCTs that student's highlighted as favourable for SB apps (e.g., self-monitoring, goal-setting, feedback on behaviour, and rewards). These results can inform future researchers designing and implementing apps into interventions and app developers interested in inspiring behaviour change.

Chapter 4: Conclusion

In conclusion, these studies were able to provide insight into the behaviour change potential of apps designed to reduce SB, university students' SB, PA and experiences with apps, and the acceptability of a SB app in a pilot intervention in this population. To summarize, several key take-away points include:

1. SB apps are lacking BCTs compared to PA apps and thus might not be sufficient for inspiring behaviour change. SB apps in their current form might best be utilized in multi-component interventions.
2. Although more students in this sample are achieving the recommended levels of PA compared to the national average, their SB is significantly higher, and sitting for school comprises the majority of their sitting time.
3. The majority of students seem aware of the independent effects of SB and PA, and thus future interventions should look beyond educational intervention and include persuasive methods to promote behaviour change, while also considering physical environment changes.
4. While additional research is needed to determine the most effective app to reduce SB among university students, some participants were able to describe positive influences the Rise & Recharge® app had, as well as indicate favourable features.
5. Beyond apps, perceived control of SB was revealed as an important consideration amongst this population.

Moving forward, we should look to explore these areas further to better address SB in university students.

Appendix A: Chapter 2

Table A1. App Coding Rules

BCT	Rule
8.4 Habit reversal/8.2 behaviour substitution and/or 7.1 Prompts/cues	To be substitution (8.2) it would need to know that you are sitting/being inactive and only prompt you then. To add habit reversal (8.4) behavioural substitution would need to be present and then also it would have to happen repeatedly (i.e. every time it happens). To be 8.2 and 8.4, it must say you have to replace something with something else (i.e. stand up and move rather than sitting down).
1.1 Goal-setting (behaviour) or 7.1 Prompts/cues	The app would have to say your goal is to X or you need to have X number of breaks.
2.3 Self-monitoring of behaviour and 2.2 Feedback for behaviour	If it is showing you or telling you how you did it is feedback.
9.1 Credible source	Code 9.1 when it is associated with a specific person/organization. Do not code 9.1 for general statements (e.g., "research says.." "according to doctors…").
8.4 Habit reversal	Need to prompt you to count as 8.4
3.1 Social support (unspecified)	Code for social support that is delivered via the app (e.g., little creatures/friends giving encouragement) (in addition to social support that is foster via interaction with other app users).
6.2 Social comparison	Code when the user can also see "friends'" activity on the app (i.e. not the user just sharing their own activity
Outcome BCTs	Calories are considered as an "outcome".
General rule	Make sure that it is associated with the behaviour (i.e. sitting), if it is not specific do not code it. However, if other pieces of the description suggest that is related to the behaviour, then include (and highlight the other pieces)

Table A2. 'By Description' Coding Free and Paid Apps

App	Store	BCTs
Free (n=36)		
App 1: Stand up! The Work Break Timer	iTunes	2.2 Feedback on behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 2: Got a Minute for Your Health?	iTunes	5.1 Information about health consequences 7.2 Prompts/cues
App 3: Sitting	iTunes	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 4: OfficeHealth	iTunes	2.4 Self-monitoring of outcome(s) of behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 5: Move Your App	iTunes	2.2 Feedback on behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 6: Healthful	iTunes	5.1 Information about health consequences 7.1 Prompts/cues
App 7: Get Moving	iTunes	2.2 Feedback on behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 8: Stand Up Tracker	iTunes	1.1 Goal setting (behaviour) 2.3 Self-monitoring of behaviour 2.4 Self-monitoring of outcome(s) of behaviour 5.1 Information about health consequences 7.1 Prompts/cues 9.1 Credible source
App 9: Standland	iTunes	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 3.1 Social support (unspecified) 5.1 Information about health consequences 10.3 Non-specific reward
App 10: Rise & Recharge	iTunes	1.1 Goal setting (behaviour) 2.3 Self-monitoring of behaviour 5.1 Information on health consequences 7.1 Prompts/cues 9.1 Credible source 10.3 Non-specific reward
App 11: Healthy Break	iTunes	None
App 12: Sitting Timer	Google Play	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 5.1 Information on health consequences 7.1 Prompts/cues

App 13: MoveUp!	Google Play	7.1 Prompts/cues
App 14: Move-Up	Google Play	2.3 Self-monitoring of behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 15: Movn Activity	Google Play	2.3 Self-monitoring of behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 16: Twenty: Stand Up	Google Play	5.1 Information about health consequences 7.1 Prompts/cues
App 17: Stand up	Google Play	2.3 Self-monitoring of behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 18: Stand up	Google Play	7.1 Prompts/cues
App 19: Take a Stand	Google Play	2.3 Self-monitoring of behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 20: Stand up	Google Play	5.1 Information about health consequences 7.1 Prompts/cues 9.1 Credible source
App 21: Stand App	Google Play	5.1 Information about health consequences 7.1 Prompts/cues 9.1 Credible source
App 22: Move it!	Google Play	7.1 Prompts/cues
App 23: Actifit	Google Play	2.3 Self-monitoring of behaviour 6.2 Social comparison
App 24: Sedentary work	Google Play	7.1 Prompts/cues
App 25: Activatr	Google Play	2.3 Self-monitoring of behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 26:Fitness IQ	Google Play	2.3 Self-monitoring of behaviour
App 27: StandUp	Google Play	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour
App 28: Office exercise	Google Play	5.1 Information on health consequences 7.1 Prompts/cues
App 29: ActiMate	Google Play	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 7.1 Prompts/cues
App 30: Up by Jawbone	Google Play	None
App 31: Movnowplus	Google	7.1 Prompts/cues

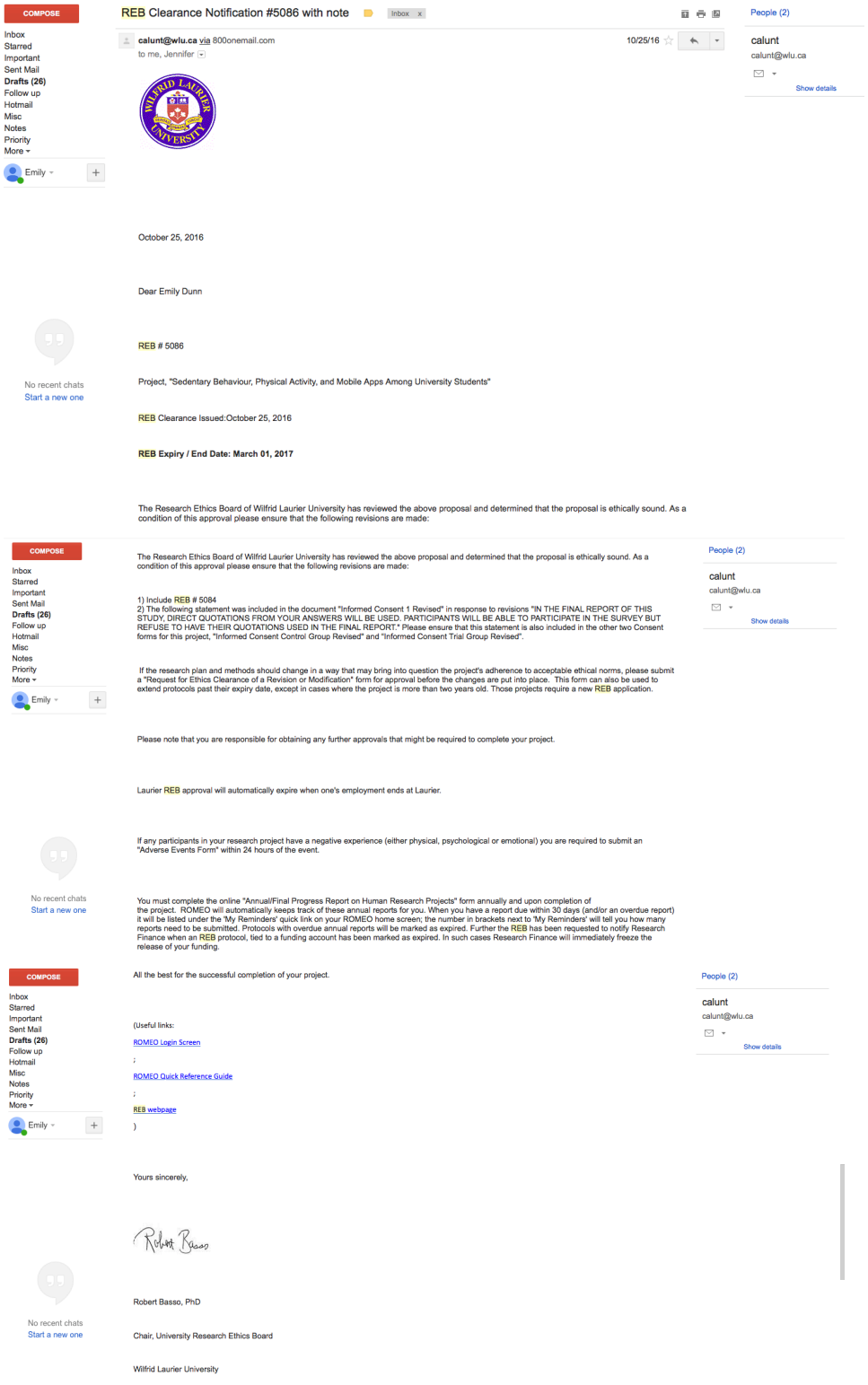
	Play	
App 32: Office wellness	Google Play	5.1 Information about health consequences 7.1 Prompts/cues
App 33: PING	Google Play	7.1 Prompts/cues
App 34: Bally total fitness	Google Play	7.1 Prompts/cues
App 35: Help the couch potato	Google Play	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 7.1 Prompts/cues
App 36: Work and stand up	Google Play	7.1 Prompts/cues 9.1 Credible source
Paid (n=14)		
App 1: Move More	iTunes	2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 5.1 Information about health consequences 6.2 Social comparison 7.1 Prompts/cues
App 2: Stop Sitting	iTunes	5.1 Information about health consequences 7.1 Prompts/cues
App 3: Get Moving	iTunes	2.2 Feedback on behaviour 5.1 Information about health consequences 7.1 Prompts/cues
App 4: Stand App *	iTunes	5.1 Information about health consequences 7.1 Prompts/cues 9.1 Credible source
App 5: Stand Alarm	iTunes	5.1 Information about health consequences 7.1 Prompts/cues
App 6: TAYB	iTunes	5.1 Information about health consequences 7.1 Prompts/cues
App 7: Desk Job	iTunes	5.1 Information about health consequences 7.1 Prompts/cues 9.1 Credible source
App 8: Stand Up Reminder PRO *	iTunes	1.1 Goal setting behaviour 2.3 Self-monitoring behaviour 2.4 Self-monitoring of outcome(s) of behaviour 5.1 Information about health consequences 7.1 Prompts/cues 9.1 Credible source
App 9: Step counter & Smart Reminder	iTunes	7.1 Prompts/cues
App 10: Stand up	iTunes	7.1 Prompts/cues
App 11: Hourly Fitness	iTunes	5.1 Information about health consequences

App 12: Wear Stand-Up	Google Play	7.1 Prompts/cues
App 13: Sedentary work PRO*	Google Play	7.1 Prompts/cues
App 14: Office Exercises & Stretch PRO*	Google Play	5.1 Information about health consequences 7.1 Prompts/cues

*These apps were available in both free and paid versions.

Appendix B: Surveys & REB

REB Clearance



REB Clearance Notification #5086 with note

calunt@wlu.ca via 800onemail.com
to me, Jennifer
10/25/16

October 25, 2016

Dear Emily Dunn

REB # 5086

Project, "Sedentary Behaviour, Physical Activity, and Mobile Apps Among University Students"

REB Clearance Issued:October 25, 2016

REB Expiry / End Date: March 01, 2017

The Research Ethics Board of Wilfrid Laurier University has reviewed the above proposal and determined that the proposal is ethically sound. As a condition of this approval please ensure that the following revisions are made:

1) Include REB # 5084
2) The following statement was included in the document "Informed Consent 1 Revised" in response to revisions "IN THE FINAL REPORT OF THIS STUDY, DIRECT QUOTATIONS FROM YOUR ANSWERS WILL BE USED. PARTICIPANTS WILL BE ABLE TO PARTICIPATE IN THE SURVEY BUT REFUSE TO HAVE THEIR QUOTATIONS USED IN THE FINAL REPORT." Please ensure that this statement is also included in the other two Consent forms for this project, "Informed Consent Control Group Revised" and "Informed Consent Trial Group Revised".

If the research plan and methods should change in a way that may bring into question the project's adherence to acceptable ethical norms, please submit a "Request for Ethics Clearance of a Revision or Modification" form for approval before the changes are put into place. This form can also be used to extend protocols past their expiry date, except in cases where the project is more than two years old. Those projects require a new REB application.

Please note that you are responsible for obtaining any further approvals that might be required to complete your project.

Laurier REB approval will automatically expire when one's employment ends at Laurier.

If any participants in your research project have a negative experience (either physical, psychological or emotional) you are required to submit an "Adverse Events Form" within 24 hours of the event.

You must complete the online "Annual/Final Progress Report on Human Research Projects" form annually and upon completion of the project. ROMEO will automatically keeps track of these annual reports for you. When you have a report due within 30 days (and/or an overdue report) it will be listed under the 'My Reminders' quick link on your ROMEO home screen; the number in brackets next to 'My Reminders' will tell you how many reports need to be submitted. Protocols with overdue annual reports will be marked as expired. Further the REB has been requested to notify Research Finance when an REB protocol, tied to a funding account has been marked as expired. In such cases Research Finance will immediately freeze the release of your funding.

All the best for the successful completion of your project.

(Useful links:
ROMEO Login Screen
;
ROMEO Quick Reference Guide
;
REB webpage
)

Yours sincerely,

Robert Basso, PhD

Chair, University Research Ethics Board

Wilfrid Laurier University

Primary Survey

If for any questions, you prefer not to answer, please leave blank or select the option for 'prefer not to specify'

Please create an ID. This will allow us to track your responses anonymously.

The ID must consist of the first two letters of your mother's name, the last 4 digits of your WLU student ID, and the first two letters of the high school you attended. For example, if your mother's name is Helen, your WLU student ID is 150661234, and your high school was McKinley High school, your participant ID will be HE1234MC.

ID: _____

1. Please indicate your age (e.g. 19). ____ years old

2. Please indicate which is your preferred gender identification (e.g., female):
   _____

3. Please indicate your height (feet, inches) and weight (lbs.)
Height = _____
Weight = _____

4. Please indicate your year of study:
□ 1
□ 2
□ 3
□ 4
□ 5
□ > 5

5. Please indicate whether you are a part time or full time:
□ Full time student
□ Part time student

6. Please indicate which department your program of study is under (e.g., English, Music, Business):

_____

7. Please indicate whether you live on campus or off campus:
□ On campus
□ Off campus

8. If you live off campus, in a typical 5 day week, how many days do you walk, bike, drive, or use public transit to get to campus?

	0	1	2	3	4	5
Walk	□	□	□	□	□	□
Bike	□	□	□	□	□	□
Drive	□	□	□	□	□	□
Public transit	□	□	□	□	□	□
Other	□	□	□	□	□	□

9. Please indicate how many **minutes** it approximately takes you to get to campus on your primary method (i.e. walk, bike, drive, or public transit):
   _____ minutes

10. Please indicate the number of **hours** of class you have a week (including labs and tutorials).
    _____ hours

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

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

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

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling? If no vigorous physical activities ***please enter 0.***

_____ days per week (0-7)

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

_____ minutes per day (e.g., 30 min/day)

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

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking. If no moderate physical activities ***please enter 0.***

_____ days per week (0-7)

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

_____ minutes per day (e.g., 30 min/day)

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

5. During the last **7 days**, on how many days did you **walk** for at least 10 minutes at a time? If no walking ***please enter 0***

_____ days per week (0-7)

6. How much time did you usually spend **walking** on one of those days?
_____ minutes per day (e.g., 30 min/day)

These next questions are about the time you spent **sitting** during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

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

_____ hours per day (e.g., 5 hours) and _____ minutes per day (e.g., and 30 minutes)

8. During the **last 7 days**, how much time did you spend **sitting** on a **weekend day** (i.e. Saturday or Sunday)?

_____ hours per day (e.g., 5 hours) _____ minutes per day (e.g., and 30 minutes)

SEDENTARY BEHAVIOUR QUESTIONNAIRE (Prapavessis et al., 2015)

On a typical WEEKDAY, how much time do you spend (from when you wake up until you go to bed) doing the following?												
	None	15 min or less	30 min	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs	7 hrs	8 hrs	9 hrs or more
1. Sitting for work or school (including using the computer).	□	□	□	□	□	□	□	□	□	□	□	□
2. Siting in a motor vehicle in order to get to work or school.	□	□	□	□	□	□	□	□	□	□	□	□
3. Watching television.	□	□	□	□	□	□	□	□	□	□	□	□
4. Using the computer for recreational purposes.	□	□	□	□	□	□	□	□	□	□	□	□
5. Reading for pleasure.	□	□	□	□	□	□	□	□	□	□	□	□
6. Listening to music.	□	□	□	□	□	□	□	□	□	□	□	□
7. Playing a musical instrument.	□	□	□	□	□	□	□	□	□	□	□	□
8. Doing arts and crafts.	□	□	□	□	□	□	□	□	□	□	□	□
9. Sitting in a motor vehicle for leisure-related transportation purposes.	□	□	□	□	□	□	□	□	□	□	□	□
10. Eating.	□	□	□	□	□	□	□	□	□	□	□	□
11. Socializing	□	□	□	□	□	□	□	□	□	□	□	□
12. Sitting for religious or spiritual pursuits.	□	□	□	□	□	□	□	□	□	□	□	□

On a typical WEEKEND DAY, how much time do you spend (from when you wake up until you go to bed) doing the following?												
	None	15 min or less	30 min	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs	7 hrs	8 hrs	9 hrs or more
1. Sitting for work or school (including using the computer)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. Siting in a motor vehicle in order to get to work or school	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. Watching television.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4. Using the computer for recreational purposes.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5. Reading for pleasure.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6. Listening to music.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7. Playing a musical instrument.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8. Doing arts and crafts.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9. Sitting in a motor vehicle for leisure-related transportation purposes.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10. Eating.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
11. Socializing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
12. Sitting for religious or spiritual pursuits.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

1. What are the Canadian physical activity guidelines for your age group? **If you do not know or are unsure, please write 'don't know'.**
    - Open-ended

2. Please indicate what is true or false for you. (True/False

	True	False
If I meet the physical activity guidelines, I can sit for most the day	□	□
If I meet the physical activity guidelines, I should still try to limit my sitting time during the day	□	□
If I don't meet the physical activity guidelines, I should try to limit my sitting time during the day	□	□
If I don't meet the physical activity guidelines, I can still sit for most of the day	□	□

3. Do you use, or have you ever used a physical activity or sedentary behaviour app? (Yes/No)
    a. Which one(s)? (Open-ended)
    b. What features did you enjoy? (Open-ended)
    c. Why did you start using it? (Open-ended)
    d. Are you still using it? If not, why did you stop using it? (Open-ended)

4. Choose which features you would like in sedentary behaviour app:
    - Linking to social media
    - Tracking of behaviour
    - Feedback on behaviour
    - Goal-setting
    - Notifications
    - Rewards
    - Other:_____

Thank you for participating in part 1 of this study!

*If you would like to be entered into the draw for a $25 gift certificate to the WLU bookstore, please enter your email address here:*_____

Your email address will be removed from your survey response file.

If you would like to receive a 1-page summary of the findings of this study please contact Emily Dunn at dunn2040@mylaurier.ca in August 2017.

Would you like the opportunity to be entered into another draw for $50 to the WLU bookstore?!

There is a part 2 to this study. The purpose of this phase is to follow up with you in 2 weeks with additional questions regarding physical activity, sedentary behaviour, and mobile apps.

If you choose to participate in part 2 you can be entered into another draw for $50 to the WLU bookstore. If you would like to participate GO TO THE NEXT PAGE for more information about part 2.

****Randomization****

****Taken to different informed consent/ information pages****

Option 1: App Group

For the next 2 weeks you are asked to trial an app! The app is called **Rise & Recharge®.** Please download this app from either the iTunes app store or Google Play marketplace for Android (links below). Rise & Recharge® is an app designed to help you take breaks from prolong sitting. It uses the accelerometer built into your phone to track your physical activity.

iTunes: https://itunes.apple.com/ca/app/rise-recharge/id962974154?mt=8

Android:
https://play.google.com/store/apps/details?id=au.edu.bakeridi.yoyo&hl=en

Please explore and trial the app for 2 weeks, however best fits into your lifestyle.

After 2 weeks we will email you to complete a final survey that take 15-20 minutes to complete about your experience with the app!

WILFRID LAURIER UNIVERSITY
INFORMED CONSENT STATEMENT
Sedentary Behaviour, Physical Activity, and Mobile Apps Among University Students

RESEARCHERS

Emily Dunn, Master of Kinesiology student; Department of Kinesiology and Physical Education, Wilfrid Laurier University
Dr. Jennifer Robertson-Wilson, Associate Professor, Department of Kinesiology and Physical Education, Wilfrid Laurier University

You are invited to participate in the second phase of this research study. The purpose of this phase is to have undergraduate students trial a mobile app, Rise & Recharge® for sedentary behaviour for 2 weeks and afterwards assess their experience with using it. In order to be included in the present study, you must be an undergraduate student at Wilfrid Laurier University aged 17-24 years old, who owns an iPhone or Android that supports the selected app, and do not have a mobility impairment (acute or chronic) that has been diagnosed by a health care professional that would limit standing and walking. You are ineligible from the study if you are younger than 17 or older then 24, are not a undergraduate at Wilfrid Laurier University, do not have an iPhone or Android that supports the selected app, or have a mobility impairment (acute or chronic) that has been diagnosed by a health care professional that would limit standing and walking.

INFORMATION

If you chose to participate in this second phase of the study, you will be asked to download and trial a free app for 2 weeks. Rise & Recharge® is an app designed to help you take breaks from prolong sitting. It uses the accelerometer built into your phone to track your physical activity. Please download Rise & Recharge from either the iTunes app store, or Google Play app store for Android. You will be asked to use the app according to your preferences, in a way that is conducive to your lifestyle. Following the 2 weeks, all participants will be contacted via email to complete a final online survey that may take between 15-20 minutes to complete. For this final survey participants will be asked questions about regarding physical activity, sedentary behaviour, and your experience using the app.

If you use an Android phone, in order for the Rise & Recharge ® app to work, you might need to download another app called Google Fit ®. Please follow the link below for more information about Google Fit ®.
https://play.google.com/store/apps/details?id=com.google.android.apps.fitness&hl=en

RISKS

By using this app, you will be encouraged to take more frequent breaks from sitting. As a result, this may lead to increased levels of light physical activity. If you are concerned with making changes to your level of physical activity due to injury, illness, or impairment (e.g., chronic low back pain), please consider completing the Physical Activity Readiness Questionnaire (http://www.csep.ca/cmfiles/ publications/parq/par-q.pdf), or consult a physician before participating in this study.

Depending on how you decide to use the app, you might be prompted to stand during unconventional times that might go against social convention (e.g., during class). However, you are advised to use the app how ever works best for your lifestyle, and not perform an activity that might lead to feelings of discomfort.

The main risk of completing the final online survey is boredom, however you may cease survey completion from the survey at any point. You will also be disclosing personal information about your physical activity and sedentary behaviour that you may later regret sharing or that may cause feelings of discomfort. If these feelings of discomfort persist, please consider contacting Laurier's Counselling Services or Laurier's Health services should you wish to discuss this further with a health care professional. [Laurier's Counselling Services (counselling@wlu.ca, 519-884-0710 x2338, Room SS2-203) and Laurier's Health Services, (519-884-0710 x3146, 2nd floor of Student Services building)]

BENEFITS

Due to the risks of prolonged sitting, and the potential of lengthy sedentary periods for university students, research in this field that lends to understanding these behaviours and how best to influence them is important for influencing individual and global health.

CONFIDENTIALITY

All data collection will be kept confidential, stored under a non-identifying code in a password-protected computer or a locked filing cabinet. The main investigators will solely be accessing this data, thus all individual information will be protected from public disclosure. All data will be destroyed by January 2021.

Quotations will be used in the presentation of the findings. Participants will not be identifiable in these quotations, they will be assigned a non-identifying code (e.g., Male participant, 3rd year student) and no personal information (e.g., location) will be associated with their quotations.

For the final survey, responses to every question are collected and stored in Survey Monkey. However, if you would like to withdraw from the study at any point and not have any of your responses used for this study, you need to contact the primary researcher Emily Dunn at dunn2040@mylaurier.ca with your participant created ID. If you chose to cease completion of the survey during any time, and do not contact the primary researcher to remove your previous responses, your data will be used in the final report of this study. Transfer of data from online to server does not assure confidentiality, but disclosure to the public will be protected as the data will only be accessed by the primary researcher (Emily Dunn) and her advisor (Dr. Robertson-Wilson) and stored on a password-protected computer or in a locked filing cabinet. SurveyMonkey does not collect participant information, except for IP addresses. IP addresses will not be used by the researchers.

If you chose to provide your email address, SurveyMonkey only stores them for us to email you. They do not use or sell these email addresses. If you would like more information about Survey Monkey's privacy policy please follow this link: https://www.surveymonkey.com/mp/policy/privacy-policy/. If you choose to provide your email addresses to be entered into the prize draw, your email address will be temporarily associated with your survey responses in the same data file. In addition, if

you chose to provide your email address, we cannot guarantee anonymity because your personal email address can potentially be identifiable. However, the researchers will strip this email from your responses after the survey closes. These emails will be moved to a separate data file.

Rise & Recharge® does collect information on your activity, but does so anonymously. If you are concerned about your privacy using this app please read their privacy policy available through the link below: http://riserecharge.com/privacy.html.

For Android users that require the app Google Fit® for Rise & Recharge® to work, if you are concerned about your privacy using this app please read Google's privacy policy through the link below: https://www.google.com/policies/privacy/

COMPENSATION

Participants who complete this second phase will be asked to provide their email address in order to be entered into a draw to win a gift card to the Wilfrid Laurier University bookstore for 50 dollars. These emails will be moved to a separate data file after the survey closes. The odds of winning depend on the number of respondents. If the participant is selected from the draw for the gift certificate, they will be emailed directly by the primary researcher (Emily Dunn) from her email address (dunn2040@mylaurier.ca).

CONTACT

If you have questions at any time about the study or the procedures, you may contact the researcher, Emily Dunn, at dunn2040@mylaurier.ca. This project has been reviewed and approved by the University Research Ethics Board (REB #5086). If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. Robert Basso, Chair, University Research Ethics Board, Wilfrid Laurier University, (519) 884-1970, extension 4994 or rbasso@wlu.ca

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study, every attempt will be made to remove your data from the study, and have it destroyed. You have the right to omit any question(s)/procedure(s) you choose. In the final report of this study, direct quotations from your answers will be used. Participants will be able to participate in the survey but refuse to have their quotations used in the final report.

FEEDBACK AND PUBLICATION

The results of this study will be summarized in a paper and presentation as part of a masters thesis defense. The results may also be presented at a professional academic conference and/or published in an academic journal.

CONSENT

Please indicate your decision in regards to participating in this study by checking the appropriate box below.

□ I have read the above information and I **agree** to participate in this study.
(clicking here brings the participant to another information page)

□ I have read the above information and I **agree** to participate in this study, however I **decline** the use of my quotations.
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(clicking here brings to disqualification page)

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Please enter the ID you created at the beginning of the survey. You will be asked to input this again at the beginning of the exit survey. This will allow you access to the final survey.

The ID must consist of the first two letters of your mother's name, the last 4 digits of your WLU student ID, and the first two letters of the high school you attended. For example, if your mother's name is Helen, your WLU student ID is 150661234, and your high school was McKinley High school, your participant ID will be HE1234MC.

ID: _____

Please also provide your email so we can contact you in 2 weeks!

Email: _____

If you have any questions over the next 2 weeks please email Emily Dunn at dunn2040@mylaurier.ca

Option 2: Control Group

In 2 weeks we will email you to complete a final survey that take 15-20 minutes to complete regarding physical activity, sedentary behaviour, and mobile apps!

WILFRID LAURIER UNIVERSITY
INFORMED CONSENT STATEMENT
Sedentary Behaviour, Physical Activity, and Mobile Apps Among University Students

RESEARCHERS

Emily Dunn, Master of Kinesiology student; Department of Kinesiology and Physical Education, Wilfrid Laurier University
Dr. Jennifer Robertson-Wilson, Associate Professor, Department of Kinesiology and Physical Education, Wilfrid Laurier University

You are invited to participate in the second phase of this research study. The purpose of this phase is to follow up with you in 2 weeks with additional questions regarding physical activity, sedentary behaviour, and mobile apps. In order to be included in the present study, you must be an undergraduate student at Wilfrid Laurier University aged 17-24 years old, who owns an iPhone or Android, and do not have a mobility impairment (acute or chronic) that has been diagnosed by a health care professional that would limit standing and walking. You are ineligible from the study if you are younger than 17 or older then 24, are not a undergraduate at Wilfrid Laurier University, do not have an iPhone or Android, or have a mobility impairment (acute or chronic) that has been diagnosed by a health care professional that would limit standing and walking.

INFORMATION

If you chose to participate in this second phase of the study, after 2 weeks, you will be contacted via email to complete a final online survey that may take between 15-20 minutes to complete. For this final survey you will be asked additional questions regarding physical activity, sedentary behaviour, and mobile apps.

RISKS

The main risk of completing the final online survey is boredom, however you may cease survey completion from the survey at any point. You will also be disclosing personal information about your physical activity and sedentary behaviour that you may later regret sharing or that may cause feelings of discomfort. If these feelings of discomfort persist, please consider contacting Laurier's Counselling Services or Laurier's Health services should you wish to discuss this further with a health care professional. [Laurier's Counselling Services (counselling@wlu.ca, 519-884-0710 x2338, Room SS2-203) and Laurier's Health Services, (519-884-0710 x3146, 2nd floor of Student Services building)]

BENEFITS

Due to the risks of prolonged sitting, and the potential of lengthy sedentary periods for university students, research in this field that lends to understanding these behaviours and how best to influence them is important for influencing individual and global health.

CONFIDENTIALITY

All data collection will be kept confidential, stored under a non-identifying code in a password-protected computer or a locked filing cabinet. The main investigators will solely be accessing this data, thus all individual information will be protected from public disclosure. All data will be destroyed by January 2021.

Quotations will be used in the presentation of the findings. Participants will not be identifiable in these quotations, they will be assigned a non-identifying code (e.g., Male participant, 3rd year student) and no personal information (e.g., location) will be associated with their quotations.

For the final survey, responses to every question are collected and stored in Survey Monkey. However, if you would like to withdraw from the study at any point and not have any of your responses used for this study, you need to contact the primary researcher Emily Dunn at dunn2040@mylaurier.ca with your participant created ID. If you chose to cease completion of the survey during any time, and do not contact the primary researcher to remove your previous responses, your data will be used in the final report of this study.

Transfer of data from online to server does not assure confidentiality, but disclosure to the public will be protected as the data will only be accessed by the primary researcher (Emily Dunn) and her advisor (Dr. Robertson-Wilson) and stored on a password-protected computer or in a locked filing cabinet. Survey Monkey does not collect participant information, except for IP addresses. IP addresses will not be used by the researchers.

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COMPENSATION

Participants who complete this second phase will be asked to provide their email address in order to be entered into a draw to win a gift card to the Wilfrid Laurier University bookstore for 50 dollars. These emails will be moved to a separate data file after the survey closes. The odds of winning depend on the number of respondents. If the participant is selected from the draw for the gift certificate, they will be emailed directly by the primary researcher (Emily Dunn) from her email address (dunn2040@mylaurier.ca).

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FEEDBACK AND PUBLICATION

The results of this study will be summarized in a paper and presentation as part of a masters thesis defense. The results may also be presented at a professional academic conference and/or published in an academic journal.

CONSENT

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□ I have read the above information and I **agree** to participate in this study, however I **decline** the use of my quotations.
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Please consider printing or saving a copy of this form for your records.

Please enter the ID you created at the beginning of the survey. You will be asked to input this again at the beginning of the exit survey. This will allow you access to the final survey.

The ID must consist of the first two letters of your mother's name, the last 4 digits of your WLU student ID, and the first two letters of the high school you attended. For example, if your mother's name is Helen, your WLU student ID is 150661234, and your high school was McKinley High school, your participant ID will be HE1234MC.

ID: _____

Please also provide your email so we can contact you in 2 weeks!

Email: _____

If you have any questions over the next 2 weeks please email Emily Dunn at dunn2040@mylaurier.ca

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Exit Survey Trial Group

Please enter the ID you created 2 weeks ago.

The ID consists of the first two letters of your mother's name, the last 4 digits of your WLU student ID, and the first two letters of the high school you attended. For example, if your mother's name is Helen, your WLU student ID is 150661234, and your high school was McKinley High school, your participant ID will be HE1234MC.

ID:_____

1. For the past 2 weeks were you using the **Rise & Recharge ® app**? (Yes/No)
□ Yes
□ No

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (Booth, 2000)

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

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

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling? If no vigorous physical activities ***please enter 0.***

_____ days per week (0-7)

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

_____ minutes per day (e.g., 30 min/day)

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe

somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking. If no moderate physical activities ***please enter 0.***

_____ days per week (0-7)

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

_____ minutes per day (e.g., 30 min/day)

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

5. During the last **7 days**, on how many days did you **walk** for at least 10 minutes at a time? If no walking ***please enter 0***

_____ days per week (0-7)

6. How much time did you usually spend **walking** on one of those days?
_____ minutes per day (e.g., 30 min/day)

These next questions are about the time you spent **sitting** during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

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

_____ hours per day (e.g., 5 hours) and _____ minutes per day (e.g., and 30 minutes)

8. During the **last 7 days**, how much time did you spend **sitting** on a **weekend day** (i.e. Saturday or Sunday)?

_____ hours per day (e.g., 5 hours) _____ minutes per day (e.g., and 30 minutes)

SEDENTARY BEHAVIOUR QUESTIONNAIRE

On a typical WEEKDAY, how much time do you spend (from when you wake up until you go to bed) doing the following?												
	None	15 min or less	30 min	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs	7 hrs	8 hrs	9 hrs or more
1. Sitting for work or school (including using the computer).	□	□	□	□	□	□	□	□	□	□	□	□
2. Siting in a motor vehicle in order to get to work or school.	□	□	□	□	□	□	□	□	□	□	□	□
3. Watching television.	□	□	□	□	□	□	□	□	□	□	□	□
4. Using the computer for recreational purposes.	□	□	□	□	□	□	□	□	□	□	□	□
5. Reading for pleasure.	□	□	□	□	□	□	□	□	□	□	□	□
6. Listening to music.	□	□	□	□	□	□	□	□	□	□	□	□
7. Playing a musical instrument.	□	□	□	□	□	□	□	□	□	□	□	□
8. Doing arts and crafts.	□	□	□	□	□	□	□	□	□	□	□	□
9. Sitting in a motor vehicle for leisure-related transportation purposes.	□	□	□	□	□	□	□	□	□	□	□	□
10. Eating.	□	□	□	□	□	□	□	□	□	□	□	□
11. Socializing	□	□	□	□	□	□	□	□	□	□	□	□
12. Sitting for religious or spiritual pursuits.	□	□	□	□	□	□	□	□	□	□	□	□

On a typical WEEKEND DAY, how much time do you spend (from when you wake up until you go to bed) doing the following?												
	None	15 min or less	30 min	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs	7 hrs	8 hrs	9 hrs or more
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2. Siting in a motor vehicle in order to get to work or school	□	□	□	□	□	□	□	□	□	□	□	□
3. Watching television.	□	□	□	□	□	□	□	□	□	□	□	□
4. Using the computer for recreational purposes.	□	□	□	□	□	□	□	□	□	□	□	□
5. Reading for pleasure.	□	□	□	□	□	□	□	□	□	□	□	□
6. Listening to music.	□	□	□	□	□	□	□	□	□	□	□	□
7. Playing a musical instrument.	□	□	□	□	□	□	□	□	□	□	□	□
8. Doing arts and crafts.	□	□	□	□	□	□	□	□	□	□	□	□
9. Sitting in a motor vehicle for leisure-related transportation purposes.	□	□	□	□	□	□	□	□	□	□	□	□
10. Eating.	□	□	□	□	□	□	□	□	□	□	□	□
11. Socializing	□	□	□	□	□	□	□	□	□	□	□	□
12. Sitting for religious or spiritual pursuits.	□	□	□	□	□	□	□	□	□	□	□	□

1. Did **this app** influence your behaviour? (Likert-scale)

Not at all influential	Slightly influential	Somewhat influential	Very influential	Extremely influential
□	□	□	□	□

Please describe how or how not. (Open-ended)

_____
_____
_____

2. How, if at all, did this app fit into your lifestyle? (Open-ended)

_____
_____
_____

3. How often did you use the app? (Likert scale)

Never	Rarely	Sometimes	Often	Very often
□	□	□	□	□

How many days in a week did you use the app? (Drop down)
1, 2, 3, 4, 5, 6, 7

4. Was this app easy to use? (Likert scale)

Not easy at all	Somewhat not easy	Neutral	Mostly easy	Very easy
□	□	□	□	□

Please describe why or why not. (Open-ended)

_____
_____
_____

5. What did you like about this app? (Open-ended)

_____
_____
_____

6. If you could, what would you change about this app? (Open-ended)

_____
_____
_____

7. Do you see yourself using this app in the future? (Likert-scale)

Will not use	Might use	Unsure	Will probably use	Will definitely use
□	□	□	□	□

Please describe why or why not. (Open-ended)

_____
_____
_____

8. Would you be willing to pay for this app or a similar app? How much would you be willing to pay? (Open-ended)

_____
_____
_____

9. Is there anything else you would like to add about your experience with this app? (Open-ended)

_____
_____
_____

10. As a student, how is sedentary behaviour a part of your lifestyle?

_____
_____
_____

11. For the past 2 weeks name other health-related apps you have been using? (Open-ended)

_____
_____
_____

12. Were you using these apps for longer than these past 2 weeks? (Yes/No)
□ Yes
□ No

If no, please indicate how long you have been using the app(s). (Open-ended)

_____
_____
_____

Thank you for participating in part 2 of this study!

If you would like to be entered into the draw for a $50 gift certificate to the WLU bookstore, please enter your email address here:_____

Your email address will be removed from your survey response file.

Exit Survey Control Group

Please enter the ID you created 2 weeks ago.

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

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

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5. Reading for pleasure.	□	□	□	□	□	□	□	□	□	□	□	□
6. Listening to music.	□	□	□	□	□	□	□	□	□	□	□	□
7. Playing a musical instrument.	□	□	□	□	□	□	□	□	□	□	□	□
8. Doing arts and crafts.	□	□	□	□	□	□	□	□	□	□	□	□
9. Sitting in a motor vehicle for leisure-related transportation purposes.	□	□	□	□	□	□	□	□	□	□	□	□
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3. Watching television.	□	□	□	□	□	□	□	□	□	□	□	□
4. Using the computer for recreational purposes.	□	□	□	□	□	□	□	□	□	□	□	□
5. Reading for pleasure.	□	□	□	□	□	□	□	□	□	□	□	□
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9. Sitting in a motor vehicle for leisure-related transportation purposes.	□	□	□	□	□	□	□	□	□	□	□	□
10. Eating.	□	□	□	□	□	□	□	□	□	□	□	□
11. Socializing	□	□	□	□	□	□	□	□	□	□	□	□
12. Sitting for religious or spiritual pursuits.	□	□	□	□	□	□	□	□	□	□	□	□

13. As a student, how is sedentary behaviour a part of your lifestyle?

_____
_____
_____

14. For the past 2 weeks have you used any health-related apps? (Open-ended)

_____
_____
_____

15. Were you using these apps for longer than these past 2 weeks? (Yes/No)

□ Yes
□ No

If no, please indicate how long you have been using the app(s). (Open-ended)

_____
_____
_____

Thank you for participating in part 2 of this study!

*If you would like to be entered into the draw for a $50 gift certificate to the WLU bookstore, please enter your email address here:*_____

Your email address will be removed from your survey response file.

Appendix C: Chapter 3

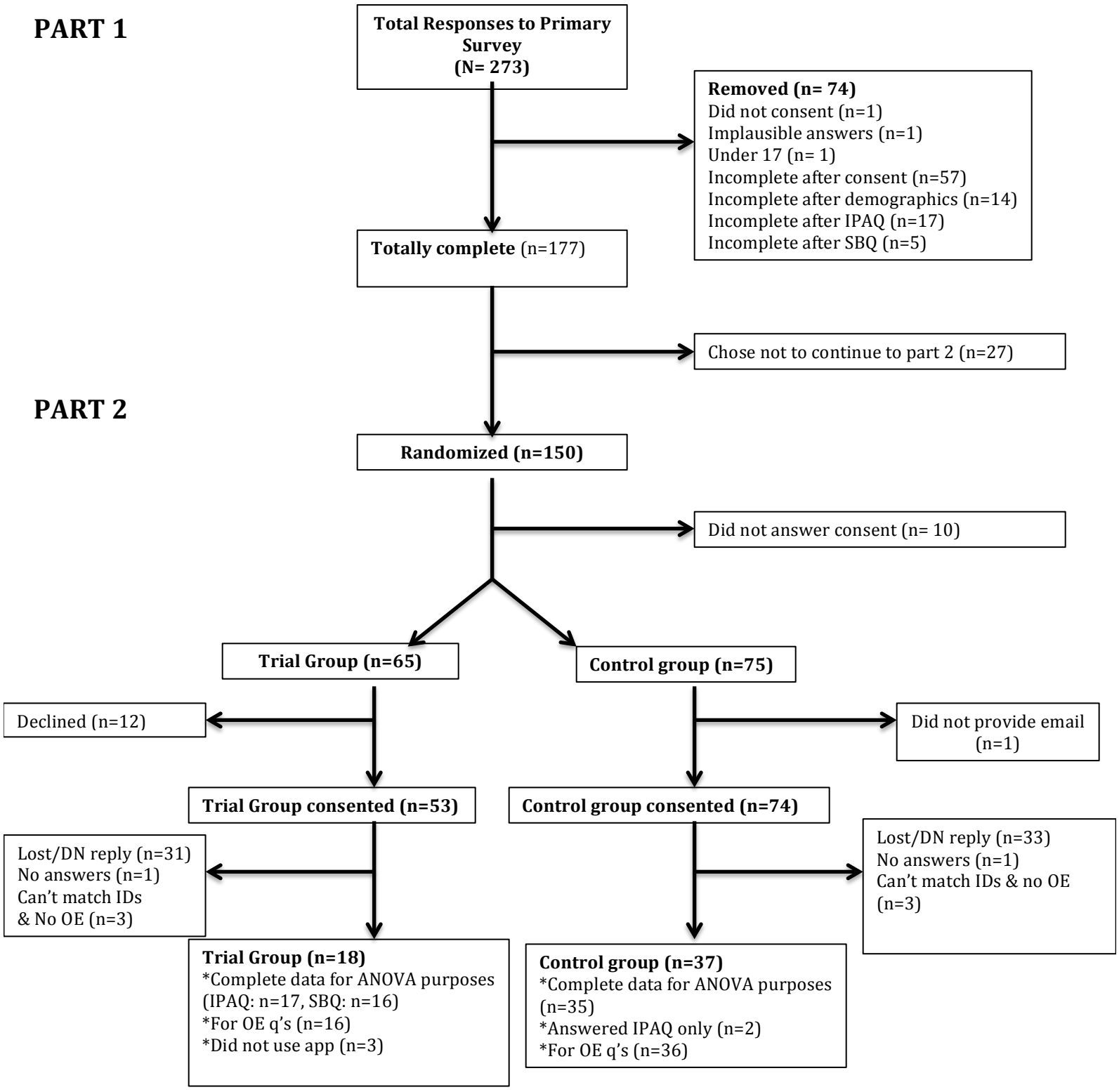

Figure C1. Flow Chart of Participant Completion, Randomization, and Dropout

Table C1. Demographic Differences Between Complete (n=177) and Incomplete (n=36) Responders (Part 2A)

Statistical Test	**Demographic Variable**
t-test	Age (*p*= 0.26) [Complete: n=177, incomplete: n=36]
	BMI (*p*= 0.96) [Complete: n=169, incomplete: n=33]
	Hours of Class (*p*= 0.09) [Complete: n=148, incomplete: n=30]
Chi square	Gender (*p*=0.53) [Complete: n=176, incomplete: n=35
	Year of study (*p*= 0.09) [Complete: n=177, incomplete: n=36]
	Full/Part time (*p*= 0.53) [Complete: n=176, incomplete: n=36]
	On/Off Campus (*p*= 0.12) [Complete: n=176, incomplete: n=36]

Table C2. Average Sitting Time in SBQ Domains

Weekday	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Sitting for work or school	148	0.50	9.00	5.13	1.90
Sitting in motor vehicle in order to get to work or school	148	0.00	3.00	0.32	0.61
Watching TV	148	0.00	5.00	0.85	1.05
Using the computer for recreational purposes	148	0.00	8.00	1.79	1.33
Reading for pleasure	148	0.00	3.00	0.38	0.60
Listening to music	148	0.00	9.00	1.68	1.71
Playing a musical instrument	148	0.00	3.00	0.09	0.32
Doing arts and crafts	148	0.00	3.00	0.07	0.32
Sitting in motor vehicle for leisure-related transportation purposes	148	0.00	2.00	0.20	0.34
Eating	148	0.25	4.00	1.44	0.84
Socializing	148	0.00	9.00	1.69	1.37
Sitting for religious or spiritual pursuits	148	0.00	2.00	0.06	0.21

Weekday	N	Minimum	Maximum	Mean	Std. Deviation
Sitting for work or school	148	0.00	9.00	3.54	2.20
Sitting in motor vehicle in order to get to work or school	148	0.00	3.00	.24	0.57
Watching TV	148	0.00	6.00	1.47	1.54
Using the computer for recreational purposes	148	0.00	8.00	2.46	1.80
Reading for pleasure	148	0.00	3.00	0.44	0.74
Listening to music	148	0.00	9.00	1.81	1.80
Playing a musical instrument	148	0.00	3.00	0.12	0.42
Doing arts and crafts	148	0.00	3.00	0.10	.34935
Sitting in motor vehicle for leisure-related transportation purposes	148	0.00	4.00	0.54	0.81
Eating	148	0.25	7.00	1.80	1.07
Socializing	148	0.00	9.00	2.52	1.83
Sitting for religious or spiritual pursuits	148	0.00	5.00	0.19	.62

Table C3. Apps Used Previously (n=72)

App	Frequency	App	Frequency
Fitbit	18	Strong Lifts	1
My Fitness Pal	14	Moves	1
Nike+	12	Workout	1
SHealth	8	Argus	1
Apple Health	4	Body building	1
Lose it	4	The Pebble Time	1
Map my run	3	Kayla Itsines	1
7 minutes	2	Map my bike	1
Google Fit	2	Runtastic	1
Train Heroic	2	Lg Health	1
Runkeeper	2	JEFIT workouts	1
Swork it	2	Pump Up	1
Couch to 5k	2	Mad Barz	1
Fitness Buddy	1	WOD life	1
So Health	1	P90x	1
Garmi	1	Under Armour	1

Table C4. Features Liked in App Used Previously (n=70)

App Features	Frequency
Tracking PA	41
Calories/food intake	24
Workout/Exercises	18
Sleep	11
Heart rate	7
Water intake	3
Alarm/reminders to be active	3
Goals	2
Convenience	1
Link to other devices	1
GPS/Location tracking	1
Tracks improvements over time	1
Schedule/planning of meals	1
Weight monitoring	1
Other	4

Table C5. Reasons for Starting Use of Previous App (n=71)

Reason	**Frequency**
The app came with something (e.g. Fitbit device)	8
Came with phone	8
Lose weight/weight goal	7
Eating/food tracking	6
Tracking PA	5
Structure or support workouts	4
Increase activity	3
Curiosity about activity	2
Quantify PA	2
Word of mouth/friends	1
Avoid gym	1
Easy to use	1
Specific exercise goal	1
Get 'healthier'	1
Other	5

Table C6. Reasons for Stopping Use of Previous Apps (n=35)

Reason	**Frequency**
Forgot about it/lost interest/became annoying	14
No time	6
Lost/ broken associated device	4
Don't need it anymore	4
Changed activity	5
Space on phone	1
New device	1
Not accurate	1
Other	1

Table C7. Demographic Differences Between Trial Group (n=18) and Control Group (n=37) (Part 2B)

Statistical Test	**Demographic Variables**
t-test	Age (p= 0.37) [Trial Group: n=18, Control Group: n=37]
	BMI (p= 0.156) [Trial Group: n=17, Control Group: n=37]
	Hours of Class (p= 0.84) [Trial Group: n=16, Control Group: n=33]
Chi square	Gender (p=0.32) [Trial Group: n=18, Control Group: n=37]
	Year of study (p= 0.86) [Trial Group: n=18, Control Group: n=37]
	Full/Part time (p= 0.50) [Trial Group: n=17, Control Group: n=37]
	On/Off Campus (p= 0.76) [Trial Group: n=18, Control Group: n=37]

Table C8. Frequency of Response to Likert Scale Questions (n=15)

Question	**1** A-'not at all influential' B-'never' C-'not easy at all' D-'will not use'	**2** A-'slightly influential' B-'rarely' C-'somewhat not easy' D-'might use'	**3** A-'somewhat influential' B-'sometimes' C-'neutral' D-'unsure'	**4** A-'very influential' B-'often' C-'mostly easy' D-'will probably use'	**5** A-'extremely influential' B-'very often' C-'very easy' D-'will definitely use'	**Mean**
A. Did this app influence your behaviour?	5	2	8	0	0	2.2 (SD= 0.94)
B. How often did you use the app?	3	3	4	4	1	2.8 (SD= 1.26)
C. Was this app easy to use?	0	2	4	6	3	3.67 (SD= 0.98)
D. Do you see yourself using this app in the future?	6	3	1	5	0	2.33 (SD= 1.35)

Table C9. Responses to how or how not Rise & Recharge® was influential (n=12)

Category	Frequency	Quotes
How it was	8	"It reminded me to get up and move around once and awhile especially when sitting for long periods of time. I didn't always pay attention to it though." "The reminders on my phone influenced me to get up and walk around" "This app showed me how much time I actually spend sitting during my day. I found myself taking breaks from whatever I was doing (schoolwork or sitting watching TV) and walking around my house to increase the number of starts I had." "Constantly made me get up, every hour i had to take a break from my studying to walk around" "At first, I got slightly obsessed with trying to earn more ""stars"" or dots, so I decidedly moved around more. After a few days, I realized I naturally got up a lot anyways, so I got tired of moving around whenever I got a notification on my phone. Instead, I just got out of my seat whenever I felt like it." "make me more conscious of how many breaks i took" "Let me visualize how many times I got up" "The app encouraged me to take more walking breaks."
How it was not	3	"It would tell me to take breaks when it wasn't convenient so then i would forget" "I did not change my behaviour"
Unclear	1	"i believe i should have gotten notificed for at least told to take a break in a manner which would somehow condition me to get up... maybe a song or something plays for the duration so u must stand in order for it to turn off and location data can be used to do this"

Table C10. Responses to how or how not Rise & Recharge® fit into lifestyle (n=12)

Category	Frequency	Quotes
Good fit	2	"yes it did, it helped me track how long i sat"
Not a good fit *App concerns	7	"I found over the course of two weeks this app increased how much I was walking around. Although at times it felt inaccurate because I did not have my phone with me 24/7 so it did not track the times I was walking without my phone on me." "It told me my number of breaks each day, but otherwise did not use However I don't always walk around with my phone and I didn't change that" "It didn't really fit into my lifestyle because I'd often leave my phone at my desk as I move around. It measures my movement through my phone, but it was too hard to keep track of when I had moved or not" "yes i am a student so i am required to sit for a majority of my time so this app would fit if it actually helped me by bringing it to my attention that i need to stand up in a more catchy manner. Honestly, i did not do the standing up at times because i forgot or did not realize i was notified to do so." "It did not it was annoying" "It was difficult at times to find time for it" "This did not fit very well into my lifestyle as i found it a hassle to use the app."
Not a good fit *Standing concerns	2	"Tbh it was more of a nuisance than anything else. My lifestyle is such that I spend a chunk of my time exercising moderately and then another chunk sitting. I don't tend to take breaks from sitting besides getting up for food/bathroom etc. so that was a bit of a change." "well, however it was a hassle getting up when i could've just continued studying."

Table C11. Responses to why or not Rise & Recharge® was easy to use (n=13)

Category	**Frequency**	**Quotes**	
Contradictory; other	3	"Recorded everything for me"	"It was inconvenient to record and use the app as it did not provide a lot of health data."
Contradictory; Simple to use or Not simple	10	"Simple user interface" "Simple interface" "it was easy to understand and set up but not catchy enough to keep me going back and using it" "It has a simple (but creative) design that makes it easy to see where in your day you are being the most sedentary." "you just had to set the timer to buzz every so often and then go walk when it buzzed."	"I didn't understand the stars or what the circle was" "The UI could be improved. It only records data for each half hour interval, so it wouldn't count if I was a few minutes off. The historic data was also very hard to access/understand." "It was a new app to me so I wasn't sure how to work it at times" "The notifications didn't work very well. The app is not very well polished at all. It was confusing what they meant by ""breaks"" it didn't track my progress well on days I was more active. Sometimes it would interrupt me in the middle of a long class and that would distract me."

Table C12. Frequencies of Classification of Responses for SB Lifestyle Questions

Broad Categories	**Smaller categories**	**Explanation**	**Frequency**
School	Large contributor	Highlighted school in general, or some specific aspect of school (e.g., classes, studying), as large contributors to their SB.	35
	Necessary	Highlighted SB as necessary for school (e.g., either being in class, for concentration, commuting).	17
	Time/opportunity for PA	Cited requirements of school as interfering with time/opportunity to be physically active.	5
	Common	Cited sitting as something that is more common for a specific school activity.	1
Outside of School	Relaxing	Cited sitting as an activity they do (or related to something they do) to relax.	5
	Health reasons	Cited sitting as something they need to do for health reasons.	1
	Vague/Unclear Response		5

Table C13. Quotes and Classifications of Responses for SB Lifestyle Questions

Trial Group (n=14)	
Response	**Classification**
"We sit and study/listen in class for a lot. I wish I had more time to go to the gym or take walks outside."	School Time/Opportunity for PA
"I never really thought I was in any danger until I started thinking about it and using this app. I realized that as a student I spend quite a bit of my time sitting."	School App Use
"i sit all the time"	Vague
"large part but mostly because i am lazy"	Vague
"It is a big part because of all my homework and readings and listening in lectures you have to be seated for"	School Necessary
"Sedentary behaviour is a huge part of my life because for the majority of my day I am sitting either waiting for my classes or actually sitting in my classes. I also commute to Laurier so that adds increased sitting time	School Necessary

as well as sitting at home and doing homework or assignments."	
"big part as it is difficult to study when working out."	Vague
"I don't like how sedentary I have to be in order to study. Sitting in class for long periods of time fatigues my body. I feel better when I get a chance to take a break and move around. However, I lead a very active lifestyle compared to other students."	School Necessary
"I feel like I am almost always sitting because of homework and assignments. It is rare that I can get up and move around, and after many days of no exercise I do not feel good about myself."	School Necessary Time/Opportunity for PA
"Large part as i spend a large portion of my time sitting and studying"	School Necessary
"Very big part of my lifestyle, often working"	School
Control Group (n=30)	
Response	**Classification**
"While learning, and relaxing only. I like to stay active"	School Relaxing
"It is necessary for my concentration to stay seated when learning and studying."	School Necessary
"I feel like I don't have the time to be active because I'm constantly doing school work or clubs or something."	School Time/opportunity for PA Necessary
"school work"	School
"I have really bad knees, so I find it hard to stand for long periods of time. I often find myself sitting for longer periods of time I usually have homework or classes, and when I'm away from work, I like to relax my mind by relaxing my body."	School Relaxing Health reasons
"I sit to do work and much of the tasks that need to be done in every day life. I find that the times I can sit and eat a relaxed meal without rushing around is a luxury that I strive for"	School Relaxing Necessary
"during exams my lifestyle becomes very sedentary"	School
"I am engaged in sedentary behaviour for long lengths of time when sitting in class, and also when completing homework"	School

"I am constantly sitting. Either for class or for work related to classes when I'm at school then when I go home, I sit and unwind by eating and watching tv."	School Relaxing
"It is part of my life style because if I have 15 hours of class a week then I am sitting down for that period of time. I am also sitting when I am doing work for those classes as well."	School Necessary
"Only time I'm sitting around is to complete school work."	School
"Im always sitting; for class, homework, on the bus, etc."	School
"I walk a lot"	Vague
"Doing all my school work!"	School
"Studying a lot, so sitting is pretty much a requirement"	School Necessary
"Being sedentary as a student is an expectation as we sit through hours of lectures."	School Necessary
"Very much so"	Vague
"I am very sedentary because I sit for long periods of time completing assignments on my laptop, studying, etc and sitting in lectures. Besides moving to get home/between classes, my weekdays are not active."	School
"It is a major part of my lifestyle. I have tons of class/lab hours during the week, where I spend tons of hours sitting. After class as well, say if I need to study or do homework, I am again sitting for hours at a time, adding to my overall sitting hours."	School Control
"As a student, one can not study or work while getting physical activity, so there is a lot of sacrifice of PA when a student wants to be successful. A balance is however required. I try to get a workout or sport in each day so that not only am I exercising, but then I have something to look forward to each day. To live healthily as a student, both management of work and exercise is necessary."	School Necessary Time/Opportunity for PA
"i sit a lot for classes, not much time to be physically active because of all the homework"	School Necessary Time/Opportunity for PA
"It is very much a part of my lifestyle as I am	School

always in class and studying”	
“The only time my body isn't moving is when I'm studying. I spend 99% of my time studying.”	School
“Sitting for schoolwork and classes”	School
“I have to sit in classes. I sit when I get home to work on the computer. My required daily tasks don't involve much movement.”	School Necessary

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