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Reducing Sedentary Behaviour In University Students Using A Text Message-Based Intervention

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REDUCING SEDENTARY BEHAVIOUR IN UNIVERSITY STUDENTS USING A TEXT MESSAGE-BASED INTERVENTION

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by

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Abstract

Sedentary behaviour (SB) has been linked to many health problems (e.g., type 2 diabetes, heart disease). Interventions aimed at office workers, overweight and obese individuals have proven successful in reducing SB; however, no studies have examined university students. Text message-based interventions have succeeded to aid in smoking cessation and increase both physical activity and healthy eating, but have not been shown to reduce SB. Eighty-two university students were randomized into intervention (SB related text messages) or control (text messages unrelated to SB) groups. Participants received daily text messages and reported various SBs (i.e., breaks from sitting, standing, light and moderate intensity physical activity) at four time points (baseline, 2, 4 and 6 weeks). Small to moderate effects that either approached or did not reach significance were found that consistently favored the intervention group for all SB measures. Findings suggest text messages have the potential to reduce SB in university students.

Keywords

Sedentary behaviour, prolonged sitting, text messages, self-efficacy, university students, breaks from sitting, light intensity physical activity, moderate intensity physical activity

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1 Introduction

1.1 Sedentary Behaviour

Sedentary behaviour such as screen viewing, reading, and riding in an automobile, can be defined as any waking activity at an energy expenditure of $\leq$1.5 METs (metabolic equivalents) while in a sitting or reclining posture (Canadian Society for Exercise Physiology, 2014). A MET is a unit that represents the metabolic equivalent of an activity expressed in multiples of resting rate of oxygen consumption, with one MET corresponding to resting metabolic rate (Tremblay, Colley, Saunders, Healy, & Owen, 2010). The World Health Organization recommends adults to get 150 minutes a week of moderate to vigorous Physical Activity (PA) in order to prevent poor health (World Health Organization, 2010). In reality, very few adults meet this recommendation, and of those that do, many are still subject to the health risks that have been attributed to sitting for long periods of time. Key findings have supported the notion that sedentary behaviour is separate from physical inactivity. Physical inactivity is a lack of being physically active (i.e., not meeting physical activity guidelines every day), whereas sedentary behaviour is the act of prolonged sitting during day-to-day life (Owen, Healy, Matthews, & Dunstan, 2010). Both physical inactivity and sedentary behaviour have overlapping health risks, but sedentary behaviour also has some distinct health risks and thus should be looked at as separate from physical inactivity (Chastin, & Granat, 2009).

1.2 Health Risks

In a large study of 4935 Canadian adults, Carson and colleagues (2014) found that the average time spent sitting per day was 10.8 hours. This indicates that adults today spend more time sitting than sleeping. This raises the question: does prolonged sitting pose serious health consequences? Researchers have found that prolonged sitting (typically in bouts of 20 minutes or more) can cause higher levels of fasting insulin, and can increase an individual’s chance of getting type 2 diabetes by up to 120% (Helmerhorst, Wijndaele, Brage, Wareham, & Ekelund, 2009; Grøntved, & Hu, 2011; Healy, Matthews, Dunstan, Winkler, & Owen, 2011; Thorp, Owen, Neuhaus, & Dunstan, 2011; Wilmot et al., 2012).

Other cardiometabolic biomarkers have also been shown to be affected by prolonged sitting such as increased waist circumference, lower levels of HDL-cholesterol, increased levels of C-reactive protein, higher levels of triglycerides and raised 2-h plasma glucose (Henson et al., 2013; Edwardson et al., 2012; Shuval et al., 2014; Healy et al., 2007, 2008b, 2011; Carson et al., 2014; Ekelund, Griffin, & Wareham, 2007; Grontved et al., 2011; Ford, & Caspersen, 2012). All of these cardiometabolic biomarkers are risk factors for metabolic syndrome (Edwardson et al., 2012), and when increased waist circumference is combined with any other two factors, the risk of fatal cardiovascular disease and all-cause mortality are increased significantly (Grontved et al., 2011; Edwardson et al., 2012, Wilmot et al., 2012; Ford et al., 2012). Another large study examined all-cause mortality rates and sitting time for 222,497 adults. The study found that compared to those who sat for less than 4 hours per day, those who sat for 4-8 hours had a 2% increase (95% CI [0.95-1.09]) in all-cause mortality, those who sat for 8-11 hours per day had a 15% increase (95% CI [1.06-1.25]), and those who sat for more than 11 hours per day had a 40% increase (95% CI [1.27-1.55]) (van der Ploeg, Chey, Korda, Banks, & Bauman, 2012). A possible explanation for the relationship between some of these health risks and prolonged sitting is that when a subject is engaged in sedentary behaviours, the subsequent loss in muscle contraction reduces glucose uptake, and suppresses the activity of skeletal muscle lipoprotein lipase (LPL). This LPL activity is necessary for the production of high-density cholesterol and triglyceride uptake (Bey, & Hamilton, 2003; Hamilton, Hamilton, & Zderic, 2004; Tremblay, Colley, Saunders, Healy, & Owen, 2010).

Aside from cardiometabolic risk factors and an increased risk of all-cause mortality, there is evidence that sedentary behaviour is related to cancer risks. A meta-analysis completed by Schmid and Leitzmann (2014), found an increased risk in colon, endometrial, and lung cancer associated with extended sedentary time. A total of 68,936 cancer cases were analyzed through 43 studies and Schmid and colleagues concluded that compared to the lowest level of sedentary time, high levels were related to average relative risks of 1.24 for colon cancer (Chow, Dosemeci, & Zheng, 1993; Boyle, Fritschi, & Heyworth, 2011; Gerhardsson, Norell, Kiviranta, Pedersen, & Ahlbom, 1986; Weiderpass et al., 2003; Simons et al., 2013; Dosemeci et al., 1993; Howard et al., 2008; Arbman, Axelson, Fredriksson, Nilsson, & Sjodahl, 1993), 1.32 for endometrial cancer (Shu, Hatch, Zheng, Gao, & Brinton, 1993; Friedenreich, Cook, Magliocco, Duggan, & Courneya, 2010; Patel et al., 2008; Arem et al., 2011; Gierach et al., 2009; Friberg, Mantzoros, & Wolk, 2006), and 1.21 for lung cancer (Lam et al., 2013; Dosemeci et al., 1993; Ukawa et al., 2013). They also found that for every 2 extra hours of sedentary time per day, there was a 10% increased risk of endometrial cancer, and an 8% risk of colon cancer (Schmid, & Leitzmann, 2014).

There are also studies, which have examined the increased risk of other health issues due to prolonged sitting. Researchers looked at depressive symptoms and sitting time in 8962 women and found that those who sat for 4 or more hours per day were 1.5 times more likely to have depressive symptoms than those who sat for less than 4 hours per day (95% CI [1.05, 1.32], & 95% CI [1.29, 1.67] respectively) (van Uffelen et al., 2013). Another study looked at telomere length in blood cells, which has been linked to longevity, in relation to sitting time in older adults who were taking part in a physical activity intervention. They discovered that the intervention group had more telomere lengthening which was associated with the reduced amount of sitting time in this group ($p=0.02$) (Sjögren et al., 2014).

The above health risks have been shown to relate to sedentary behaviour irrespective of whether or not individuals were reaching moderate-to-vigorous physical activity recommendations (Grontved et al., 2011; Healy et al., 2011; Helmerhorst et al., 2009; Schmid et al., 2014; Thorp et al., 2011; van der Ploeg et al., 2012; van Uffelen et al., 2013). Affectionately labeled, "the active couch potato," an individual can engage in prolonged television or computer screen viewing but still be considered active by meeting public health guidelines (Owen et al., 2010).

The reason that meeting moderate-to-vigorous physical activity (MVPA) guidelines does not attenuate these health risks is largely due to the fact that MVPA is unrelated to time spent sitting; however, light-intensity physical activity is almost perfectly inversely related to sitting time (Healy et al., 2011). This suggests that any prolonged sitting time is being displaced from light intensity physical activity, causing an increase in waist circumference, and overall weight gain, which is related to metabolic syndrome, type 2 diabetes, as well as cancer (Lynch, 2010; McCullough et al., 2011; Kushi et al., 2012; Schmid, & Leitzmann, 2013).

1.3 Breaking up sitting time

With all of the poor health outcomes associated with sedentary behaviour, it is important to learn how to reduce these risks. While there are currently no recommendations of how long adults should spend sitting, or how often to break up prolonged sitting, many researchers have examined how to prevent some of the known health risks. A study carried out by Healy and colleagues (2008) looked at the number of breaks from sitting in relation to several biological markers of metabolic risk in 168 adults. They found that those who took the most breaks from sitting had a smaller waist circumference (β= -0.16, 95% CI [-0.31, -0.02]), lower body mass index (β= -0.19, 95% CI [-0.35, -0.02]), lower levels of triglycerides (β= -0.18, 95% CI [-0.34, -0.02]), and lower 2-h plasma glucose levels (β= -0.18, 95% CI [-0.34, -0.02]) compared to those who took the least amount of breaks from sitting (Healy et al., 2008). A later study by Healy and colleagues (2011) found an association between breaks from sitting and waist circumference, C-reactive protein, and fasting plasma glucose, irrespective of total sitting time (Healy, Matthews, Dunstan, Winkler, & Owen, 2011).

Researchers have looked into what constitutes an effective break from sitting, and have found that although standing is better than sitting, light intensity physical activity is the most beneficial. A study by Bailey and Locke (2014) found that breaking up sitting with standing did not improve postprandial glucose levels, however light-intensity walking did (p<0.001). Dunstan and colleagues (2012) also found a decrease in glucose levels following both a light-intensity break from sitting (5.2 mmol/L, 95% CI [4.1, 6.6]) and moderate intensity break from sitting (4.9 mmol/L, 95% CI [3.8, 6.1]) compared to uninterrupted sitting (6.9 mmol/L, 95% CI [5.5-8.7], p<0.001). They also found reduced levels of insulin after both light and moderate intensity breaks (633.6 pmol/L, 95% CI [552.4, 727.1], 737.6 pmol/L, 95% CI [555.5, 731.9], respectively), compared to uninterrupted sitting (828.6 pmol/L, 95% CI [722.0, 950.9], p<0.0001) (Dunstan et al., 2012). Howard and colleagues (2013) found that interrupting sitting with a 2-minute bout of light-intensity walking every 20 minutes decreased plasma fibrinogen by 0.17 $g \bullet L^{-1}$ (95% CI [0.01, 0.32], $p<0.05$) compared to uninterrupted sitting. They also found that both moderate and light intensity breaks attenuated the reduced plasma volume and increased hematocrit, hemoglobin and red blood cell count found in uninterrupted sitting (Howard et al., 2013). Another study examining breaks from sitting found that interrupting 8 hours of sitting with hourly 8-minute moderate-intensity cycling bouts reduced levels of C-peptide compared to uninterrupted sitting ($p<0.017$) (Altenburg, Rotteveel, Dunstan, Salmon, & Chinapaw, 2012).

Beneficial breaks from sitting in the above studies were typically 2-4 minutes in length, for every 20 minutes of sitting, which could lead to future guidelines recommending these types of breaks. As for total amount of time sitting, one study found that reducing sitting to less than 3 hours per day could result in a 2-year gain in life expectancy (Katzmarzyk, & Lee, 2012) As previously mentioned, women who sat for less than 4 hours per day had a much lower prevalence of depressive symptoms (van Uffelen, 2013), and adults who sat for less than 4 hours, regardless of gender, had a reduction in all-cause mortality (van der Ploeg et al., 2012). Although there are no official recommendations, early evidence suggest that sitting for 4 hours or less per day may prevent many of the aforementioned health risks.

1.4 Interventions in the workplace

There have been many interventions aimed at decreasing sedentary behaviour and they have been met with varying levels of success. Since a large portion of an adult’s day is spent at work, and many adults work desk jobs, numerous studies have explored reducing sedentary time in office workers. Alkhajah and colleagues (2012) gave 18 office-workers sit-stand workstations and were able to reduce sitting time by 143 minutes/workday (95% CI [-184, -102], $p<0.001$) compared to controls after 1 week. These findings were maintained at a 3-month follow-up. They also looked at HDL cholesterol and found an increase of 0.26mmol/L (95% CI [0.10, 0.42], $p<0.003$) compared to controls (Alkhajah et al., 2012). Another study added a multi-component aspect to the sit-stand workstations and included a group that received e-mails, face-to-face coaching and phone calls from management, on top of receiving the new workstations (Neuhaus, Healy, Dunstan, Owen, & Eakin, 2014). After 3 months, the multi-component group decreased sitting by 89 minutes per workday (95% CI [130, 47]), whereas the workstations-only group only decreased their sitting by 33 minutes (95% CI [74, 7]) (Neuhaus et al., 2014). A third study using sit-stand devices was able to reduce sitting time by 66 minutes per day in 7 weeks (p=0.03) (Pronk, Katz, Lowry, & Rodmyre Payfer, 2012). They also found the devices helped with musculoskeletal pain by reducing upper back and neck pain by 54% (p=0.008) and once the sit-stand devices were removed, all of the observed effects went back to baseline levels within 2 weeks (p=0.027) (Pronk et al., 2012). Healy and colleagues (2013) installed the same sit-stand workstations and emphasized three messages to the intervention group; “Stand Up, Sit Less, & Move More”. After 4 weeks, the intervention group reduced their sitting time by 125 minutes (95% CI [-161, -89]) and increased standing time by 127 minutes (95% CI [92, 162]) (Healy et al., 2013). Sitting was exclusively replaced by standing, which does have some benefits; however, the “Move More” message was not adopted, which would offer the most health benefits.

A major obstacle that is encountered when attempting to encourage office workers to move more during the workday is the fact that they cannot leave their desk without losing productivity. When sit-stand workstations were installed in the workplace, several researchers were able to reduce sitting and replace it with standing; however, none of the above studies succeeded in increasing light or moderate physical activity. Carr and colleagues (2013) used portable pedal machines in an effort to have office workers replace passive sitting with active sitting. The intervention group reduced daily sedentary time by 58.7 minutes per day (95% CI [-118, 0.99]) compared to controls whom increased sedentary time by 55.5 minutes per day (95% CI [2.8, 108.1]; Carr, Karvinen, Peavler, Smith, & Cangelosi, 2013). The intervention group used the pedal machines 37.7% of the days they had access to them, and for an average of 31.1 minutes on the days they used them (Carr et al., 2013). Another method of increasing light intensity physical activity amongst office workers is by introducing treadmill desks into the work place. A study by John and colleagues (2011) used treadmill desks in an intervention to reduce sitting time and increase steps. They found a reduction of sitting time from 1238 to 1150 minutes per day, an increase in standing from 146 to 203 minutes per day and an increase in stepping time from 52 to 90 minutes per day after 9 months ($p < 0.05$) (John et al., 2011). A second study also introduced treadmill desks and found a decrease from 1,020 minutes of sedentary time per day to 978 minutes after 1 year ($p < 0.001$). They also found an increase in walking from 70 minutes per day at baseline, to 109 minutes after 1 year ($p < 0.001$) (Koepp et al., 2013). These results are promising for office workers who want to replace sedentary time with light intensity physical activity, rather than just standing. Another encouraging finding with workplace interventions is that several studies looked into the effect they had on productivity and found that none of the interventions decreased productivity, and that one study actually found an increase in productivity (Davis et al., 2009; Ebara et al., 2008; Husemann et al., 2009; Nerhood and Thompson, 1994). This evidence could help to encourage companies to include various interventions in the work place to reduce sedentary behaviour in their employees without impinging on productivity.

1.5 Interventions with specific populations

Several interventions have been aimed at overweight and obese populations in order to reduce their risk of developing type 2 diabetes or cardiovascular disease, since these individuals are typically at a greater risk of developing these diseases. One study combined face-to-face meetings and personalized e-mails to set goals for reducing sedentary behaviour (SB) and increasing steps in obese women (Adams, Davis, & Gill, 2013). Self-reported SB of the intervention group dropped significantly from 57.9 hours per week to 45.9 hours after 6 weeks ($p = 0.004$) whereas waitlisted-controls had an insignificant drop from 45.2 to 40.3 hours per week (Adams et al., 2013). Bond and colleagues (2014) used a Smartphone-based intervention to reduce sedentary behaviour in overweight/obese individuals with an application that prompted the participants to get up after a bout of prolonged sitting. The participants completed 3 different conditions in a counter-balanced order which were: a reminder to get up for 3 minutes for every 30 minutes spent sitting, 6 minutes for every 60 minutes sitting or 12 minutes for every 120 minutes sitting (Bond et al., 2014). All conditions decreased SB and increased light intensity physical activity (LIPA), with the 3-min condition reducing sitting the most with 47.2 minutes per day (95% CI [-66.3, -28.2]) and increasing LIPA by 31 minutes per day (95% CI [15.8, 46.2]) (Bond et al., 2014).

Overweight and obese individuals who have already been diagnosed with type 2 diabetes have been shown to benefit from an increase in physical activity levels through various PA programs; however, these interventions often have high drop-out rates, are expensive and time consuming, and maintaining physical activity long-term has rarely been successful (Ecclestone, Myers, & Paterson, 1998; Dunn et al., 1999; Tudor-Locke et al., 2004). Rather than enroll patients into exercise programs, which have a high rate of failure, a shift towards lifestyle interventions has found more success (Richardson et al., 2007). Decreasing sedentary behaviour has been shown to reduce the same health risks as PA; however, changes in sedentary behaviour can be done in small increments throughout the day and participants are able to conveniently implement healthy behaviours into their everyday life, instead of having to follow a structured program (Dunn et al., 1999). De Greef and colleagues (2010) combined a pedometer-based lifestyle intervention with telephone support to reduce sedentary behaviour and increase steps in obese patients with type 2 diabetes. Those in the intervention group increased their daily steps by 2744 after 24 weeks and maintained an increase of 1872 steps after 1 year ($p < 0.001$). Controls on the other hand reduced their daily steps by 1256 at 24 weeks and 1275 after 1 year ($p < 0.001$). The researchers also found a significant difference in the results between the two groups with regards to changes in sedentary time. The intervention group decreased their sedentary time by 12 minutes per day, and the control group increased their sedentary time by 48 minutes per day ($p < 0.001$) (De Greef et al., 2010).

1.6 Summary of Intervention work

The vast majority of sedentary behaviour interventions have been aimed at office workers, and overweight/obese adults; however very few, if any, target university students specifically (Deliens, Deforche, Bourdeauhuij, & Clarys, 2015). Students are an inherently sedentary population as they spend a great deal of their time either in class or studying. Studies have shown that weight gain often occurs during young adulthood (Venn et al., 2007; Deliens et al., 2015), and those who led a sedentary lifestyle in college remained sedentary 5 or 10 years later (Sparling, & Snow, 2002; Keating, Guan, Castro Piñero, & Bridges, 2005). Aiming interventions at this population are therefore worth implementing when attempting to prevent high levels of sedentary behaviour and reduce overweight/obesity rates in adults. A study investigating the feasibility of reducing sedentary behaviour in libraries installed portable pedal machines (Maeda, Quartiroli, Vos, Carr, & Mahar, 2014). They found a mean cumulative pedal time of 95.5 minutes per day, and that 7% of students who used the library used the pedal machines at least once (Maeda et al., 2014). This is promising as a way to reduce sedentary behaviour in public spaces such as universities; however, interventions aimed at individual students may be more effective.

1.7 Text message interventions

Although there have been successful interventions developed to reduce sedentary behaviour, very few utilize screen-based technology. Modern society is largely based around the use of devices that make our lives easier and more efficient. One of the more common of such devices is arguably the cell phone. Cell phones are used for a wide variety of tasks, from communication, to gaming, to online banking and shopping. Cell phone users are typically sitting when using their phones and the ease of using a cell phone often replaces the need to get up and move. Many studies have utilized cell phones to create health behaviour interventions through the use of text messages (Brendryen, & Kraft, 2008; Head, Noar, Iannarino, & Harrington, 2013; Obermayer, Riley, Asif, & Jean-Mary, 2014). Text messages allow researchers to conveniently reach a large population, either locally or globally, relatively inexpensively and without consuming a great deal of time by either the researchers or the participants. Some of the health behaviours targeted by this method include improving diet, smoking cessation, diabetes management and increasing physical activity levels. A meta-analysis conducted by Head and colleagues (2013) looked at the efficacy of these text-message based interventions as a means for health promotion. They found that the interventions aimed at smoking cessation and increasing physical activity were the most successful; however, other interventions were still effective and were favourably comparable to other types of health promotion interventions (Head, Noar, Iannarino, & Harrington, 2013). The interventions that were analyzed differed in the types of messages that were delivered, the frequency and the timing of messages, the ability to reply to texts and by the length of the interventions. The meta-analysis broke down various moderators of the interventions to determine if any were more effective than others. They found that there was no significant difference between studies that combined text messages with other components (i.e., websites, print materials or contact with counselors) and those who used text messages only. They also found no difference between studies who gave participants the ability to text back to the researcher and those who only used one-way communication. However, they did find a significant difference in the results based on the frequency of text messages, and found that the studies which decreased the frequency of messages over time, and the studies which allowed the participants to individualize the timing of messages were most effective (Head et al., 2013).

A closer examination of the smoking cessation studies demonstrated that texts that were typically sent during high stress times, at times that individuals would usually crave a cigarette, or if the individuals could text the researchers for encouragement and tips during these times the participant was able to overcome the craving. A study done by Brendryen and Kraft (2008) used e-mails, web-pages, and text messages along with nicotine-replacement therapy to help young adults quit smoking. The intervention group had greater success with a 22.3% abstinence rate, whereas the control group only had a 13.1% abstinence rate (Brendryen, & Kraft, 2008). In another study, completed after the meta-analysis, a 6-week follow-up revealed 43% of participants had made at least one 24-hour attempt to quit, and 22% had abstained for a least a week (Obermayer et al., 2014). This is encouraging for the use of text messages to aid in smoking cessation research, and the results of the studies focusing on physical activity are producing hopeful results as well.

Fjeldseo and colleagues (2010) aimed to increase exercise frequency in postnatal women using text messages. They sent 3-5 texts per week, plus 2 texts to a social support person (i.e., a partner or friend) and were able to increase physical activity frequency by 1.82 days per week after 13 weeks ($p=0.038$) (Fjeldsoe, Miller, & Marshall, 2010). A study by Prestwich and colleagues (2009) used implementation intentions paired with text messages to improve exercise frequency and found those in the implementation intentions group who also received text messages increased their exercise frequency significantly more than implementation intentions or text messages alone (Prestwich, Perugini, & Hurling, 2009). Some studies have focused on increasing steps and walking time rather than increasing moderate-vigorous physical activity which would be consistent with an intervention aimed at reducing sitting time, since light intensity physical activity most often replaces sedentary time. Another study by Prestwich and colleagues (2010) used implementation intention combined with text messages that either served as plan reminders or as goal reminders to increase brisk-walking time. Both intervention groups received text messages over 4 weeks and significantly increased the number of days they spent brisk walking for 30 minutes or more compared to the control group (whom didn't receive any text messages) ($p<0.05$). The study found that 42% of the goal reminder group, 45% of the plan reminder group and only 22% of the control group increased their walking by at least 2 days per week (Prestwich, Perugini, & Hurling, 2010). Fukuoka and colleagues (2010) used a text messaging intervention to increase daily steps in sedentary women. After one week of measuring their steps, participants were asked through text to increase their steps by 20% compared to their previous weeks'. At the end of 3 weeks they increased their daily steps by an average of 816, from 5394 to 6210 (95% CI [5379, 7041], $p < 0.001$) (Fukuoka, Vittinghoff, Jong, & Haskell, 2010).

The above studies were conducted with adult populations and have proven to be efficacious, but studies using text messages to increase any form of health behaviour have not focused on students specifically. A large study found that 96% of American undergraduate students owned a cell phone (Pew Internet and American Life Project, 2011) which indicates that any text messaged-based intervention that is aimed at university students should be accessible by the vast majority of this population. It has also been shown that those who use their cell phones most frequently, use them more for sedentary activities such as gaming, texting, surfing the web, compared to those who use them less frequently as they appeared to use their phones for meeting up with friends to participate in some form of physical activity together (Lepp, Barkley, Sanders, Rebold, &

Gates 2013). These findings show potential for cell phones being used as a way to reduce sedentary behaviour in students specifically.

1.8 Message framing and the current intervention

From the previously mentioned meta-analysis by Head and colleagues (2013), we know that text message-based health interventions can be effective, and we know several components that make these interventions most successful. An important component of an intervention using text messages is the design of the actual messages themselves. It is important to differentiate if the effectiveness of text messages is solely due to receiving attention from the researcher/study, or if it is the actual content of the message that is causing the effect. Most of the previous studies that have used text messages have not given groups equal contact; some studies have texted the intervention group daily, and texted the control groups either not at all or somewhere between 1-2 times over 2 weeks. This makes it hard to determine if receiving a text is acting as a prompt to move, or if it is the information inside the text that is being utilized. Therefore, using equal contact with different message content could provide more insight into the actual mechanism behind the interventions. The current intervention will ensure each treatment condition is receiving different text messages throughout the entire trial.

Message framing has been studied from a health promotion point of view and there have been some findings that are relevant to designing a text message-based intervention. Latimer and colleagues (2011) did a review of the most efficacious types of messages that have been used in physical activity interventions and found gain-framed rather than loss-framed messages. This means that the messages need to focus on what individuals will gain by doing some behavior, rather than telling them what they will lose if they don't do the behaviour. An example of a gain-framed message is: "achieving 150 minutes of MVPA every week will reduce your risk of type 2 diabetes", whereas a loss-framed version of the same fact would be: "not achieving 150 minutes of MVPA every week will increase your risk of developing type 2 diabetes" (Latimer et al,. 2011). The review also stated that messages that are tailored and targeted to the recipient were most effective. Tailoring and targeting are important for the individuals to find the messages relevant to themselves and their current lifestyles and for them to feel as though the messages are being personalized to them (i.e., by using their name).

1.9 Self-efficacy

Self-efficacy, defined by Bandura (1997) as one's belief in one's ability to perform a behaviour successfully, is often looked at in relation to health behaviours. Bandura has stated that self-efficacy affects health behaviours through goals, outcome expectations, and socio-structural factors, as well as affecting these behaviours directly. It has been shown that perceived self-efficacy is related to adopting new health behaviours through the search and adoption of new health knowledge (Bandura, 2004; Rimal, 2000, 2001). This indicates that one's preexisting self-efficacy has a large influence on the likelihood of adopting a behaviour. However it is also possible to increase one's self-efficacy through an outside source, and thus increasing the likelihood of adopting change. Those with high self-efficacy for a certain behaviour will typically perform harder to achieve goals, especially in the face of barriers.

Self-efficacy as a determinant of physical activity has been studied frequently, and results show that those with higher self-efficacy for physical activity will spend more time being physically active (Sallis, & Hovell 1990; Marcus, & Simkin, 1993; Dishman, 1994; Nigg, & Courneya, 1998). Specifically in university students, it has been shown that self-efficacy is an essential factor for physical activity behaviours and those who had a higher self-efficacy for physical activity had higher levels of exercise participation (Wallace, Buckworth, Kirby, & Sherman, 2000; Wallace, & Buckworth, 2003; Keating et al., 2005). They also found that self-efficacy was one of the highest contributing factors to exercise behaviour change among female students, which is key for getting non-exercisers to begin exercising. Another study found a positive relationship between VO_2 max (a common measure of one's fitness level) with self-efficacy for physical activity (β=0.26, p = 0.049; Lepp 2013).

Maibach and colleagues (1991**)** found that a health campaign focusing on healthy eating and regular exercise was able to increase participants' self-efficacy thus increasing the adoption of those healthy habits (Maibach, Flora, & Nass, 1991). It would then follow that by educating people about the benefits of sitting less, and by providing ways to break up sitting and to reduce overall sedentary behaviour, their self-efficacy would increase, and they would then be more likely to achieve these target behaviours. Presently, there is a shortage of research that examines self-efficacy for reducing sedentary behaviour. If one does not believe they can successfully break up their sitting more often, or reduce their overall sitting, they will be less likely to attempt doing so. Sitting less is a daunting task because sitting, in many situations, is an automatic behaviour. We sit at school, at work, at home, in the car, and in many public spaces. If there is a chair in the room or if others are sitting, we usually take that as a cue to sit, and sitting is seen as the norm in society.

Owen and colleagues (2011) have shown that using self-monitoring (i.e., tracking the amount of time spent sitting) and setting realistic and measurable goals (i.e., using TV commercials as times to get up and move around)—two methods to bolster self-efficacy—can reduce sedentary behaviour (Owen et al., 2011). Having participants in the present study fill out the amount of time they spend sitting in a day may serve as means of self-monitoring. Similarly, the text messages themselves will not only give reminders to move around, but will also give small goals for participants to work towards each week. Therefore, using text messages to increase self-efficacy for reducing sedentary behaviour seems plausible.

Theoretically, the differences between types of self-efficacy are important for gaining a complete understanding of the relationship between self-efficacy and sedentary behaviour. McAuley and Mihalko (1998) suggest that self-efficacy measures generally represent one of two broad categories or components of the self-efficacy construct; namely, a *task* component or a *regulatory* component. The *task* component, refers to beliefs an individual has about his or her simple motor skills or ability to perform a specific behaviour. The regulatory component, which is the primary focus of this work, refers to an individual's belief that they can consistently execute the targeted behaviour in different situations or domains. It is important that sedentary behaviour efficacy measures correspond with the targeted sedentary behaviours (Bandura, 2006). For instance, there is good correspondence between efficacious beliefs to take frequent breaks from prolonged sitting and the number of sitting breaks one takes, whereas there is poor correspondence between efficacious beliefs to take frequent breaks and how much light intensity physical activity one does.

Purpose

The primary purpose of the current study was to determine whether a text message intervention would increase break frequency and length of break from sitting, time spent standing, and time spent in light and moderate intensity physical activity in university students.

A secondary purpose was to determine whether the intervention would increase self-efficacious beliefs regarding break frequency and length of break from sitting and total sitting time.

Another secondary purpose was to determine if self-efficacious beliefs towards length and frequency of breaks and if self-efficacious beliefs towards sitting less would be related to actual break behaviour, time spent standing, and time spent in light and moderate intensity physical activity.

Hypothesis

H1. It was hypothesized that those in the intervention group (who received text messages with tips, reminders, facts and goals to sit less) would report a greater decrease in time between breaks, a greater increase in length of breaks, as well as a greater increase in time spent standing and in light and moderate intensity physical activity compared to controls (who received text messages unrelated to sitting less).

H2. It was also hypothesized that those in the intervention group would report a greater increase in self-efficacy for breaks and sitting less compared to their control counterparts.

H3. Relationships would be found between self-efficacious beliefs regarding break frequency, length of break from sitting and sitting less, and their corresponding behaviour (e.g., self-efficacy towards break frequency and frequency of breaks taken; self-efficacy towards break length and the length of breaks from sitting taken; and self-efficacy towards sitting less and time spent standing, and in LIPA and MIPA).

2 The Current Study

The subsequent methods are reported in accordance with CONSORT principles (www.consort-statement.org). The conduct of this study adhered to the guidelines outlined in the Declaration of Helsinki (World Medical Association, 2013) and the Handbook for Good Clinical Research Practice (WHO, 2002). Ethical approval was granted from Western University's Health Sciences Research Ethics Board (#105615; Appendix A). All participants were given the Letter of Information (Appendix A) and gave implied consent by filling out the first questionnaire.

2.1 Methods

Design

This research study used a 6-week parallel two-arm randomized equal contact control trial with randomization being done using a computer-generated 0 or 1 allocation.

Sample Size Calculation

Due to the novelty and exploratory nature of this study, there was a dearth of evidence available from which to base a sample size power calculation.

Participants

Inclusion criteria: (1) 18-64 years of age, (2) be able to read and write in English, (3) own and be able to operate a cell phone that has texting capabilities and a plan with unlimited incoming text messages, (4) be a student at Western University. Eighty-two participants (Mean age 21.43 years, SD 5.16, Males = 21) who satisfied all criteria completed the baseline measurements and were randomized into one of two conditions: the intervention arm (sedentary behaviour centered text messages), or the control arm (text messages unrelated to sedentary behaviour).

Primary Outcome Measures

Frequency of breaks. The frequency of breaks taken from sitting was measured by the following question "I currently take a break to get up and move around every _ minutes I spend sitting". The options the participants could choose from were; every 30 minutes or less, 45 minutes, 60 minutes, 75 minutes, 90 minutes, 120 minutes, 180 minutes or 240 minutes or more.

Length of breaks. Length of breaks taken from sitting was measured by the following question: "Currently, which number best represents the length of your breaks you usually take from sitting?" The answers included 30 seconds or less, 1-minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, 10 minutes or 15 minutes.

Standing and light intensity physical activity. Time spent standing and time spent doing light intensity physical activity (LIPA) were measured using items 2, 4, 9, 10, 12, 19 and items 3, 7, 8, 11, 13, 14, respectively, of the Sedentary and Light Intensity Physical Activity Questionnaire. The SLIPA measures time spent doing typical daily sedentary or light intensity physical activities. The SLIPA has been validated against ActiGraph GTX3 accelerometers and the cut off points for sedentary behaviour and light intensity physical activity, were anything under 100 counts per minute and 100-1951 counts per minute, respectively. The SLIPA is typically used as a 7-day log; however, to ease participant burden, the current study asked participants to fill out the items based on a typical weekday and a typical weekend day. Internal consistency Cronbach alphas for the scale constructs were acceptable (see Table 2). Although the SLIPA provides a measure of sedentary behaviour, the goal of this text intervention was to directly target and positively change standing and light intensity physical activity. After careful examination of the sedentary behaviour items (items 1, 5, 6, 15, 16, 17 and 18), it became evident that some items were not relevant to the text intervention (e.g., driving a car) or overlapped with each other (e.g., sitting-studying, writing, desk work, typing vs. sitting-using a computer) causing many overestimated data points. For these reasons, this sitting measure was not calculated and used in subsequent analyses.

Physical Activity. The short form of the Seven-Day Physical Activity Recall Questionnaire was used to measure current levels of physical activity (PAR; Sallis et al., 1985). The questionnaire measures (1) moderate, (2) hard, and (3) very hard physical activity. Participants were asked to estimate the number of minutes they spent doing each during the last 7 days. Participants were also asked to determine how many days in the past week they acquired 30 minutes or more of (1) hard or very hard activity, and (2) moderate, hard or very hard activity. In order to determine if these numbers represented their typical weeks, a final question was asked that compared their physical activity levels over the last 7 days with the previous three months. Moderate intensity was being targeted by some of the texts in the intervention (i.e. "Your challenge for tomorrow is to do 30 squats for every episode of TV you watch"), whereas hard and very hard were not specifically targeted, and thus only moderate intensity was analyzed in the results.

Secondary Outcome Measures

Self-Efficacy. To measure self-efficacy, a purpose-built questionnaire was designed. This questionnaire was comprised of 3 questions, each with several statements. The first being "I am __% confident I can decrease the amount of time I sit every day by 20 minutes", with possible answers ranging from 0-100 in intervals of 5%. The question was repeated with 30, 45, 60, 75 and 90 minutes. The second question was "I am __% confident I can take a break from sitting every 240 minutes" which was repeated for 180, 120, 90, 75, 60, 45 and 30 minutes or less. The third question was "I am __% confident I can increase the length of my breaks from sitting by 30 seconds", and was also repeated for 1, 2, 3, 4, 5, 10 and 15 minutes. All questions had the same possible answers. The self-efficacy scales demonstrated acceptable internal consistency (see Table 2).

Other Measures

Demographics. The following demographic information was obtained: name, age, phone number, gender, ethnicity, level of education (undergraduate, graduate or other), number of hours in class per week, number of hours at work per week, as well as height and weight in order to calculate Body Mass Index.

Intervention

Sedentary behaviour related text messages. The intervention group received text messages twice daily, one in the morning or early afternoon and one in the evening, depending on when they reported not being in class or meetings during the first questionnaire. They received one fact about sedentary behaviour at the beginning of each week such as; “By breaking up your sitting time you will reduce your risk of developing Type II diabetes”, and included different health risks outlined by Thorpe and colleagues (2011). They then received various challenges, tips and reminders throughout the week. The challenges started out easy and directly related to the self-efficacy questions such as; “Your challenge for the next 7 days is to get up every hour for 5 minutes”, and got increasingly harder until they were being challenged to get up every 30 minutes for a 5 minute break. The tips and reminders were sent in between challenges and facts and included ways to decrease sitting, such as; “Get up and set a timer on your phone for 5 minutes and don’t sit down again until the timer ends”, “Get off the bus a stop or two early and walk the rest of the way”, or “Don’t forget to get up every hour today and walk around for 5 minutes”. A complete list of text messages can be found in Appendix B. As shown by the review by Latimer et al. (2011), tailored and gain framed messages are the most successful for behaviour change outcomes, therefore, the text messages used in the current intervention will include gain-framed facts about sedentary behaviour (i.e. reducing sedentary behaviour will decrease your risk of developing type 2 diabetes”, rather than “sitting too much will increase your risk of developing type 2 diabetes). The texts will be targeted to the participants’ current lifestyle and will include tips such as trying to sit less at school, during exam time and during other typical student activities. The texts will correspond to the times that have been indicated that will work best for each participant and the texts will also be personalized and use each participant’s name several times a week. The current intervention will only include text messages, and participants will not have the ability to reply to the text messages as this was not deemed necessary for an effective intervention. In terms of frequency, it is not clear how many texts will be most effective to reduce stationary behaviour. It was demonstrated that anywhere from 1 text a day to 1 text a week was beneficial to increase physical activity; however, reducing sitting time is a different type of behaviour and therefore, more frequent prompts may be necessary. In order to continuously give participants new goals to meet and more tips and reminders to attain these goals throughout the week, they will be receiving 1-2 texts per day, whereas controls will receive 1 text per day (unrelated to sedentary behaviour) to keep near similar contact for both groups.

Text messages unrelated to sedentary behaviour. The control group received daily text messages in the evenings about random health or nutrition facts such as; “Raw pumpkin seeds contain essential fatty acids and beneficial proteins” or “Between 25% to 33% of the population sneeze when they are exposed to light.”

Procedure

The study was advertised through e-mails sent out to various faculties at Western University and students who were interested in the study e-mailed the researcher to sign up. The study was also advertised through an article in the university newspaper due to the interest of a reporter. Once participants signed up they received a link via e-mail that sent them to the first questionnaire, which was administered through a third party website called SOSCI. Upon completion of the baseline measurements, participants were randomized into either the intervention group or the control group and entered into a contact list on the text messaging website called Oh Don’t Forget (ODF). ODF is an online application that works through Recess Mobile to send messages from a computer to mobile phone numbers that are programmed into the application. Recess mobile and ODF use a secure server to save all information that is entered into the website in order to keep this information protected. The researcher can then program all future messages that are to be sent during the study and the messages will be sent automatically at the correct date and time.

All participants began receiving text messages within 3 days of completing the questionnaire. Every participant received the same daily texts as each other participant in their group, with times varying slightly depending on their schedule. After two weeks of receiving texts, participants received the link to the second questionnaire in an e-mail and were also reminded via text to complete it. This was repeated at 4 and 6 weeks as well. All questionnaires contained the same measures as described previously (except for demographics which were only asked at baseline, and physical activity recall which was only asked at baseline and at 6 weeks in order to reduce the length of the questionnaires). Upon completion of the final questionnaire the participants were notified that they would no longer be receiving text messages and that the study was completed. All questionnaires can be found in Appendix B.

Statistical Analyses

Primary and secondary outcome analyses

A series of 2 (intervention vs. controls) x 4 (time – baseline, 2 weeks, 4 weeks and 6 weeks) repeated measures ANOVA were used to determine if there were any significant time or time by group interaction effects. Bivariate correlations were conducted on the self-efficacy questionnaires and their matching behaviours. Linear regression was used to determine how much of the variance in the behaviour could be predicted by the matching self-efficacy questionnaire.

The level of significance was accepted at $p < .05$ for all tests (Tabachnick & Fidell, 1996). Effect sizes (η_ρ^2) accompany all reported findings. Data were analyzed using IBM SPSS Statistics (Version 23).

2.2 Results

Treatment of Data

Missing Data

Last observation carried forward was used for missing data from dropouts as an intent to treat analysis. Independent t-tests revealed no differences between those who gave complete data and those who dropped out at any time points, thus drop-outs were random. Due to several extreme outliers, a winsorization technique was used to replace any data points over the 95th percentile with the value of the 95th percentile. A total of 196 data points out of more than 6,000 in the SLIPA questionnaire were imputed this way (60 in the control group and 136 in the intervention group). This method has been shown as a valid way to treat outliers by several authors (Dixon & Tukey, 1968; Duan, 1999; Guttman & Smith, 1969; Hawkins, 1980; Tukey & McLaughlin, 1963).

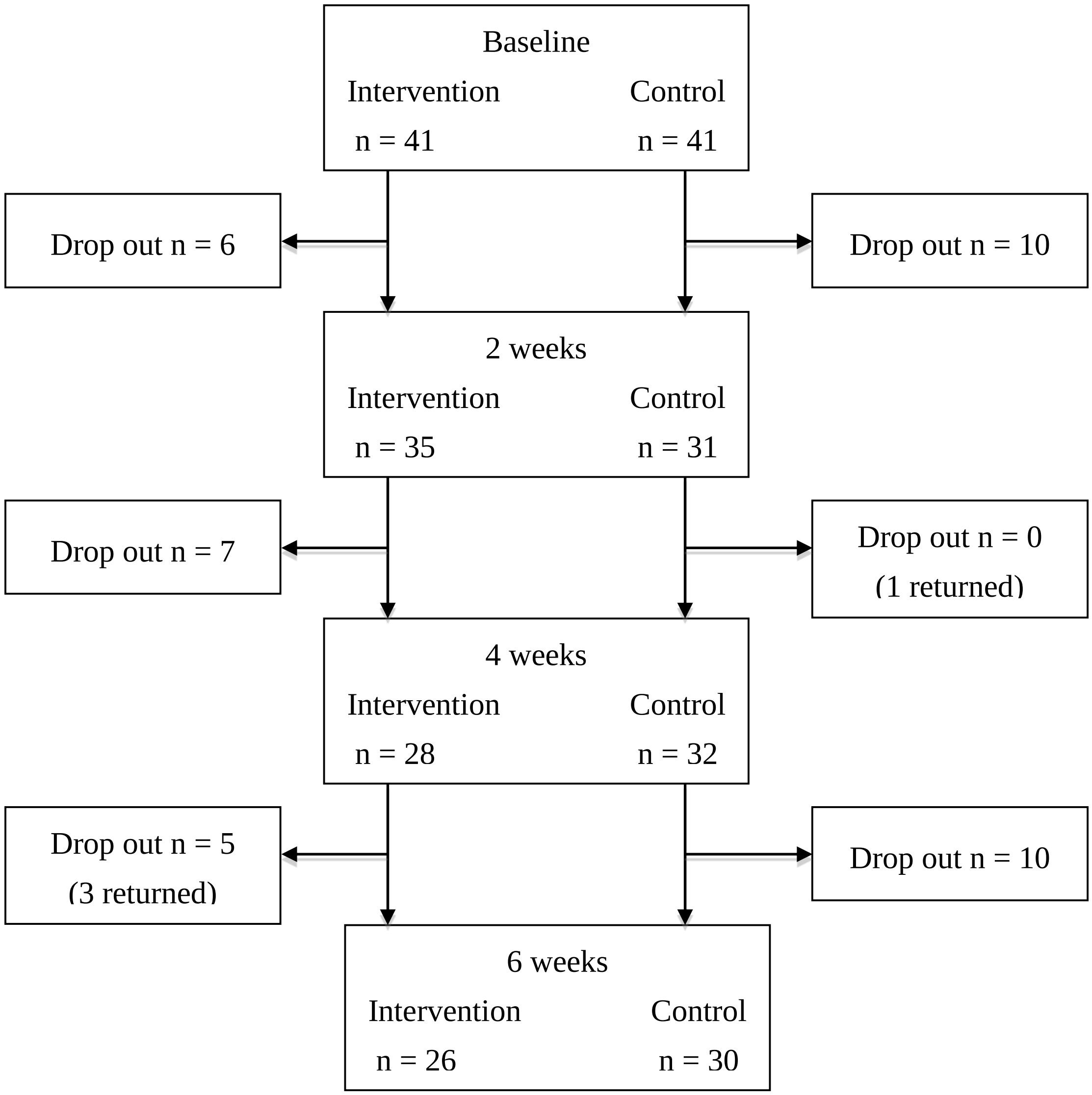

Figure 1: Flow of participants throughout the study.

Assumptions of statistical techniques

The following assumptions were met in the current study. 1) The dependent variables were continuous, 2) a random sample was drawn from the population, 3) each observation was independent from all other observations, 4) significant outliers were identified and treated before data analysis, 5) the dependent variable has normal distribution according to skewness values (no values over 2) and kurtosis values (no values over 3), and 6) Levene's test showed homogeneity of variances since no values were less than .05 and therefore not significant.

Fidelity check

All texts were sent as intended. The 'Oh Don't Forget' website produces a sent receipt for each message and ensures the same amount of confidence in messages being sent as any text from a phone. Participants were also asked at each time point if they had been receiving daily texts and all responded that they had.

Group Equivalency at Baseline

Descriptive statistics for the demographic and physical activity variables are shown in Table 1. Independent t-tests showed no significant group differences for demographic measures at baseline for age, t (79) = -.605, p = 0.547, BMI, (79) = -1.709, p = 0.091, hours of class per week, t (79) = .029, p = 0.977, hours of work per week, t (79) = -.179, p = 0.858, moderate physical activity per week, t (79) = .704, p = 0.484, hard physical activity per week, t (79) = -.405, p = 0.687, very hard physical activity per week, t (79) = .160, p = 0.873, number of days in the past week they achieved 30 minutes or more of hard or very hard physical activity, t (79) = .240, p = 0.811, or number of days in the past week they achieved 30 minutes or more of moderate, hard or very hard physical activity, t (79) = .130, p = 0.897.

Baseline descriptive statistics for break, standing, and LIPA behaviours as well as corresponding self-efficacy behaviours are shown in Tables 3 through 9. Independent t-tests showed no significant group differences at baseline for frequency of breaks from sitting, t (80) = -.457, p = .649, length of breaks from sitting, t (80) = -.351, p = .727, time spent standing, t (80) = .522, *p* = .139, time spent in light intensity physical activity, t (80) = -.488, *p* = .627, confidence to take more frequent breaks, t (80) = -.989, *p* = .326, confidence to increase break length, t (80) = .089, *p* = .342, or confidence to decrease overall sitting time, t (80) = -.571, *p* = .570.

Table 1: Demographic Variables

	Intervention Group			Control Group		
Variable	M	SD	%	M	SD	%
Gender (Male)			24.4			26.8
Age (years)	21.37	3.60		21.02	4.76	
Body Mass Index	24.57	3.56		23.22	3.54	
Hours of class/week	15.63	7.42		15.67	6.73	
Hours of work/week	6.33	8.99		5.94	10.35	
Type of student:						
Undergraduate			87.8			78
Graduate student			12.2			17
Other			0			4.8
Physical Activity:						
Moderate[1]	151.25	170.10		175.00	131.57	
Hard[1]	94.12	120.63		83.24	121.42	
Very Hard [1]	93.23	113.23		97.61	131.70	
Days with hard	2.80	2.34		2.93	2.40	
Days with moderate	4.25	3.61		4.34	2.66	

1. Expressed in minutes per week

Table 2: Reliability of Scales (Interclass correlation coefficients)

Scale	Baseline	2 weeks	4 weeks	6 weeks
SLIPA				
Stand	.75	.80	.87	.75
LIPA	.67	.75	.84	.81
Self-efficacy				
Frequency of breaks	.85	.85	.87	.87
Length of breaks	.89	.93	.93	.92
Sit less	.94	.96	.93	.94

All scales had good or excellent reliability at all time points (all ICC values over .7 or .9 respectively) except for the light intensity physical activity items of the SLIPA at baseline

Main Analyses

Primary Outcomes – Break frequency and length, standing, light intensity physical activity and moderate intensity physical activity

Descriptive statistics for the variable of interest are shown in Tables 3 through 7 and Figures 2 through 6. These data show the intervention group increasing the frequency of their breaks from every 81.95 minutes to every 58.90 minutes of sitting, and from every 77.56 minutes to every 69.15 minutes for the control group. These data also reveal that length of break from sitting increased from 6.71 minutes to 7.49 minutes for the intervention group and 6.37 to 6.56 for the controls**.** Finally these data show that the intervention group increased standing by 18.25 minutes per day, light by 50.07 mins/day, moderate by 13.03 mins/day (total increase in PA/standing of 81.35 minutes). The control group decreased standing by 6.05 mins/day, decreased light by 24.27 mins/day and increased moderate by 3.06 mins/day (total net decrease of 27.26 mins).

There were significant time effects for break frequency: $F(3, 78) = 6.32$, $p = 0.001$, Wilks' $\Lambda = 0.80$, $\eta_\rho^2 = .20$, time spent in light intensity PA: $F(3, 78) = 2.75$ $p = 0.048$, Wilks' $\Lambda = 0.90$, $\eta_\rho^2 = .10$, and time spent moderate intensity PA: $F(3, 80) = 5.25$, $p = 0.025$, Wilks' $\Lambda = 0.94$, $\eta_\rho^2 = .06$. There were no significant time effects for break length: $F(3, 78) = 0.73$ $p = 0.537$, Wilks' $\Lambda = 0.97$, $\eta_\rho^2 = .03$ or time spent standing: $F(3, 78) = 0.45$, $p = 0.715$, Wilks' $\Lambda = .98$, $\eta_\rho^2 = .02$.

There were no significant treatment group by time interaction effects for break frequency: $F(3, 78) = 1.28$, $p = 0.287$, Wilks' $\Lambda = 0.95$, $\eta_\rho^2 = .05$, break length: $F(3, 78) = 0.73$ $p = 0.629$, Wilks' $\Lambda = 0.98$, $\eta_\rho^2 = .02$, time spent standing: $F(3, 78) = 0.72$, $p = 0.544$, Wilks' $\Lambda = .97$, $\eta_\rho^2 = .03$, or time spent in moderate: $F(3, 80) = 2.01$, $p = 0.160$, Wilks' $\Lambda = 0.98$, $\eta_\rho^2 = .03$. However, there was a trend effect for time spent in light: $F(3, 78) = 2.43$ $p = 0.071$, Wilks' $\Lambda = 0.91$, $\eta_\rho^2 = .09$.

Secondary Outcomes - Self-efficacy

Descriptive statistics for the variables of interest are shown in Tables 8 through 10 and Figures 7 through 9. As for the change scores for the self-efficacy measures; confidence to increase frequency of breaks increased from 81.16 to 88.90 (+7.74%) for the intervention group, and from 77.84 to 82.18 (+4.34%) for controls. Confidence to increase length of break increased from 85.63% to 86.53% in the intervention group (+0.90%), and decreased from 82.39% to 81.02% for the controls (-1.37%). Confidence to decrease sitting time increased from 67.42 to 78.86 (+11.44%) for the intervention group, and from 64.61 to 70.92 (+6.31) for the controls.

There were significant time effects for confidence to increase break frequency: $F\ (3, 78) = 9.79$ $p = 0.000$, Wilks' $\Lambda = 0.73$, $\eta_\rho^2 = .27$, confidence to increase break length: $F\ (3, 78) = 6.41$ $p = 0.001$, Wilks' $\Lambda = 0.80$, $\eta_\rho^2 = .20$ and confidence to sit less: $F\ (3, 78) = 8.54$ $p = 0.000$, Wilks' $\Lambda = 0.75$, $\eta_\rho^2 = .25$.

There were trend interaction effects for confidence to increase break frequency $F\ (3, 78) = 2.52$ $p = 0.064$, Wilks' $\Lambda = 0.91$, $\eta_\rho^2 = .09$ and for confidence to increase break length: $F\ (3, 78) = 2.06$ $p = 0.112$, Wilks' $\Lambda = 0.93$, $\eta_\rho^2 = .07$. There was a significant interaction effect for confidence to sit less: $F\ (3, 78) = 3.09$ $p = 0.032$, Wilks' $\Lambda = 0.89$, $\eta_\rho^2 = .11$.

Associations between self-efficacy and behaviours

Baseline

Correlations between the self-efficacy constructs and the actual targeted behaviours are shown in table 11. Linear regressions were performed on variables of interest to determine how much variance of the behaviours were predicted by the cognitions. Percentages reported are the R square values.

Confidence to increase break frequency predicted 33.1% of the variance of actual break frequency, 1.7% of actual break length, 3.9% of standing time, 3% of LIPA, and 4.2% of MIPA. Confidence to increase break length predicted 10.8% of actual break length, 0% of the variance of actual break frequency, 1.7% of standing time, 6.7% of LIPA, and 0% of MIPA. Confidence to sit less predicted 0% of the variance of break frequency, 2.2% of break length, 1.6% of standing time, 1.8% of LIPA, and 1.5% of MIPA.

6 weeks

Correlations between the self-efficacy constructs and the actual targeted behaviours are shown in table 12. Linear regressions were performed on variables of interest to determine how much variance of the behaviours were predicted by the cognitions. Percentages reported are the R square values.

Confidence to increase break frequency predicted 16.6% of the variance of actual break frequency, 9.6% of actual break length, 2.9% of standing time, 2.4% of LIPA, and 3.0% of MIPA. Confidence to increase break length predicted 31.4% of actual break length, 13.5% of the variance of actual break frequency, 2.6% of standing time, 6.7% of LIPA, and 6.3% of MIPA. Confidence to sit less predicted 15.8% of the variance of break frequency, 12% of break length 4.8% of standing time, 10.1% of LIPA, and 11.3% of MIPA.

Table 3: Means, Standard Deviations, and 95% Confidence Intervals for Frequency of Breaks at Each Time Point. M (minutes)

	Intervention Group			Control Group		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	81.95	45.39	[67.63, 96.28]	77.56	41.47	[64.47, 90.65]
2 weeks	65.49	20.88	[58.90, 72.08]	64.76	21.06	[58.11, 71.41]
4 weeks	60.00	23.72	[52.51, 67.49]	60.20	22.99	[52.94, 67.45]
6 weeks	58.90	20.78	[52.34, 65.46]	69.15	36.57	[57.60, 80.69]

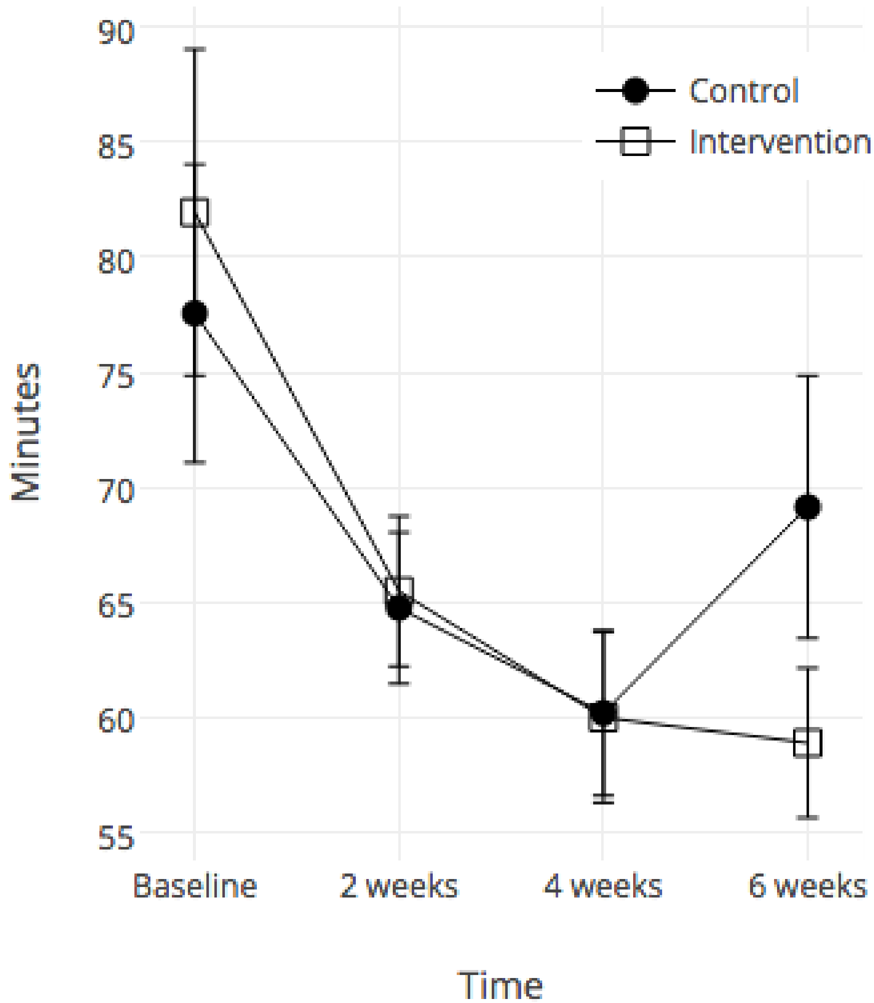

Figure 2: Frequency of breaks from sitting at each time point. Error bars represent standard error.

Table 4: Means, Standard Deviations, and 95% Confidence Intervals for Length of Break at Each Time Point. M (minutes)

	Intervention Group			Control Group		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	6.71	4.08	[5.42, 7.99]	6.37	4.71	[4.88, 7.85]
2 weeks	6.76	4.14	[5.45, 8.06]	6.68	4.14	[5.38, 7.99]
4 weeks	7.12	3.64	[5.97, 8.27]	6.93	4.16	[5.61, 8.24]
6 weeks	7.49	4.39	[6.10, 8.86]	6.56	4.18	[5.24, 7.88]

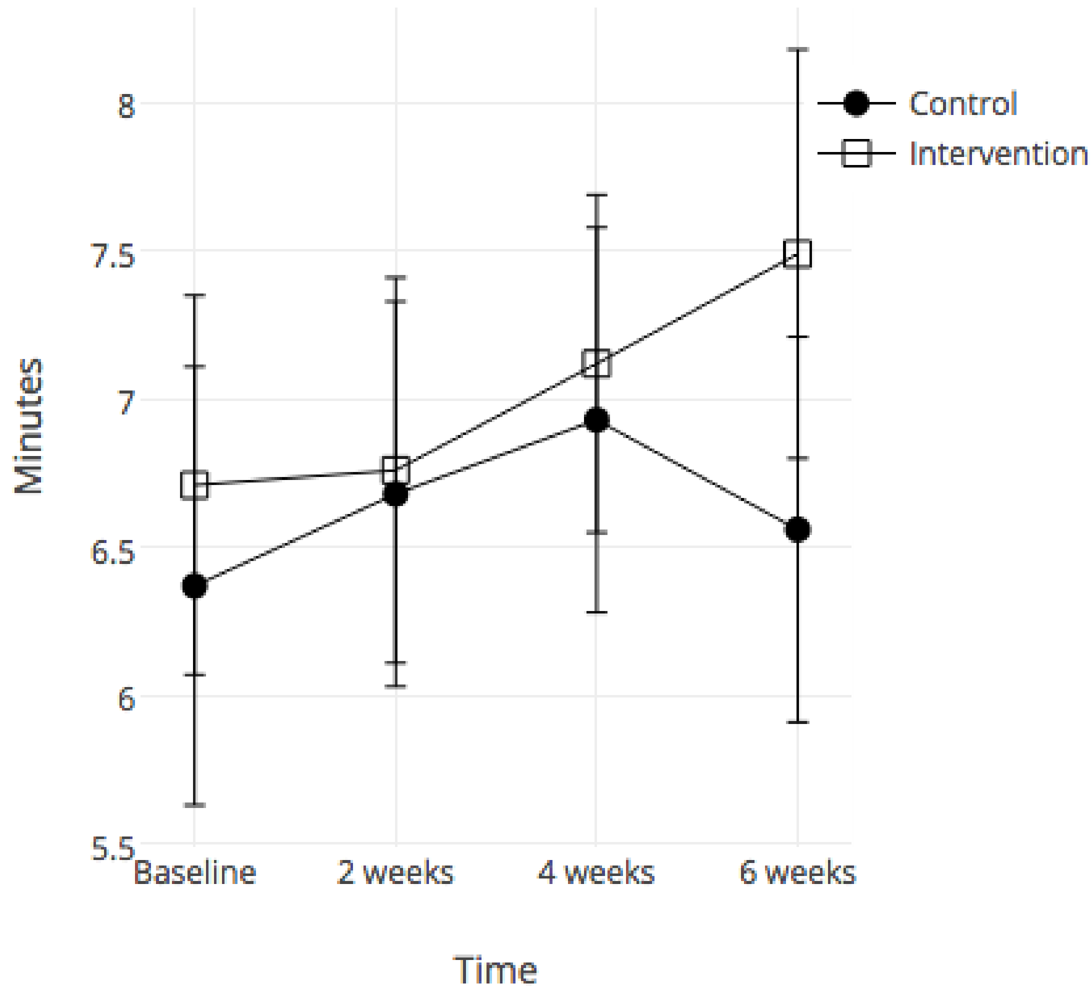

Figure 3: Length of break at each time point. Error bars represent standard error.

Table 5: Means, Standard Deviations, and 95% Confidence Intervals for Time Spent Standing at Each Time Point. M (minutes/day)

	Intervention Group			Control Group		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	517.02	327.04	[413.80, 620.25]	409.34	325.68	[306.54, 512.13]
2 weeks	533.22	392.93	[409.19, 657.25]	408.24	317.00	[308.19, 508.30]
4 weeks	497.88	386.63	[375.84, 619.91]	409.49	323.94	[307.24, 511.74]
6 weeks	535.27	399.22	[409.26, 661.28	403.29	280.02	[314.92, 491.68]

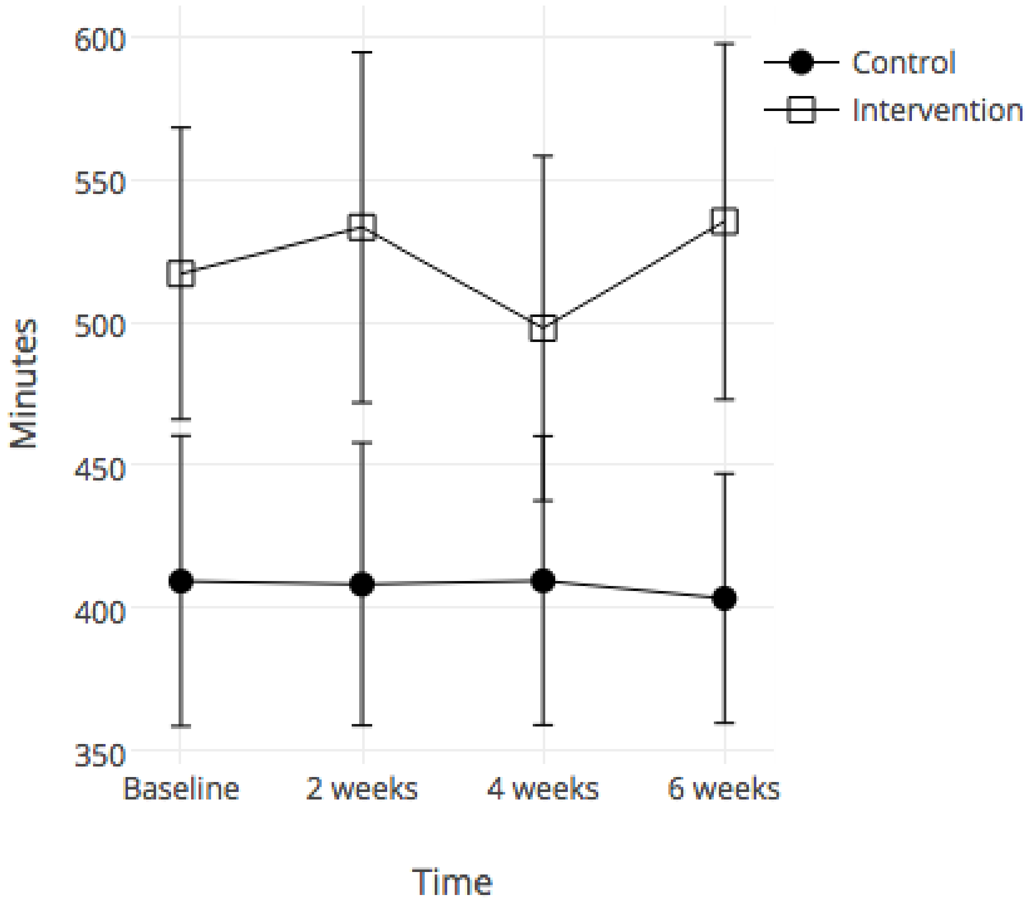

Figure 4: Time spent standing per day at each time point. Error bars represent standard error.

Table 6: Means, Standard Deviations, and 95% Confidence Intervals for Time Spent in Light Intensity Physical Activity per Day at Each Time Point. M (minutes/day)

	Intervention Group			Control Group		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	315.05	150.57	[267.52, 362.58]	297.98	166.02	[245.57, 350.38]
2 weeks	338.83	239.73	[263.16, 414.50]	289.63	164.35	[237.76, 341.51]
4 weeks	378.80	247.77	[300.60, 457.01]	304.41	201.22	[240.90, 367.93]
6 weeks	365.12	235.56	[290.77, 439.47]	273.71	152.96	[225.43, 321.99]

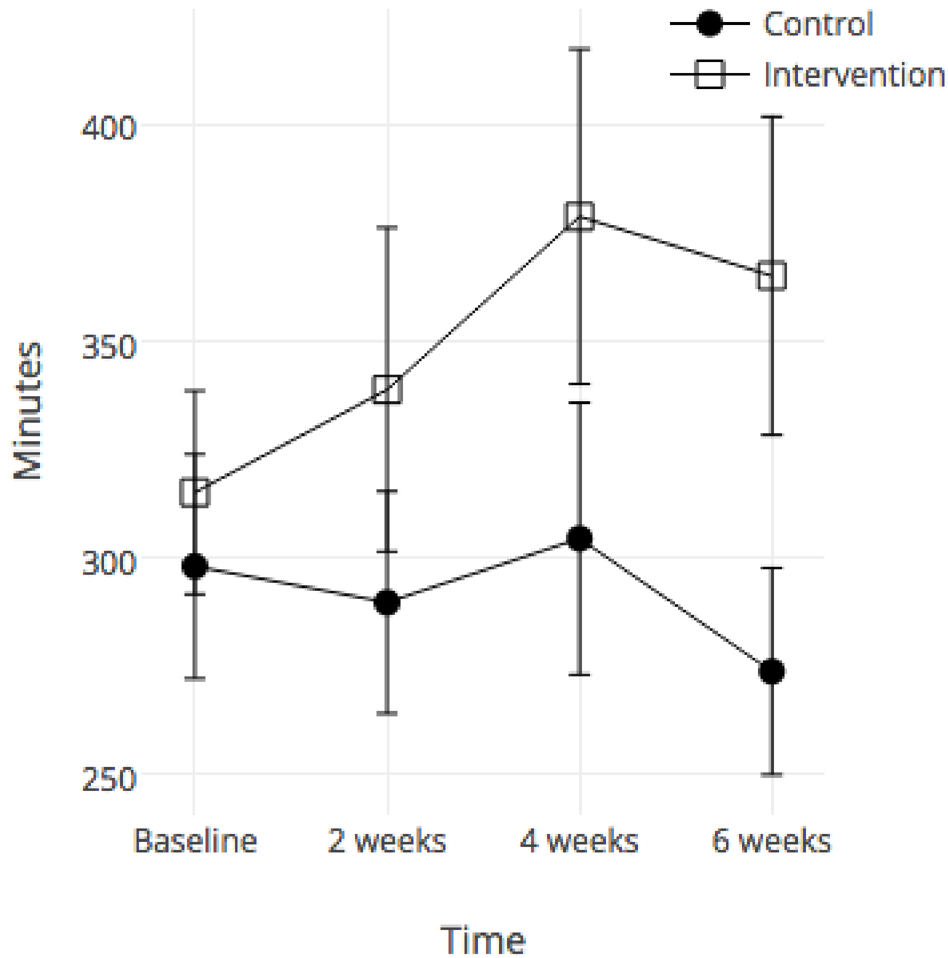

Figure 5: Time spent doing light intensity PA per day at each time point. Error bars represent standard error.

Table 7: Means, Standard Deviations, and 95% Confidence Intervals for Time Spent in Moderate Intensity Physical Activity at Baseline and After 6 weeks. M (minutes/week)

	Intervention Group			Control Group		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	184.15	269.40	[99.11, 269.18]	203.54	183.98	[145.47, 261.61]
6 weeks	275.37	267.04	[191.08, 359.65]	224.98	207.40	[159.51, 290.44]

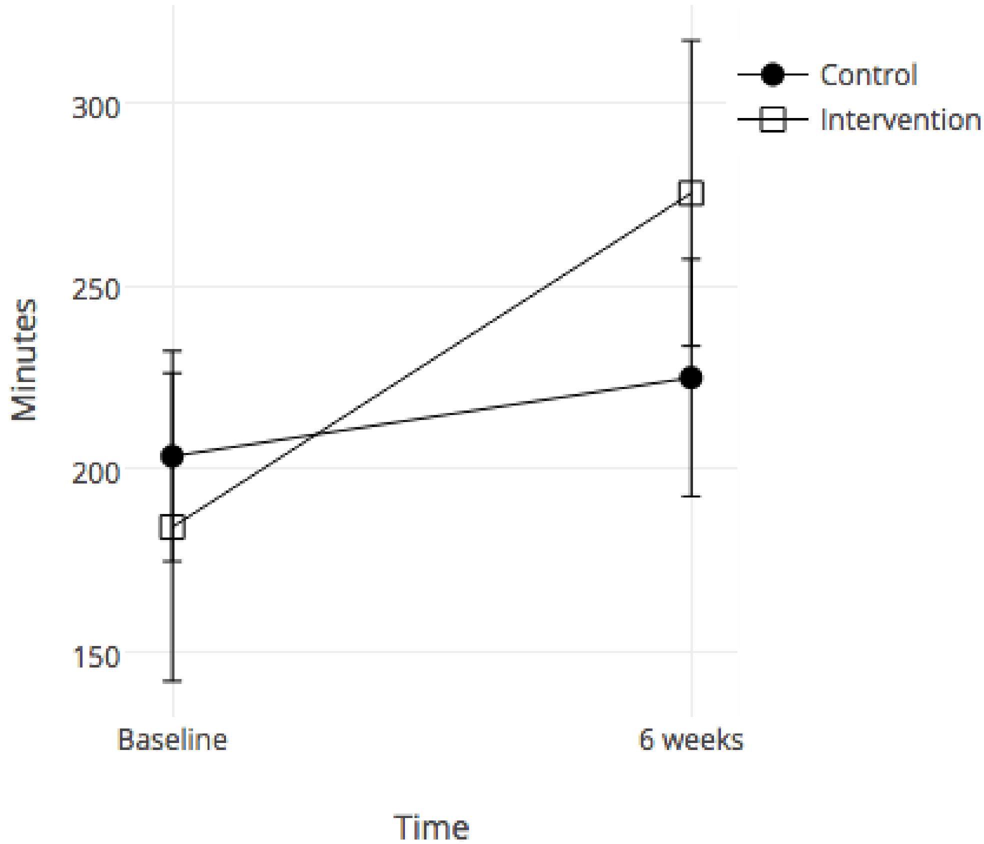

Figure 6: Time spent in MVPA per week at each time point. Error bars represent standard error.

Table 8: Means, Standard Deviations, and 95% Confidence Intervals for Self-Efficacy of Frequency of Breaks at Each Time Point. M (%)

	Intervention Group			Control Group		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	81.16	14.12	[76.70, 85.62]	77.84	16.22	[72.72, 82.96]
2 weeks	86.06	14.07	[81.62, 90.50]	76.15	18.71	[70.24, 82.06]
4 weeks	89.07	12.43	[85.15, 92.99]	84.52	14.35	[79.98, 89.05]
6 weeks	88.90	12.19	[85.05, 92.75]	82.18	14.50	[77.60, 86.76]

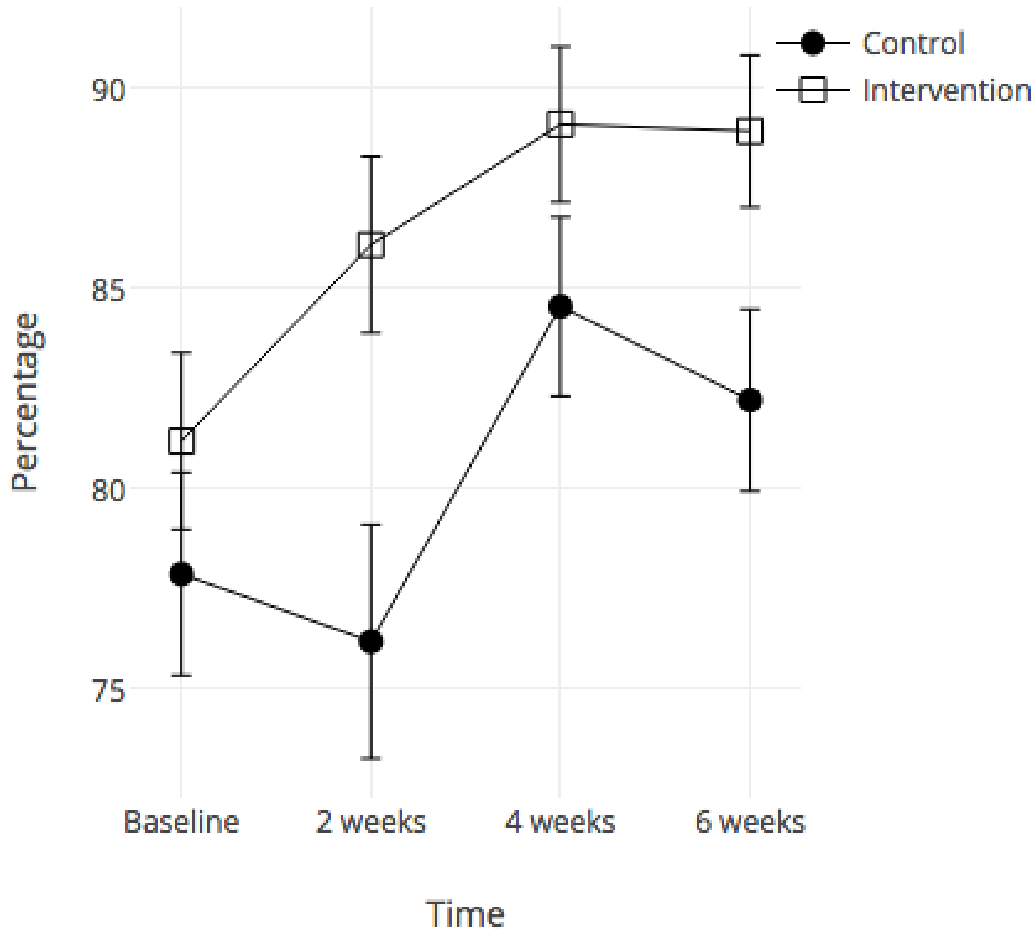

Figure 7: Confidence in taking more frequent breaks from sitting at each time point. Error bars represent standard error.

Table 9: Means, Standard Deviations, and 95% Confidence Intervals for Self-Efficacy of Length of Breaks at Each Time Point M (%)

	Intervention Group			Control Group		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	85.63	14.40	[81.08, 90.17]	82.39	16.16	[77.29, 87.50]
2 weeks	81.25	17.68	[75.67, 86.83]	78.68	16.91	[73.34, 84.01]
4 weeks	81.85	18.21	[76.10, 87.60]	80.61	16.69	[75.34, 85.88]
6 weeks	86.53	15.11	[81.76, 91.30]	81.02	17.17	[75.60, 86.44]

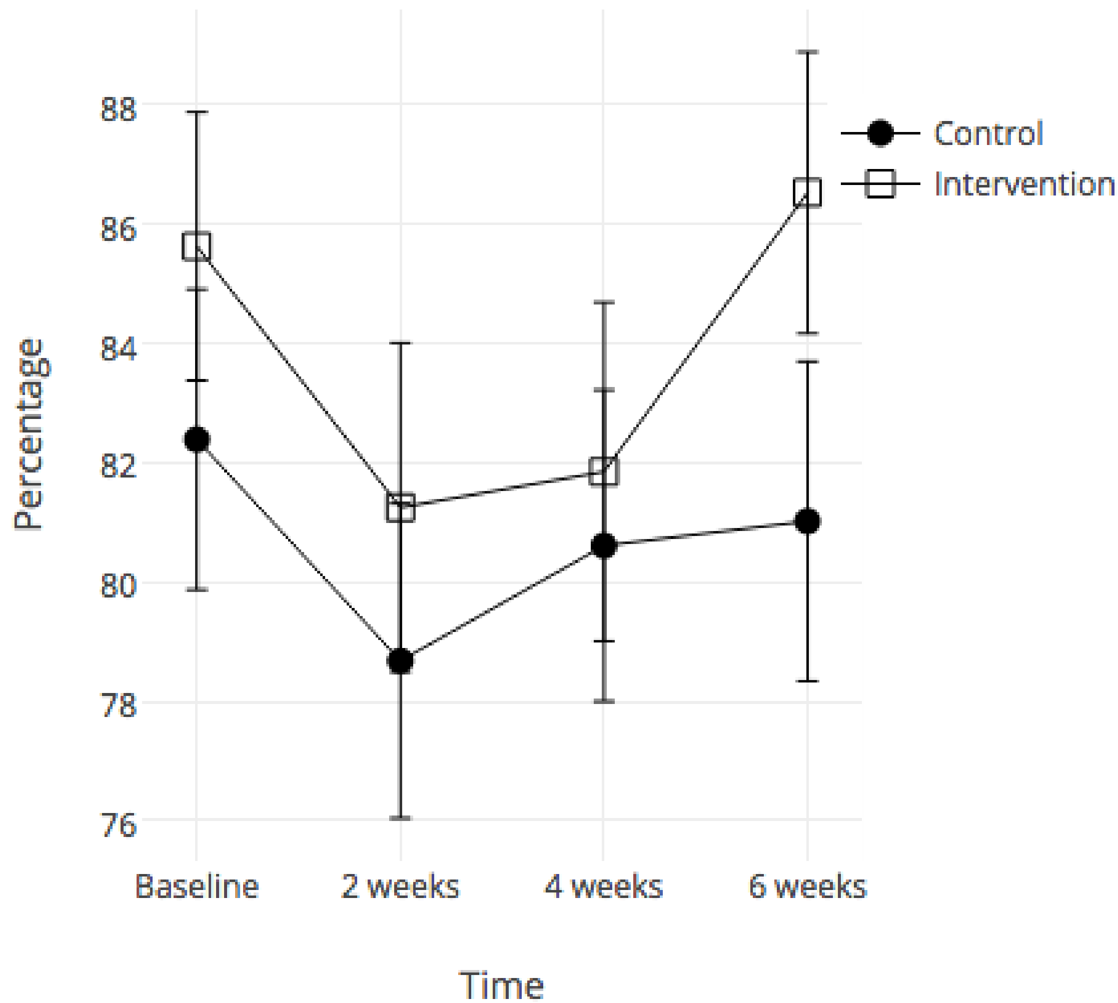

Figure 8: Confidence in taking longer breaks from sitting at each time point. Error bars represent standard error.

Table 10: Means, Standard Deviations, and 95% Confidence Intervals for Self-Efficacy of Decreasing Daily Sitting Time at Each Time Point. M (%)

	Intervention Group			Control Group		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	67.42	21.93	[60.42, 74.26]	64.61	21.26	[57.90, 71.32]
2 weeks	67.07	23.58	[59.63, 74.52]	69.11	17.03	[63.73, 74.48]
4 weeks	73.19	21.19	[66.50, 79.88]	69.57	18.12	[63.85, 75.29]
6 weeks	78.86	20.75	[72.31, 85.41]	70.92	18.12	[65.20, 76.64]

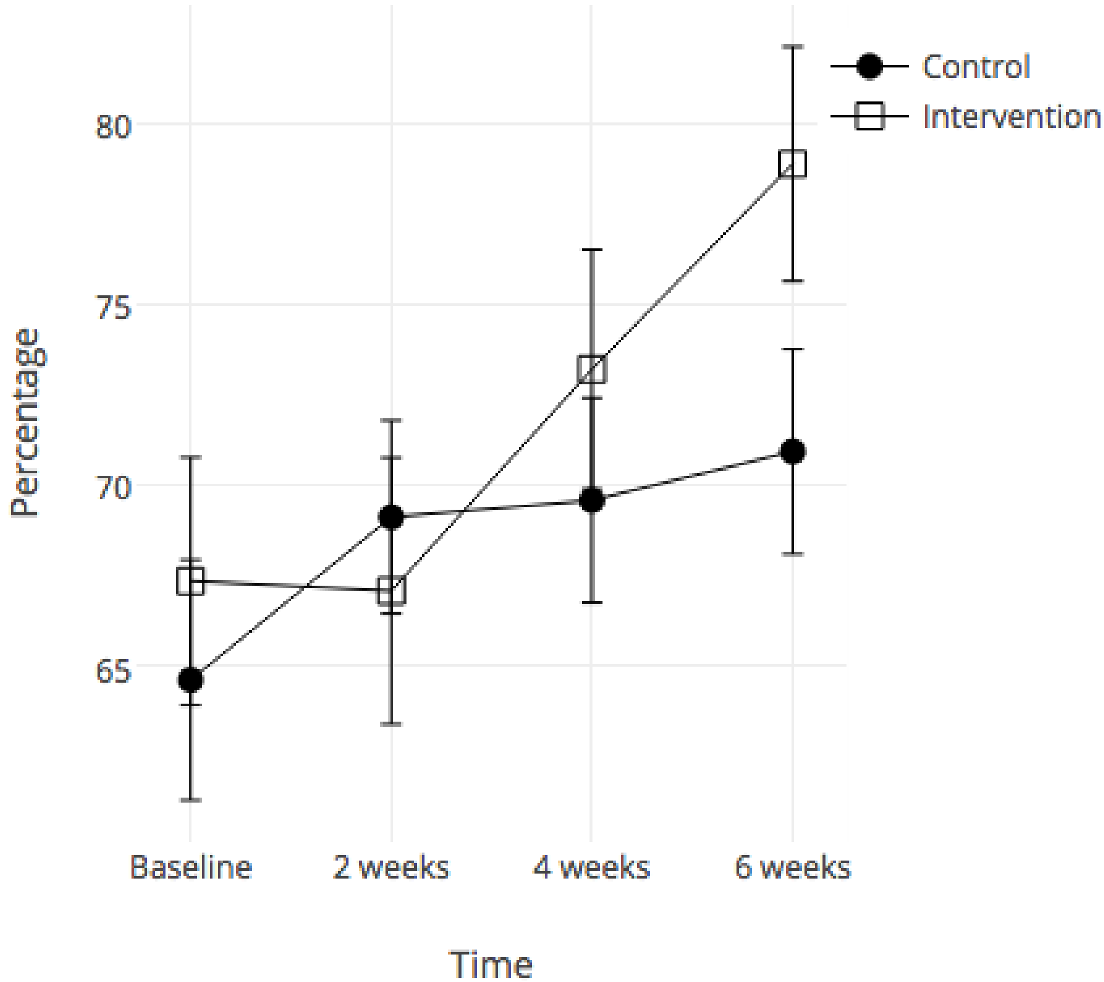

Figure 9: Confidence in reducing daily sitting time at each time point. Error bars represent standard error.

Table 11: Correlation between self-efficacy and target behaviours at baseline

	SE-BFreq.	SE-BLength	SE-SitLess	Break Freq.	Break Length	Stand	LIPA	MIPA
SE-BFreq.	-	.374**	.347**	-.576**	.130	.198	.174	.204
SE-BLength		-	.487**	-.091	.329**	.130	.258*	.032
SE-SitLess			-	-.093	.147	.125	.137	.123
Break Freq.				-	-.114	.079	.161	.064
Break Length					-	-.073	-.100	-.208
Stand						-	.665**	.251*
LIPA							-	.195
MIPA								-

**$p < 0.001$, * $p < 0.005$ Note: SE-BFreq. = self-efficacy for break frequency, SE-BLength = self-efficacy for break length, SE-SL = self-efficacy for sitting less

Table 12: Correlation between self-efficacy and target behaviours at 6 weeks

	SE-BFreq.	SE-BLength	SE-SitLess	Break Freq.	Break Length	Stand	LIPA	MIPA
SE-BFreq.	-	.478**	.585**	-.408**	.310**	.171	.157	.172
SE-BLength		-	.637**	-.367**	.560**	.163	.260*	.251*
SE-SitLess			-	-.398**	.347**	.219*	.318**	.336**
Break Freq				-	-.241*	-.128	-.180	-.146
Break Length					-	-.089	.194	.323**
Stand						-	.693**	.305**
LIPA							-	.396**
MIPA								-

**p < 0.001, * p < 0.005 Note: SE-BFreq. = self-efficacy for break frequency, SE-BLength = self-efficacy for break length, SE-SL = self-efficacy for sitting less

3 Discussion

The present study aimed to use text messages to increase (a) the frequency and length of breaks from sitting, (b) the amount of time spent standing, and (c) and the amount of time engaged in light and moderate intensity physical activity. The study also aimed to increase self-efficacy for breaks and for reducing overall sitting time. The study included an intervention group and a control group. The intervention group received text messages twice a day for 6 weeks that offered tips, reminders, facts and challenges to decrease sitting and increase light and moderate physical activity. The control group received daily text messages, which consisted of random health facts. Both groups filled out questionnaires at baseline, 2, 4, and 6 weeks. The questionnaires collected information on sitting time as well as standing, light intensity physical activity, moderate intensity physical activity, frequency and length of breaks from sitting, as well as three self-efficacy measures. Overall small to moderate effects that either approached or did not reach significance were found that consistently favored the text intervention group for all primary outcome behaviours. Irrespective of behaviour, the largest difference between treatment groups occurred at 6 weeks. Moderate to large effects that either approached or reached significance were also found consistently favoring the text intervention group for all self-efficacy constructs measured. Again, irrespective of self-efficacy measure, the largest difference between treatment conditions occurred at 6 weeks. Finally, significant relations were found when correspondence was high between the self-efficacious constructs and the primary outcome behaviours. Beyond these general observations the following specific issues warrant commentary.

Break Frequency and Length of Break from Sitting

Frequency of break from sitting increased by 23.05 minutes for the intervention group and only 8.41 minutes for the control group. This leaves a net difference of 14.64 minutes between groups, favouring the intervention group. Although this difference is not statistically significant, it could still be clinically meaningful as the intervention group is getting up to move around more frequently. Previous studies (Healy et al., 2008; Healy et al., 2011) often used objective measures to count number of breaks, rather than frequency of breaks; however, asking participants how many times they get up in a day would have been too difficult to track. Asking participants how long they typically sit before taking a break, represents a meaningful yet manageable estimate to make. Furthermore, measuring break frequency in this manner is in line with recommendations of getting people up and moving around every 30 to 60 minutes (Altenburg, et al., 2012; Healy et al., 2008).

Length of break from sitting increased by .78 minutes for the intervention group and by 0.19 minutes for the control group. This small non-significant increase is not surprising because the intervention was aiming at taking 3-6 minutes for every 30 minutes or 6-10 minutes every hour from sitting. The intervention group was above 6 minutes every hour, and thus behaving consistently with recommendations of previous research (Healy et al., 2008, Altenburg, et al., 2012).

Standing, Light and Moderate Physical Activity

The intervention group increased standing time by 18.25 minutes per day and the controls decreased standing by 6.05 minutes per day. This resulted in a non-significant net difference of 24.3 minutes per day favoring the intervention condition. The main focus of the text messages were replacing sitting with light to moderate physical activity rather than standing. Perhaps if more text messages had focused on increased standing per se, a larger net difference would have been shown. Time spent doing LIPA increased by 50.07 minutes/day for the intervention group and decreased by 24.27 minutes/day for the controls. This resulted in a net difference of 74.34 minutes per day that approached significance. With respect to time spent in moderate intensity physical activity, the intervention group had a larger increase with 91.22 minutes per week (13.03 minutes per day) compared to the control group who only increased by 21.44 minutes per week (3.06 minutes per day). This resulted in a net difference if 9.97 minutes per day favoring the intervention condition.

Previous studies have shown a range of increased standing time from 57 minutes per day (John et al., 2011), to 127 minutes per day (Healy et al., 2013). The current study only increased standing by 18.25 minutes/day. Studies which focused on increasing LIPA were successful in increasing it by 31 minutes/day after 4 weeks (Bond et al., 2014), 21 minutes/day after 6 months (De Greef, et al., 2011), and 39 minutes per day after 1 year (Koepp et al., 2013). The current study was able to increase LIPA by 50.07 minutes/day. One study that looked at standing and LIPA increase standing by 57 minutes/day and LIPA by 38 minutes/day for a total increase of 95 minutes after 9 months (John et al., 2011). The change seen in the current intervention had a combined increase in standing and PA of 81 minutes per day. Most studies focused on standing or LIPA; however, the study by Carr et al. (2013) also measured moderate intensity physical activity and found an increase of 8.8 minutes per day, a 2.2 minute increase in vigorous, along with an increase of 6.4 minutes of LIPA per day. The current study observed an increase of 13.03 minutes per day of moderate physical activity. Taken together, our findings provide evidence that text messaging as a way to increase standing, LIPA and MVPA is, for the most part, in line with other interventions. Failure for the net differences highlighted above to reach statistical significance is likely due to the variances of responses being widely dispersed around the means, and with the current sample size, left the analyses underpowered.

Taking more frequent and longer breaks from sitting means there should be an increase in non-sitting behaviours, and this is evident through the increase in time spent standing, and in light and moderate physical activity. To illustrate, during an 8-hour period of sitting, both groups would spend 39 minutes in breaks from sitting at baseline. At 6 weeks, the intervention group would spend an average of 60 minutes in breaks and the control group would spend an average of 45 minutes in breaks. The increase in frequency and length of time spent in breaks along with the increase in standing, LIPA and MIPA throughout the day may help explain what participants in this study are doing during their breaks. However the small and non-significant correlations found between breaks (frequency and length) and behaviour (standing and LIPA) suggest that there is not a direct 1:1 displacement occurring here. A moderate size and significant correlation was only found between break length and engagement in MIPA. This discrepancy of displacement may be due to participants choosing to spend more time in LIPA and MIPA outside of breaks from sitting, possibly instead of sitting at all, and thus their breaks may not have increased by as much as their physical activity levels.

Self-efficacy

Confidence to sit less increased by 11.44% in the intervention group and by 6.31% in the control group. This net difference of 5.13% reached statistical significance. Confidence to take more frequent breaks increased in the intervention group by 7.74% and 4.34% in the control group. This net difference of 3.4% approached statistical significance. Confidence to increase length of breaks from sitting increased by 0.90% in the intervention group and decreased in the control group by 1.37%. This net difference 2.27% approached statistical significance. Overall, the net differences were small and favored the intervention group. The interaction effects were either significant or approaching significance and could be due to the variances of responses being tightly centered around the mean, and thus any change, regardless of how small, is being picked up as significant.

At baseline and at 6 weeks, confidence to take more frequent breaks predicted significant amounts of variance in reported breaks. Also, confidence to take longer breaks predicted significant amounts of variance in reported break length. Efficacy towards increasing frequency and length of breaks was able to explain less variance in reported standing, LIPA and MIPA. These findings underscore the importance of scale correspondence between the cognition matching the targeted behaviour. Confidence to sit less was unrelated to breaks, standing, LIPA, and MIPA at baseline. However at 6 weeks, significant relationship emerged among these variables. This suggests that those who are more confident in being able to sit less will take longer and more frequent breaks, and spend more time standing, in LIPA and MIPA. It also could mean that those demonstrate these behaviours are more confident in sitting less. Future work should shed light on whether efficacious beliefs towards breaks and sitting less are antecedents or consequences of sitting less behaviours. Future work might also focus on developing scales that measure efficacious beliefs towards standing as well as using existing scales that measure efficacious beliefs towards LIPA and MIPA (Dishman, 1994; Marcus, & Simkin, 1993; Nigg, & Courneya, 1998; Sallis, & Hovell 1990).

Strengths and Limitations

The current study had several strengths, one being the use of a randomized control trial, which allowed for any observed effects in the intervention group to be compared to a control group. Another strength was using an equal contact design where both groups received text messages daily, to determine whether it was the content of the text or if it was simply receiving a text/attention from the researcher that caused any change in behaviours. A third strength was that this study provided a novel use of text messages for targeting sedentary behaviour, as they have been used for many other health behaviours in the past but not for specifically reducing sitting time. A further strength was the use of targeted and tailored text messages for the intervention group, based on the findings of studies looking at the most effective construction of messages. Another strength was measuring breaks in terms of frequency (i.e., every 60 minutes) rather than in numbers (i.e., 20/day), which makes it possible to directly compare the results with current recommendations for breaks.

As for limitations, the main one was the use of a subjective self-report measure of sedentary behaviour. Although the Sedentary and Light Intensity Physical Activity Questionnaire has been shown to be a valid and reliable measure in the past, and received acceptable reliability in the current study, it was problematic. Many people over-estimated how much time they spend doing various activities (which was shown when their days would add up to many more than 24 hours). This caused many data points to be extreme outliers and necessitated trimming them to a more reasonable value. The use of an objective measurement tool, such as an accelerometer, would allow for more accurate data as well as more valuable data. If the accelerometer was worn throughout the study, it would give an exact amount of time that was displaced from inactivity to other behaviours. It would also allow for the researchers to observe if the participants were actually utilizing the prompts from the texts by checking the data at the time the texts were received. If a text was sent that told them to get up and move around for 5 minutes, the researchers could examine the accelerometer data at that time and see if the participant did indeed move around for 5 minutes right away, if they were delayed, or if they did not move at all. As with most studies, it is hard to generalize the findings to populations outside of the one studied. Since the current study used students, it is unknown whether the same intervention could be used for other populations.

Another limitation was the study being advertised as a way to reduce sedentary behaviour, and thus participants in both groups self-selected into the study because they were highly motivated to change their behaviours. This may partially explain why large net differences were not found between intervention and control group participants.

A limitation for data analysis is the small sample size and therefore large variances (especially for the primary outcome variables) in the populations. Effects that may have been significant were washed out due to very high standard deviations around means, and these would be reduced with a larger sample size. In short, the study was underpowered for many of the positive effects favoring the intervention to reach statistical significance.

A further limitation is the length of the study. Text message studies for health behaviours have varied in length from 4 weeks to 1 year, with varying success for each length of study. The current study was 6 weeks in length, which may have limited the significance of the results, especially since the greatest differences between groups occurred at 6 weeks for all of the measures. If the study was longer there may have been stronger effects and findings may have become significant.

A final limitation is due to the design of the study. Each assessment time point was fairly long and likely contributed to participant loss due to the burden of filling out questionnaires every two weeks. The feedback collected at the end of the 6 weeks included many comments on the difficulty of estimating the time spent doing various activities throughout the day, which is an issue that would also be removed with the use of an accelerometer.

Future Directions

This study was conducted using a sample of university students, however it could easily be replicated using many other populations. Since cell phones are so common, anyone who uses one daily could benefit from this type of intervention. It could be adapted to specific groups, such as office workers, by having messages scheduled during their lunch breaks, or in the evenings, to remind them to get up and move around, rather than just sit in front of their computer or T.V. It could also be used for retired adults, to keep them active once they no longer have the daily routines that they had during the years they spent working. Another use of this type of intervention could be with those who have been hospitalized for accidents or illnesses that cause them to become sedentary during their medical care. Once these patients are well enough to start being mobile again, they could possibly benefit from text reminders to help motivate them to move, and return to active habits. Any future replications of the present study may want to add a 2^{nd} control group that receives no messages as both groups seemed to perform similarly, which may have been due to both groups receiving texts. A group that received no attention would help identify if the effect was due to receiving a text or the content of the messages.

Using messages similar to those from this intervention could be combined with existing technology to create other interventions that utilize fitness trackers, or smart-phone applications.

Conclusion

The present study provides evidence that facts, tips, reminders and challenges delivered in the form of text messages have potential to decrease sedentary behaviour in university students. It also shows cognitions on sedentary behaviour can be improved over time, which has potential implications for health behaviour change. Future research should be conducted using a larger sample size and objective measures to provide more robust evidence for the effectiveness of text messages in changing these targeted behaviours and cognitions.

References

Adams, M.M., Davis, P.G., Gill, D.L. (2013). A hybrid online intervention for reducing sedentary behavior in obese women. *Frontiers in Public Health,* 1: 45.

Ainsworth, B.E., Haskell, W.L., Whitt, M.C., et al. (2000). Compendium of physical activities: an update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise, 32*(9), S498–504.

Alkhajah, T.A., Reeves, M.M., Eakin, E.G., Winkler, E.A.H., Owen, N., Healy, G.N. (2012). Sit–stand workstations: a pilot intervention to reduce office sitting time. *American Journal of Preventive Medicine, 43*, 298–303.

Altenburg, T.M., Rotteveel, J., Dunstan, D.W., Salmon, J., Chinapaw, M.J. (2013). The effect of interrupting prolonged sitting time with short, hourly, moderate intensity cycling bouts on cardiometabolic risk factors in healthy, young adults. *Journal of Applied Physiology, 115*, 1751–1756

Arbman, G., Axelson, O., Fredriksson, M., Nilsson, E., Sjodahl, R. (1993) Do occupational factors influence the risk of colon and rectal cancer in different ways? *Cancer, 72*(9), 2543–2459.

Arem, H., Irwin, M.L., Zhou, Y., et al. (2011). Physical activity and endometrial cancer in a population-based case-control study. *Cancer Causes & Control, 22*(2), 219–226.

Bailey, D. P., & Locke, C. D. (2015). Breaking up prolonged sitting with light-intensity walking improves postprandial glycemia, but breaking up sitting with standing does not. *Journal of Science and Medicine in Sport*, *18*(3), 294-298. doi:http://dx.doi.org.proxy1.lib.uwo.ca/10.1016/j.jsams.2014.03.008

Bandura A (1997). *Self-Efficacy: The Exercise of Control*. New York, Freeman.

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior*, *31*(2), 143-164.

Barwais, F.A., Cuddihy, T.F., Tomson, L.M. (2013). Physical activity, sedentary behavior and total wellness changes among sedentary adults: a 4-week randomized controlled trial. *Health and Quality of Life Outcomes, 11*, 183.

Bey, L., Hamilton, M.T. (2003). Suppression of skeletal muscle lipoprotein lipase activity during physical inactivity: a molecular reason to maintain daily low-intensity activity. *Journal of Physiology, 551*(Pt 2), 673–82.

Bond, D. S., Thomas, J. G., Raynor, H. A., Moon, J., Sieling, J., Trautvetter, J., … Wing, R. R. (2014). *B-MOBILE* - A Smartphone-Based Intervention to Reduce Sedentary Time in Overweight/Obese Individuals: A Within-Subjects Experimental Trial. *PLoS ONE*, *9*(6), e100821.

Boyle, T., Fritschi, L., Heyworth, J., Bull, F. (2011). Long-term sedentary work and the risk of subsite-specific colorectal cancer. American Journal of Epidemiology, 173(10), 1183–1191.

Brendryen, H., Drozd, F., & Kraft, P. (2008). A Digital Smoking Cessation Program Delivered Through Internet and Cell Phone Without Nicotine Replacement (Happy Ending): Randomized Controlled Trial. *Journal of Medical Internet Research*, *10*(5), e51. doi:10.2196/jmir.1005

Canadian Society for Exercise Physiology. (2014). Sedentary behaviour guidelines. Retrieved from www.csep.ca/guidelines

Carr, L.J., Karvinen, K., Peavler, M., Smith, R., Cangelosi, K. (2013). Multicomponent intervention to reduce daily sedentary time: a randomized controlled trial. *BMJ Open, 3,* e003261.

Carson, V., Wong, S.L., Winkler, E., Healy, G.N., Colley, R.C., Tremblay, M.S. (2014). Patterns of sedentary time and cardiometabolic risk among Canadian adults. *Preventive Medicine, 65C*, 23–7. doi: 10.1016/j.ypmed.2014.04.005

Chastin, S. F. M., & Granat, M. H. (2010). Methods for objective measure, quantification and analysis of sedentary behaviour and inactivity. *Gait & Posture, 31*(1), 82-86. doi:http://dx.doi.org.proxy1.lib.uwo.ca/10.1016/j.gaitpost.2009.09.002

Chow, W.H., Dosemeci, M., Zheng, W., et al. (1993) Physical activity and occupational risk of colon cancer in Shanghai, China. *International Journal of Epidemiology, 22*(1), 23–29.

Cronbach L. (1951). Coefficient alpha and the internal structure of tests. *Psychomerika*, *16*, 297-334. 10.1007/BF02310555

Davis, K.G., Kotowski, S.E., Sharma, B., Herrmann, D., Krishnan, A.P. (2009). Combating the effects of sedentary work: postural variability reduces musculoskeletal discomfort. *Proceedings of the Human Factors and Ergonomics Society 53rd Annual Meeting*, pp. 884e886.

De Greef, K.P., Deforche, B.I., Ruige, J.B. et al. (2011). The effects of a pedometer-based behavioral modification program with telephone support on physical activity and sedentary behavior in type 2 diabetes patients. *Patient Education and Counseling*, *84*, 275–279.

Deliens, T., Deforche, B., De Bourdeaudhuij, I., & Clarys, P. (2015). Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health*, *15,* 201. doi:10.1186/s12889-015-1553-4

Dishman, R.K. (1994). The measurement conundrum in exercise adherence research. *Medicine & Science in Sports & Exercise, 26,* 1382–90.

Dixon, W. J., & Tukey, J. W. (1968). Approximate behavior of the distribution of Winsorized T (Trimming/Winsorization 2). *Technometrics. 10*, 83-98.

Dosemeci, M., Hayes, R.B., Vetter, R., et al. (1993). Occupational physical activity, socioeconomic status, and risks of 15 cancer sites in Turkey. *Cancer Causes & Control*, *4*(4), 313–321.

Duan, B. (1999). The robustness of trimming and winsorization when the population distribution is skewed. Available from PsycINFO. (619441973; 1999-95006-202)

Dunn, A.L., Marcus, B.H., Kampert, J.B., et al. (1999) Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness: a randomized trial. *Journal of the American Medical Association, 281*, 327–34.

Dunstan, D.W., Kingwell, B.A., Larsen, R., et al., (2012). Breaking up prolonged sitting reduces postprandial glucose and insulin responses. *Diabetes Care 35*(5), 976–983.

Ebara, T., Kubo, T., Inoue, T., Murasaki, G., Takeyama, H., Sato, T., Suzumura, H., Niwa, S., Takanishi, T., Tachi, N., et al., (2008). Effects of adjustable sit-stand VDT workstations on workers' musculoskeletal discomfort, alertness and performance. *Industrial Health, 46*, 497e505.

Ecclestone, N.A., Myers, A.M., Paterson, D.H. (1998). Tracking older participants of twelve physical activity classes over a three-year period. *Journal of Aging and Physical Activity*, *6*, 70–82.

Edwardson, C.L., Gorely, T., Davies, M.J., Gray, L.J., Khunti, K., et al. (2012). Association of sedentary behaviour with metabolic syndrome: a meta-analysis. *PLoS One, 7*, e34916.

Ekelund, U., Griffin, S.J., Wareham, N.J. (2007). Physical activity and metabolic risk in individuals with a family history of type 2 diabetes. *Diabetes Care, 30,* 337–342.

Fjeldsoe, B.S., Miller, Y.D., Marshall, A.L. (2010). MobileMums: a randomized controlled trial of an SMS-based physical activity intervention. *Annals Behavioral Medicine, 39*(2), 101–11.

Ford, E.S., Caspersen, C.J. (2012). Sedentary behaviour and cardiovascular disease: a review of prospective studies. *International Journal of Epidemiology, 41*, 1338–1353.

Friberg, E., Mantzoros, C.S., Wolk, A. (2006). Physical activity and risk of endometrial cancer: a population-based prospective cohort study. *Cancer Epidemiology & Biomarkers Prevention, 15*(11), 2136–2140.

Friedenreich, C.M., Cook, L.S., Magliocco, A.M., Duggan, M.A., Courneya, K.S. (2010). Case-control study of lifetime total physical activity and endometrial cancer risk. *Cancer Causes & Control, 21*(7), 1105–1116.

Fukuoka, Y., Vittinghoff, E., Jong, S., & Haskell, W. (2010). Innovation to motivation—pilot study of a mobile phone intervention to increase physical activity among sedentary women. *Preventive Medicine*, *51*(3–4), 287–289.

Gerhardsson, M., Norell, S.E., Kiviranta, H., Pedersen, N.L., Ahlbom, A. (1986). Sedentary jobs and colon cancer. *American Journal of Epidemiology, 123*(5), 775–780.

Gierach, G.L., Chang, S.C., Brinton, L.A., et al. (2009). Physical activity, sedentary behavior, and endometrial cancer risk in the NIH-AARP Diet and Health Study. *International Journal of Cancer, 124*(9), 2139–2147.

Grontved, A., Hu, F.B. (2011). Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: a meta-analysis. *Journal of the American Medical Association, 305*, 2448–2455.

Gunman, I., & Smith, D. E. (1969). Investigation of rules for dealing with outliers in small samples from the normal distribution. I: Estimation of the mean. *Technometrics. 15,* 385-404.

Hamilton, M.T., Hamilton, D.G., Zderic, T.W. (2004). Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exercise and Sport Sciences Reviews, 32*(4), 161–6.

Hamilton, M.T., Healy, G.N., Dunstan, D.W., Zderic, T.W., Owen, N. (2008). Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior. *Current Cardiovascular Risk Reports, 2*(4), 292–8

Hawkins, D. M. (1980). *Identification of outliers* (Vol. 11). London: Chapman and Hall.

Head, K. J., Noar, S. M., Iannarino, N. T., & Grant Harrington, N. (2013). Efficacy of text messaging-based interventions for health promotion: A meta-analysis. *Social Science & Medicine, 97*(0), 41-48. doi:http://dx.doi.org.proxy1.lib.uwo.ca/10.1016/j.socscimed.2013.08.003

Healy, G.N., Dunstan, D.W., Salmon, J., et al., 2007. Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. *Diabetes Care, 30*(6), 1384–1389.

Healy, G.N., Dunstan, D.W., Salmon, J., et al., (2008a). Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care*, *31*(4), 661–666.

Healy, G.N., Wijndaele, K., Dunstan, D.W., et al., (2008b). Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Life- style Study (AusDiab). *Diabetes Care*, *31*(2), 369–371.

Healy, G.N., Matthews, C.E., Dunstan, D.W., Winkler, E.A., Owen, N. (2011). Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003–06. *European Heart Journal*, *32*(5), 590–7.

Healy, G.N., Eakin, E.G., Lamontagne, A.D. et al. (2013). Reducing sitting time in office workers: short-term efficacy of a multicomponent intervention. *Preventive Medicine, 57*, 43–48.

Helmerhorst, H. J. F., Wijndaele, K., Brage, S., Wareham, N. J., & Ekelund, U. (2009). Objectively Measured Sedentary Time May Predict Insulin Resistance Independent of Moderate- and Vigorous-Intensity Physical Activity. *Diabetes, 58*(8), 1776–1779. doi:10.2337/db08-1773

Henson, J., Yates, T., Biddle, S.J. et al. (2013). Associations of objectively measured sedentary behaviour and physical activity with markers of cardiometabolic health. *Diabetologia, 56*, 1012–1020.

Howard, R.A., Freedman, D.M., Park, Y., et al. (2008). Physical activity, sedentary behavior, and the risk of colon and rectal cancer in the NIH-AARP Diet and Health Study. *Cancer Causes & Control, 19*(9), 939–953.

Husemann, B., Von Mach, C.Y., Borsotto, D., Zepf, K.I., Scharnbacher, J. (2009). Comparisons of musculoskeletal complaints and data entry between a sitting and a sit-stand workstation paradigm. *Human Factors*, *51*(3), 310e320.

John, D., Thompson, D.L., Raynor, H., Bielak, K., Rider, B., Bassett, D.R. (2011). Treadmill workstations: a worksite physical activity intervention in overweight and obese office workers. *Journal of Physical Activity and Health, 8,* 1034–1043

Katzmarzyk, P.T., Lee, I.M. (2012). Sedentary behaviour and life expectancy in the U.S.: a cause-deleted life table analysis. *BMJ Open*, *2*(4), pii:e000828.

Keating, X.D. (2005). A meta-analysis of college students Physical activity behaviors. *Journal of American College Health, 54*, 116-25.

Koepp, G.A., Manohar, C.U., McCrady-Spitzer, S.K., et al. (2013). Treadmill desks: a 1-year prospective trial. *Obesity (Silver Spring), 21*, 705–711

Kozey Keadle, S., Lyden, K., Staudenmayer, J. et al. (2014). The independent and combined effects of exercise training and reducing sedentary behavior on cardiometabolic risk factors. *Applied Physiology, Nutrition, and Metabolism, 39*, 770–780.

Kushi, L.H., Doyle, C., McCullough, M., et al. (2012). American Cancer Society Guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. *CA: A Cancer Journal for Clinicians, 62*(1), 30–67.

Lam, T.K., Moore, S.C., Brinton, L.A., et al. (2013). Anthropometric measures and physical activity and the risk of lung cancer in never-smokers: a prospective cohort study. *PLoS One, 8*(8), e70672.

Latimer, A. E., Brawley, L. R., & Bassett, R. L. (2010). A systematic review of three approaches for constructing physical activity messages: What messages work and what improvements are needed? *The International Journal of Behavioral Nutrition and Physical Activity, 7,* 36. doi:10.1186/1479-5868-7-36

Lepp, A., Barkley, J. E., Sanders, G. J., Rebold, M., & Gates, P. (2013). The relationship between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a sample of U.S. college students. *The International Journal of Behavioral Nutrition and Physical Activity, 10,* 79. doi:10.1186/1479-5868-10-79

Lynch, B.M. (2010). Sedentary behavior and cancer: a systematic review of the literature and proposed biological mechanisms. *Cancer Epidemiology, Biomarkers & Prevention, 19*(11), 2691–2709.

Maeda, H., Quartiroli, A., Vos, P. W., Carr, L. J., & Mahar, M. T. (2014). Feasibility of retrofitting a university library with active workstations to reduce sedentary behavior. *American Journal of Preventive Medicine, 46*(5), 525-528. doi:http://dx.doi.org.proxy1.lib.uwo.ca/10.1016/j.amepre.2014.01.024

Maibach, E., Flora, J., Nass, C. (1991). Changes in self-efficacy and health behavior in response to a minimal contact community health campaign. *Health Communication, 3,* 1-15.

Marcus, B.H., Simkin, L.R. (1993). The stages of exercise behavior. *Journal of Sports Medicine and Physical Fitness, 33,* 83–8.

McCullough, M.L., Patel, A.V., Kushi, L.H., et al. (2011). Following cancer prevention guidelines reduces risk of cancer, cardiovascular disease, and all-cause mortality. *Cancer Epidemiology, Biomarkers, & Prevention, 20*(6), 1089–1097.

Nerhood, H.L., Thompson, S.W., (1994). Adjustable sit-stand workstations in the office. In: *Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting*, pp. 668e671.

Neuhaus, M., Healy, G.N., Dunstan, D.W., Owen, N., Eakin, E.G. (2014). Workplace sitting and height-adjustable workstations: a randomized controlled trial. *American Journal of Preventive Medicine, 46,* 30–40.

Nigg, C.R., Courneya, K.S. (1998). Transtheoretical model: examining adolescent exercise behavior. *Journal of Adolescent Health, 22*, 214–24.

Obermayer, J. L., Riley, W. T., Asif, O., and Jean-Mary, J. (2004). College smoking cessation using cell phone text messaging. *Journal of American College Health 53*, 71–78. doi: 10.3200/JACH.53.2.71-78

Owen, N., Healy, G.N., Matthews, C.E., Dunstan, D.W. (2010). Too much sitting: the population health science of sedentary behavior. *Exercise and Sport Sciences Reviews, 38*(3), 105–13.

Patel, A.V., Feigelson, H.S., Talbot, J.T., et al. (2008). The role of body weight in the relationship between physical activity and endometrial cancer: results from a large cohort of US women. *International Journal of Cancer, 123*(8), 1877–1882.

Pew Internet and American Life Project. Trend data (teens). 2011. pewinternet.org/Static-Pages/Trend-Data-(Teens)/Teen-Gadget-Ownership.aspx.

Prestwich, A., Perugini, M., & Hurling, R. (2009). Can the effects of implementation intentions on exercise be enhanced using text messages? *Psychology & Health, 24*(6), 677–687.

Prestwich, A., Perugini, M., & Hurling, R. (2010). Can implementation intentions and text messages promote brisk walking? A randomized trial. *Health Psychology, 29*(1), 40–49.

Pronk, N.P., Katz, A.S., Lowry, M., Payfer, J.R. (2011). Reducing occupational sitting time and improving worker health: the Take-a-Stand Project. *Prevention of Chronic Diseases, 9,* E154.

Richardson, C. R., Mehari, K. S., McIntyre, L. G., Janney, A. W., Fortlage, L. A., Sen, A., et al. (2007). A randomized trial comparing structured and lifestyle goals in an internet-mediated walking program for people with type 2 diabetes. *International Journal of Behavioral Nutrition and Physical Activity*, *4*(1), 59.

Rimal, R. N. (2000). Closing the knowledge-behavior gap in health promotion: the mediating role of self-efficacy. *Health communication*, *12*(3), 219-237.

Rimal, R. N. (2001). Perceived risk and self- efficacy as motivators: Understanding individuals' long- term use of health information. *Journal of Communication, 51*(4), 633-654.

Sallis, J.F., Hovell, M.F. (1990). Determinants of exercise behavior. *Exercise and Sport Sciences Reviews, 11*, 07–30.

Schmid, D., & Leitzmann, M. (2014). Television Viewing and Time Spent Sedentary in Relation to Cancer Risk: A Meta-Analysis. *JNCI Journal of the National Cancer Institute, 106*(7): dju098 doi:10.1093/jnci/dju098

Shu, X.O., Hatch, M.C., Zheng, W., Gao, Y.T., Brinton, L.A. (1993). Physical activity and risk of endometrial cancer. *Epidemiology*, *4*(4), 342–349.

Shuval, K., Finley, C. E., Barlow, C. E., Gabriel, K. P., Leonard, D., & Kohl III, H. W. (2014). Sedentary behavior, cardiorespiratory fitness, physical activity, and cardiometabolic risk in men: The cooper center longitudinal study. *Mayo Clinic Proceedings, 89*(8), 1052-1062. doi:http://dx.doi.org.proxy1.lib.uwo.ca/10.1016/j.mayocp.2014.04.026

Simons, C.C., Hughes, L.A., van Engeland, M., et al. (2013). Physical activity, occupational sitting time, and colorectal cancer risk in the Netherlands cohort study. *American Journal of Epidemiology, 177*(6), 514–530.

Sjögren, P., Fisher, R., Kallings, L., Svenson, U., Roos, G., & Hellénius, M. L. (2014). Stand up for health—avoiding sedentary behaviour might lengthen your telomeres: secondary outcomes from a physical activity RCT in older people. *British Journal of Sports Medicine*, *48*(19), 1407-1409.

Tabachnick, B. G., & Fidell, L. S. (1996). *Using multivariate statistics* (3rd ed.). New York: Harper Collins.

Thorp, A.A., Owen, N., Neuhaus, M., Dunstan, D.W. (2011). Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996–2011. *American Journal of Preventive Medicine, 41*, 207–215.

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Applied Physiology, Nutrition, and Metabolism, 35*(6), 725-740.

Tudor-Locke, C., Bell, R. C., Myers, A. M., Harris, S. B., Ecclestone, N. A., Lauzon, N., & Rodger, N. W. (2004). Controlled outcome evaluation of the First Step Program: a daily physical activity intervention for individuals with type II diabetes. *International Journal of Obesity, 28*(1), 113-119.

Tukey, J. W., & McLaughlin, D. H. (1963). Less vulnerable confidence and significance procedures for location based on a single sample: Trimming/Winsorization I. *Sankhva. A, 25*, 331-325.

Ukawa, S., Tamakoshi, A., Wakai, K., et al. (2013). Prospective cohort study on television viewing time and incidence of lung cancer: findings from the Japan Collaborative Cohort Study. *Cancer Causes & Control*, *24*(8), 1547–1553. doi: 10.1007/s10552-013-0231-z.

Van der Ploeg, H. P., Chey, T., Korda, R. J., Banks, E., & Bauman, A. (2012). Sitting time and all-cause mortality risk in 222 497 Australian adults. *Archives of internal medicine, 172*(6), 494-500.

van Uffelen, J. G. Z., Wong, J., Chau, J. Y., van der Ploeg, H. P., Riphagen, I., Gilson, N. D., . . . Brown, W. J. (2010). Occupational sitting and health risks: A systematic review. *American Journal of Preventive Medicine, 39*(4), 379-388. doi:http://dx.doi.org.proxy1.lib.uwo.ca/10.1016/j.amepre.2010.05.024

Venn, A. J., Thomson, R. J., Schmidt, M. D., Cleland, V. J., Curry, B. A., Gennat, H. C., & Dwyer, T. (2007). Overweight and obesity from childhood to adulthood: a follow-up of participants in the 1985 Australian Schools Health and Fitness Survey. *Medical Journal of Australia, 186*(9), 458.

Wallace, L.S., Buckworth, J. (2003). Longitudinal shifts in exercise stages of change in college students. *Journal of Sports Medicine and Physical Fitness, 43*, 209–212.

Wallace, L.S., Buckworth, J., Kirby, T.E., Sherman, W.M. (2000). Characteristics of exercise behavior among college students: application of social cognitive theory to predicting stage of change. *Preventive Medicine, 31*, 494–505.

Weiderpass, E., Vainio, H., Kauppinen, T., et al. (2003). Occupational exposures and gastrointestinal cancers among Finnish women. *Journal of Occupational and Environmental Medicine*, *45*(3), 305–315.

Wilmot, E., Edwardson, C., Achana, F., Davies, M., Gorely, T., et al. (2012). Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia, 55*, 2895– 2905.

World Health Organization. 2010. Global recommendations on physical activity for health. World Health Organization. Geneva, Switzerland.

World Medical Association. (2013). World medical association declaration of Helsinki: Ethical principles for medical research involving human subjects.

Journal of American Medical Association, 310(20), 2191-2194. doi:10.1001/jama.2013.281053

Appendix A

Recruitment E-mail

Subject Line: Invitation to participate in research to reduce sedentary behaviour

You are being invited to participate in a study that we, Emma Cotten and Dr. Harry Prapavessis are conducting that is looking at reducing sedentary behaviour using text messages. It will be starting at the beginning of January and if you are looking to make a resolution to be healthier in the New Year, this could help! We are looking for 150 students who will be asked to fill out a few questionnaires and give their cell phone number. You will then receive daily text messages for 6 weeks (starting around Jan. 5th). There will be a draw at the end of the study for 3 $100 prizes, if you complete the entire study you get more chances to win! We are hoping to do some pre-recruitment in order to get things started right away in January so if you are interested please e-mail Emma at ********* with your first name, last initial, and cell phone number.
The letter of information about this study is attached, and if you would like to know more about this study please contact the researcher (Emma) at the following e-mail addres: *****

Thank you,
Emma Cotten

Ethics Approval

Western Research

Research Ethics

Western University Health Science Research Ethics Board
HSREB Full Board Initial Approval Notice

Principal Investigator: Prof. Harry Prapavessis
Department & Institution: Health Sciences\Kinesiology,Western University

HSREB File Number: 105615
Study Title: Reducing Sedentary Behaviour Using Text Messages
Sponsor:

HSREB Initial Approval Date: November 04, 2014
HSREB Expiry Date: May 31, 2015

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Instruments	Example text messages to be sent - Intervention group	2014/07/18
Instruments	Questionnaires	2014/08/16
Recruitment Items	Recruitment poster	2014/08/16
Instruments	Random Facts Texts PDF	2014/10/05
Letter of Information	LOI PDF	2014/10/05
Recruitment Items	Student Recruitment E-mail	2014/10/05
Recruitment Items	E-mail to administrative assistants of various departments	2014/10/05
Recruitment Items	E-mail to administrative assistants of various departments	2014/10/05
Western University Protocol	Western Protocol	2014/08/16

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review. If an Updated Approval Notice is required prior to the HSREB Expiry Date, the Principal Investigator is responsible for completing and submitting an HSREB Updated Approval Form in a timely fashion.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Ethics Officer, on behalf of Dr. Joseph Gilbert, HSREB Chair

Ethics Officer to Contact for Further Information

[redacted]

This is an official document. Please retain the original in your files.

Letter of Information

Study Title: Reducing Sedentary Behaviour Using Text Messages

Principal Study Investigator:

Harry Prapavessis, Ph.D. (School of Kinesiology, The University of Western Ontario)

Co-Investigator:

Emma Cotten, B.A. (Department of Psychology, University of Waterloo)

LETTER OF INFORMATION

You are being invited to participate in a research study examining the effects of a text-message based intervention aiming at reducing sedentary behaviour. You are being asked to participate because we are looking at a population of students between the ages of 18 to 64 who are prone to sitting for prolonged periods. The purpose of this letter is to provide you with the information required to make an informed decision on participating in this research. Please take the time to read this carefully and feel free to ask questions if anything is unclear.

Purpose of the Study
The purpose of the study is to use text messaging as a way to decrease sedentary behaviour.

The rationale behind this study is in response to the current research indicating that too much sitting can increase certain health risks despite meeting physical activity guidelines. Some of the health risks include cardiovascular disease, mortality, type II diabetes, and obesity. Some interventions have proven successful at reducing sitting time but very few have looked at using text messages as a means of doing so.

Participants
150 students will be recruited from multiple faculties from Western University and Mohawk College. To be eligible to participate, you must meet the following criteria: (a) 18 to 64 years of age (b) Be able to read and write in English (c) Own and be able to operate a cell phone that has texting capability and unlimited incoming text messages as part of your cell phone plan.

Research Procedure

If you choose to take part in this study, you will be asked to complete a questionnaire package online during your own time, which should take no longer than 40 minutes. The questionnaire is not a test, and you are free from answering any questions you are uncomfortable with. Following the completion of the questionnaire package you will then begin to receive daily text messages. The text messages will include messages about the benefits of reducing sitting time as well as reminders to get up and walk around. You will be scheduling the approximate time of delivery and general content of these messages as part of the questionnaire package. Text messages will be sent from the time you begin the study to the end of classes for the fall school term. If at any time you want to stop getting text messages you may e-mail the researcher to request being removed from the study. Approximately every 2 weeks and at the end of the study you will receive an e-mail to fill out the same questionnaire package.

On the SoSci website, you will complete a questionnaire package that contains four items: socio-demographics (Item 1), Sedentary Behaviour Questionnaire (Item 2), modified Sedentary Behaviour Questionnaire (Item 3), a Sedentary Habit questionnaire (Item 4), a Self-Efficacy and Sedentary Behaviour questionnaire (Item 5) and a questionnaire about the actual text messages you will be receiving (Item 6).

Experimental Description (Items 1-6)

1. Demographic Questionnaire
Time involvement: 1-2 minutes
Demographic questions (e.g. gender, age, ethnicity, faculty affiliation, etc.) will be asked in order to better characterize the sample. Your name will also be asked in order to personalize the text messages.

2. The Seven Day Physical Activity Recall Questionnaire
Time involvement: 3-5 minutes
Will be used to measure current levels of physical activity (type, duration and intensity of physical activity) over the previous seven days.

3. Sedentary Behaviour Questionnaire
Time involvement: 7-10 minutes
The Sedentary Behaviour Questionnaire measures the quantity of time spent doing 9 behaviours (watching television, playing computer/video games [volitional use], sitting while listening to music, sitting and talking on the phone, doing paperwork or office work [non-volitional use], sitting and reading, playing a musical instrument, doing arts and crafts, sitting and driving/riding in a car, bus, or train to get to work or school). For the purpose of this study, this questionnaire was modified to be more comprehensive and include the following additional sedentary activities: driving/riding in a car, bus, or train for leisure-related transportation purposes, sitting and eating, sitting for religious or spiritual pursuits. These items are presented for a typical weekday and for a typical

weekend day. Response options include: none, 15 minutes or less, 30 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7 hours, 8 hours or 9 hours or more.

4. Sedentary Habit Questionnaire.
Time involvement: 7-10 minutes
The Sedentary Habit Questionnaire has been modified from the Exercise Habit Questionnaire but contains similar 23 items that is designed to assess automaticity, patterned action, negative consequences, cue-driven, and amotivation regarding the behaviour (i.e. sedentarism). Responses will be made on a 6-point bipolar scales, anchored by "not true for me" and "very true for me".

5. Self Efficacy & Sedentary Behaviour Questionnaire
Time involvement: 4-5 minutes
You will be asked about your confidence in being able to take breaks from sitting as well as the amount of time you spend in different levels of activity.

6. Text message details
Time Involvement: 5-10 minutes
You will also schedule when you would like to receive text messages, and the number of text messages per day you would like to receive, between 1-3.

Risks

Anticipated risks or discomforts associated with participating in this study include disruption of your personal time. These feelings are normal and should be momentary.

Benefits

You may not directly benefit from participating in this study but information gathered may provide benefits to society as a whole which include the ability to develop text message interventions to reduce sedentary behaviour.

Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your academic status. If you decide to take part you will be given this Letter of Information to . If you withdraw from the study, you maintain the right to request that any data collected from you not be used in the study. If you make such a request, all of the data collected from you will be destroyedIf you are participating in another study at this time, please inform the study researchers right away to determine if it is appropriate for you to participate in this study.

Confidentiality

We will be collecting information from 150 participants for this study. All the information you provide to the researcher will be kept in the strictest confidence. All data will be stored on a university local hard drive accessible only to research staff in a secure office. Email addresses will be stored on a master list separate from the data on an electronic file that is password protected. No information obtained during the study will be discussed with anyone outside of the research team.

Representatives of the Western University Health Sciences Research Ethics Board and regulatory bodies (Health Canada) may contact you or require access to your study-related records to monitor the conduct of the research. If we find information we are required by law to disclose, we cannot guarantee confidentiality. We will strive to ensure the confidentiality of your research-related records. Absolute confidentiality cannot be guaranteed, as we may have to disclose certain information under certain laws.

Compensation

By signing up for this study you will be entered into a draw to win 1 of 3 $100 gift cards.

Appendix B

Demographics

What is your first name?

What is your last initial?

With which gender do you identify?

How old are you?

What is your ethnicity?

How tall are you?

How much do you weigh?

What type of student are you?

How many hours of class do you have per week?

How many hours do you work per week?

Physical Activity Recall

Moderate activity is activity, which feels similar to a brisk walk.

Hard activity is activity, which feels harder than a brisk walk.

Very hard activity is activity, which feels similar to running or jogging.

1. Number of minutes spent last week doing moderate activity: _____
2. Number of minutes spent last week doing hard activity: _____
3. Number of minutes spent last week doing very hard activity: _____
4. Number of days with 30 minutes or more of hard or very hard activity:__
5. Number of days with 30 minutes or more of moderate, hard or very hard activity:__

Self-Efficacy for break frequency

Please select the most accurate percentage from the pull down menus for each statement.

I am ___% confident I can take a break from sitting every 240 minutes (4 hours)

I am ___% confident I can take a break from sitting every 180 minutes (3 hours)

I am ___% confident I can take a break from sitting every 120 minutes (2 hours)

I am ___% confident I can take a break from sitting every 90 minutes (1 hour 30)

I am ___% confident I can take a break from sitting every 75 minutes (1 hour 15)

I am ___% confident I can take a break from sitting every 60 minutes (1 hour)

I am ___% confident I can take a break from sitting every 45 minutes

I am ___% confident I can take a break from sitting every 30 minutes or less

Current break frequency

I currently take a break to get up and move around for every ____ minutes I spend sitting. (For example, if you normally get up once every hour to move around, choose 60).

○	○	○	○	○	○	○	○
240 or more	180	120	90	75	60	45	30 or less

Self-Efficacy for length of break

Please select the most accurate percentage from the pull down menus for each statement.

I am ___% confident I can increase the length of my breaks from sitting by 30 seconds.

I am ___% confident I can increase the length of my breaks from sitting by 1 minute.

I am ___% confident I can increase the length of my breaks from sitting by 2 minutes.

I am ___% confident I can increase the length of my breaks from sitting by 3 minutes.

I am ___% confident I can increase the length of my breaks from sitting by 4 minutes.

I am ___% confident I can increase the length of my breaks from sitting by 5 minutes.

I am ___% confident I can increase the length of my breaks from sitting by 10 minutes.

I am ___% confident I can increase the length of my breaks from sitting by 15 minutes.

Current length of break

Currently, which number best represents the length of your breaks you usually take from sitting.

○	○	○	○	○	○	○	○
30 seconds or less	1 min	2 mins	3 mins	4 mins	5 mins	10 mins	15 mins

Self-Efficacy to sit less

Please select the most accurate percentage from the pull down menus for each statement.

I am ___% confident I can decrease the amount of time I sit every day by 20 minutes.

I am ___% confident I can decrease the amount of time I sit every day by 30 minutes.

I am ___% confident I can decrease the amount of time I sit every day by 45 minutes.

I am ___% confident I can decrease the amount of time I sit every day by 60 minutes.

I am ___% confident I can decrease the amount of time I sit every day by 75 minutes.

I am ___% confident I can decrease the amount of time I sit every day by 90 minutes.

Sedentary and Light Intensity Physical Activity Questionnaire

Please fill out how many minutes you spend doing the following things for a typical weekday. If you don't spend any time doing an activity, please put 0.

1. Sitting- studying, writing, desk work, typing? __ minutes

2. Standing at school or work – miscellaneous? __ minutes

3. Walking at school, (between class, or on campus) very slow? __ minutes

4. Standing – light work (filing, talking, assembling)? __ minutes

5. Riding in a car or bus? __ minutes

6. Driving a car (sitting)? __ minutes

7. Walking from house to car or bus, from car or bus to go places? __ minutes

8. Light cleaning? __ minutes

9. Wash dishes – standing? __ minutes

10. Standing at home – miscellaneous? __ minutes

11. Cooking or food preparation? __ minutes

12. Standing quietly (standing in a line)? __ minutes

13. Shopping? __ minutes

14. Walking very slowly? __ minutes

15. Lying quietly, watching television? __ minutes

16. Reclining – writing, talking or talking on phone, reading? __ minutes

17. Sitting – using a computer, card playing, playing board games? __ minutes

18. Sitting quietly and watching television, listening to music, reading? __ minutes

19. Standing – talking or talking on the phone? __ minutes

List of text messages sent to intervention group

Hi Name12345, welcome to the study. You will be receiving texts with challenges, tips and reminders every day for the next 6 weeks.

Wondering why reducing sitting time is so important? By breaking up your sitting time, you can reduce your risk of heart disease.

For the next seven days, your challenge is to make sure outside of class and meetings you get up at least once every hour.

If you've been sitting for more than an hour it is time to get up and move around! Right now!

Keep remembering to get up every hour. Try walking around or doing some light stretching while standing.

Hey Name12345, take a break from all that studying... Or TV watching. Get up and stretch your legs.

On top of getting up every hour, your challenge for today is to replace 20 minutes of sitting with walking. Walk to school instead of

Have you gone for a walk yet today? It's not too late if you haven't!

Just because it's the weekend doesn't mean it's time to be totally lazy. Keep breaking up your sitting every hour and try to replace an

Are you watching TV? Be sure to take a break between episodes to get up and move around!

Make sure to get that walk in today and to avoid sitting for more than an hour at a time. You got this!

Your challenge for tomorrow is to do 30 squats for every episode of TV you watch. Choose your shows wisely!

Hey Name12345, make sure you are keeping track of any TV you watch today so you get enough squats in.

Tomorrow be sure to replace 20 minutes of sitting with walking again. If it's easier, you can break it up into smaller amounts.

Are those legs sore from all the squats yesterday? Stretching is a great way to fix that!

Get up and stretch or walk around every hour.

Need a tip to sit less? Try walking to school or the store if you live close enough, or if you drive, park further away from where you are

Here is another reason to sit less: taking a break from sitting to walk around or do some light stretching can help strengthen your bones.

Your 7 day callenge is to get up for at least 3 minutes every hour. Start a timer, put on a 3 minute song or if you are really bored,

Good morning Name12345, make sure you are getting up every hour and staying up for 3 minutes today!

It's almost the weekend. To celebrate, go for a nice, long, 40 minute walk tomorrow. It'll help you destress from the week!

TGIF, am I right? Keep getting up every hour for 3 mins today, and don't forget about that walk! It'll be good for you.

This weekend aim to replace an hour and a half of sitting time with walking or exercise. That's only 45 minutes a day! Easy!

Have you been spending a long time on the computer today? For every hour you spend online, try to go for a 20 minute walk. Or skip

Time to get up, especially if you've been sitting for a while! Go run up and down some stairs or do some jumping jacks for a few minutes!

Don't forget about that 45 minutes of exercise today. Maybe some fresh air will help clear your mind for the upcoming week.

Continue breaking up your sitting every hour with at least a 3 minute break for the next few days. Squats, lunges and jumping jacks

It's been 2 weeks! Check your e-mail for the next questionnaire, it should only take 20 minutes. Why not do it standing up?

Tomorrow, try to replace as many sedentary activities with active ones! Text or e-mail standing up, take the stairs instead of elevator,

Reminder to complete the 2 week questionnaire if you have not done so yet!

Hey Name12345, hope you were able to make a lot of active choices today! Keep it up and soon they will become great healthy habits!

You're going to want to stand up to read this one! Studies show we sit for an average of 7.7 hours/day, with some of us sitting for up to

For the next 7 days aim to get up every 45 minutes outside of class time and stay up for 4 minutes.

Keep up with those 4 min breaks every 45 minutes and on top of that try to replace 60 minutes of sitting a day with exercise. An hour

Hey Name12345, are you starting to feel groggy or tired? Try taking a short walk to wake up.

If working out isn't for you and you still need ideas to sit less, try some pick up sports at the gym, doing yoga or even just going for a walk, it'll

Get up! Do some jumping jacks, walk around or stretch. Your body will thank you.

For every 45 mins you spend studying (or watching TV) this week, give your brain a break and do some light exercise or walk around.

As Bob Marley says, "Get up, Stand up, Stand up for your health". Okay those aren't quite the lyrics, but you get it. Stand up!

Next time you finish reading a page in your textbook, or next commerical take a break to walk around.

If you ever find yourself sitting for a long time during class or a meeting, consider making up for it by sitting less, later.

Those who sit for 3 hours or more per day watching TV are 64% more likely to die from heart disease. This includes watching TV online!

I hope you didn't think I'd give you a scary fact without a tip on how to avoid it! From now on, your challenge is to increase your breaks

Here's a tip to decrease your sitting time: if you ride the bus to work or school try standing instead of sitting.

On top of yesterday's challenge, try to replace 80 minutes of time usually spent sitting (before these texts changed your life) with walking

Pick 5 exercises (squats, lunges, jumping jacks, calf raises, push-ups, etc.) and do each one for a minute during one of your breaks.

Watching a show? Make it a rule to get up for 5 minutes between episodes, whether it’s on TV, online or Netflix!

This weekend try to get in 90 minutes of walking or exercise each day during times that would normally be spent sitting.

If you've been sitting for a while it's time to get up! Move around for 5 minutes before you sit down again.

How's that weekend exercise coming? It may seem daunting but you'll feel much better afterwards!

Hope you had a great, active break. Please check your e-mail for the week 4 questionnaire!

For every half hour of time spent online today, on your phone or computer, do 5 minutes of exercise! Pick whatever form of exercise

If you haven't filled out the questionnaire yet please do so today!

Got a break between classes? Go for a walk around campus, or explore some of the underground passages instead of sitting down.

Breaking up your sitting time can reduce your risk for certain types of cancer. You have more control over our health than you think!

With there only being 2 weeks left of these texts it's time to make sure you are on track with the recommendations for sitting.

For the next 7 days your challenge is to replace 80 minutes a day of sitting with any type of exercise.

How has taking more frequent breaks from sitting been? Hopefully it makes you feel energized and less lazy!

This weekend try to replace 2 hours a day of sitting with any type of activity. Maybe your room needs some tidying up,

Weekends usually mean a whole lot more sitting, try to limit it as much as possible. You can still have fun and relax, just find a way to

Got some errands to run this weekend? One way to replace sitting is to walk to as many places as you can instead of driving or bussing.

If you are still having trouble finding a way to stop sitting, grab a friend or a roommate and go for a walk together, or to the gym!

Tomorrow your challenge is to do 5 squats for every minute you spend on Facebook, or Instagram, etc. Maybe it'll make your more

Don't forget about your squat challenge. Monitor your time closely and if you underestimate you're only lying to yourself!

For the last 7 days your challenge is to replace 100 minutes of sitting with walking or activity each day. This may seem like a lot, but if

If you don't have time for a long walk every day, break up the 100 minutes throughout the day. Your body will thank you for getting up

Is that 100 minutes still feeling overwhelming? If you get up every 30 minutes for a 5 min break during your free time, that counts for

Hey name12345, it's been 6 weeks, please check your e-mail for the final questionnaire. Time to keep up these goals on your own.

If you haven’t done the questionnaire yet please do it ASAP. Once you’re done, why not go stretch your legs on a nice walk outside?

List of text messages sent to control group

Welcome to the study. You will now be receiving daily texts with health facts and tips for the next 6 weeks.

Over half of Canadian adults are overweight or obese. This is mainly due to poor eating and exercise habits. Let's try to change that!

One can of pop contains 10 teaspoons of sugar. If you drink pop try to cut it down to once a week or less!

Sweet potatoes contain calcium, are high in Vitamins A & C and contain thiamine. Try some sweet potato fries instead of regular ones.

Of the 206 bones in the average human adult's body, 106 are in the hands and feet. (54 in the hands and 52 in the feet)

Green-tipped bananas are healthier than over-ripe ones but instead of throwing brown ones out, peel them & freeze them for smoothies!

Sleep helps strengthen your memory, so if you are preparing for an exam be sure to get enough sleep once you're done studying!

The attachment of the human skin to muscles is what causes dimples.

Broccoli contains almost twice as much vitamin C as an orange. Don't replace your orange juice with broccoli juice in the morning, but add some to your dinner tonight.

Having trouble eating enough veggies? Try throwing some greens into a smoothie, you won't taste it but you'll still get the benefits!

Right-handed people live, on average, nine years longer than left-handed people. The world just wasn't built for left-hands!

Avocados are rich in monounsaturated fat, which is easily burned for energy. Add some to your salads or make some guacamole!

Want a healthier alternative to pasta? Try spaghetti squash, once cooked it comes out looking just like spaghetti. Top it with your fav sauce for a delicious dinner.

In 1977, a 13 year old child found a tooth growing out of his left foot. Wonder if he went to a dentist or a podiatrist to get it out..

Asparagus is a good source of vitamins A, C, E and B, plus contain potassium and zinc. Try them grilled for dinner this week!

You are about 1 centimeter taller in the morning than in the evening. Our days literally weigh us down.

Tomatoes are an excellent source of vitaminc C which is most concentrated in the jelly-like substance around the seeds.

Kale is an excellent source of calcium, iron and vitamins A & C. Mix it with other greens for an extra healthy salad.

Between 25% to 33% of the population sneeze when they are exposed to light.

Raw pumpkin seeds contain essential fatty acids and beneficial proteins. Try some on a salad.

Onions are nutritionally optimal raw and or lightly steamed, so if you can put up with onion breath, go for it!

Curriculum Vitae

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Post-secondary Education and Degrees:	University of Waterloo Waterloo, Ontario, Canada **Bachelor of Arts**, Honours Psychology 2009-2013
	Western University London, Ontario, Canada **Master of Arts**, Kinesiology, Exercise and Health Psychology 2013-2015
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