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STANDING UP TO SEDENTARY BEHAVIOUR; EVALUATING THE UTILITY OF BEHAVIOURAL CHOICE THEORY

by

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Acknowledgements

Abstract

Background: Prolonged time spent sedentary has been linked with numerous adverse health outcomes. However sedentary-reducing interventions are sparse and none measure the effectiveness of behaviour change theories being employed.

Purpose: To evaluate the utility of an intervention governed by behavioural choice theory to reduce and break up sedentary time among adults.

Methods: Participants (N=45; 62% female; 18-65 years) wore the ActiGraph wGT3X-BT accelerometer to objectively measure sedentary behaviour for 7 days at baseline. Participants were then randomised into 3 groups (intervention n=15, prompt n=15 or control n=15). Participants continued wearing the ActiGraph wGT3X-BT during the intervention phase for a further 7 days, where they would either receive messages governed by behavioural choice theory (intervention), receive neutral messages (prompt), or receive no messages (control).

Results: A non-statistically significant reduction of 0.63% in time spent in sedentary was seen in the intervention group after 1 week of intervention No significant between-group differences were observed attributed to being underpowered. Compliance with the study was very high as 90% of participants fulfilled minimum accelerometer wear time requirements.

Conclusions: This study demonstrated a practical methodological approach to evaluate the effectiveness of an intervention underpinned by behavioural choice theory to bring out reductions in sedentary time. It is recommended that future research is power sufficiently to detect group differences.

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Standing up to sedentary behaviour; evaluating the utility of behavioural choice theory

1.1. Physically active vs inactive vs sedentary behaviour

Being '*physically active*' is well documented as being associated with numerous health benefits (McKinney, Lithwick, Isserow, Heilbron, & Krahn, 2016; Reiner, Niermann, Jekauc, & Woll, 2013; Warburton, Nicol, & Bredin, 2006). Physiological benefits from regular physical activity include reduced risk of: coronary heart disease, metabolic syndrome, high blood pressure, type 2 diabetes, stroke, colon and breast cancer, and all-cause mortality (Lee et al., 2012; Kyu, Bachman, Alexander, 2016; Reiner, Niermann, Jekauc, & Woll, 2013). Psychologically, regular physical activity improves cognitive functioning, boosts self-esteem, provides stronger mental resilience, enhances mood, reduces stress, lowers anxiety and regulates depressive symptoms (Peluso, & Andrade, 2005; Penedo, & Dahn, 2005). Although information on these benefits is widely recognised, a substantial amount of adults fail to meet the required guidelines to be considered physically active of 150 minutes per week of moderately intensive physical activity (HSCIC, 2015). Recent figures show as many as 33 percent of U.K. men and 45 percent of U.K. women are not currently meeting these guidelines and as such are deemed '*physically inactive'* (HSCIC, 2015).

With such low adoption rates, it is no wonder that the prevalence of U.K adults classified as being obese is increasing (HSCIC, 2013). Solving the obesity epidemic and getting people physically active, has unsurprisingly garnered much of researchers' and health professional's attention using interventions to address the problems associated with an unhealthy population (Van Lerberghe, 2008). However, new research emerging suggests physically inactivity should not be the only concern, as '*sedentary behaviours'* carry their own health risks (Mansoubi, Pearson, Biddle, & Clemes, 2014). Ekelund et al., (2016) recognise the

increased prevalence of sedentary behaviours in high income countries, and this is reflected in their meta-analysis showing as many as eight countries are researching into the issue.

1.2. Sedentary Behaviour

1.2.1. What is sedentary behaviour?

Sedentary behaviour is distinctly different from physical inactivity, and is defined as activities with low levels of energy expenditure ≤1.5 metabolic equivalents (METs) take place sitting or reclining during waking hours (Tremblay et al., 2017). Differences between sedentary behaviour and physical activity equate to the intensity of the activity with light physical activities (LPA) measured between 1.6 and 3.0 METs and moderate-vigorous activities (MVPA) measured as ≥3.0 METs (Tudor-Locke et al., 2010). Some examples of sedentary behaviour include; watching television, using a computer, playing inactive video games, time spent sitting while in a car, time spent reading, as well as other behaviours spent sitting, reclined, or lying down while at work, school or at home (Dietz, 2007). Despite the neologism 'sitting disease', given to describe the health consequences of sedentary behaviour, not all behaviours performed while sitting down constitute sedentary behaviour (Hamilton, Hamilton & Zderic, 2007). Indeed, whilst still seated, if the behaviour performed emits greater energy expenditure which exceeds the 1.5 METs, then it is not classed as a sedentary behaviour (Hamilton et al., 2007). Examples of which include; using exercise equipment like the rowing machine or stationary exercise bike, pushing yourself in a wheel chair, or performing chair based exercises (Tremblay et al., 2017).

1.2.2. Sedentary Behaviour a risk independent of physical activity?

It is widely believed, that the risks of sedentary behaviours can be alleviated by being physically active. A growing body of research, dictates the risks associated with prolonged sedentary behaviour are independent of how much physical activity is undertaken (Koster et al., 2012; Matthews, et al., 2012; Rollo Gaston & Prapavessis, 2011; Thorp, Owen, Neuhais & Dunstan, 2011; Wilmot et al., 2012). However, Ekelund et al., (2016) recently conducted a meta-analysis to extend the current knowledge on whether physical activity has an impact on sedentary risk factors. In the 16 studies reviewed, Ekelund et al., 2016 found that:

High levels of moderate intensity physical activity (i.e, about 60–75 min) per day, seem to eliminate the increased risk of death associated with high total sitting time. However, this high activity level attenuates, but does not eliminate the increased risk associated with high TV-viewing time (p. 1302).

The authors deem it is plausible that the associated risk magnitude differs between studies measuring TV-viewing time and total sitting time, due to the differences in reporting sedentary behaviours (Ekelund et al., 2016). Alternatively, there is also reason to believe, that individuals are worse at breaking up sedentary time while watching TV then at any other point during the day (Ekelund et al., 2016). Nevertheless, the amount of physical activity needed to eradicate the health risks associated with sedentary behaviours, far outstrips how much is needed to be physically active. It should be noted, while these findings go against previous research stating, no amount of physical exercise can alleviate sedentary risk factors (Koster et al., 2012; Matthews et al., 2012; Thorp et al., 2011; Wilmot, et al., 2012) they support the notion that an individual who physically active is still vulnerable to the risks of prolonged sedentary behaviours (Ekelund et al., 2016).

1.3. Existing landscape

The notion that an individual can be physically active but still vulnerable to health risks from being sedentary, poses new challenges to health professionals. Sedentary behaviours permeate all aspects of daily life, and are commonly undertaken during the working day in the office or at school but also commonly arises whilst travelling, and at home during leisure time (Rollo, Gaston & Prapavessis, 2016). Technological advances, attributed to making our lives more convenient, have been largely blamed for the increase in sedentary behaviours (Nigg, 2003; Sandercock, Alibrahim & Bellamy, 2016). Indeed, the landscape that exists today, has changed significantly. Increased car ownership, the evolution of jobs and the preference for screen based actives during leisure time have shaped the amount of time spent sedentary (Matthews et al., 2008). These factors contribute to a greater proportion of people sitting down for prolonged periods, and with that, are more at risk with the accompanying health risks of sedentary behaviour (Rezende, et al., 2014; Thorp et al., 2011; Wilmot et al., 2012).

This is highlighted by self-report data, which emphasises that on average a European adult will spend 5 hours per weekday sedentary (Bennie, Chau, Pleog, Stamatakis & Bauman, 2013). This figure potentially increases in the U.K dependant on the type of job, with office workers the most susceptible. Ryan, Grant, Dall and Granat (2011), using objective measures of sedentary behaviour, found that office workers spend 5.3 hours sitting throughout the average working day. Another study, which measured sitting patterns from 7 am to 11pm, found the amount of time spent sedentary amongst office workers increased to 10.6 hours on average, when also taking into account leisure time (Smith, et al., 2015). These findings show that prolonged sedentary patterns are not exclusive to either the working day or leisure

time spent outside of work. As a result, researchers should focus on the utility of sedentary behaviour interventions that tackles behaviour change all throughout the day.

1.4. How is sedentary behaviour measured?

Previous data on adult sedentary behaviour (Bennie, et al., 2013; Ryan, et al., 2011; Smith, et al., 2015) has been retrieved using different methods of investigation (Racette, Deusinger, & Deusinger, 2003). Both subjective and objective measurements have been used to capture sedentary behaviours and quantify them effectively (Healy, Clark, Winkler et al., 2011). Other methods of investigation include: direct observation, doubly labelled water and indirect calorimetry, though these techniques have been disregarded within population based studies (Tremblay, Colley, Saunders, Healy, & Owen, 2010). As it stands, subjective measures are the most commonly employed method for investigating sedentary behaviours (Gardner, Smith, Lorencetto, Hamer & Biddle, 2016; Hegarty, Mair, Kirby, Murtagh & Murphy, 2016).

1.4.1. Subjective measurements

Sedentary behaviours can be captured via questionnaires, behavioural logs, and short term recall diaries (Clark, Sugiyama, Healy, et al., 2009). Self-reported questionnaires are the most popular subjective measure of sedentary behaviour, and epitomise why there has been a preference within the literature, over objective measures (Hegarty et al., 2016). While questionnaires do not explore complex issues in any great depth, the standardised set of questions are an effective means of gathering considerable amounts of information form a large sample size (Gratton & Jones, 2010). This is on the basis that questionnaires are; easily distributed, cost effective, and are not too taxing on the participants who complete them (Kang & Rowe, 2015).

Before sedentary behaviour had been identified as an independent health risk, it was commonly measured using physical activity questionnaires (Zhu & Owen, 2017). The International Physical Activity Questionnaire (IPAQ – Craig et al., 2003) for example was designed as a tool to measure both physical activity and sedentary behaviours, yet the questionnaire only incorporates one question on sitting time. Researchers looking to measure sedentary behaviours using a physical activity questionnaire, like the IPAQ, run the risk of introducing inaccuracies by wrongly classifying what sedentary behaviour is (Kozàkovà et al., 2010). This imbalance towards sedentary behaviour measurement, has since been addressed, with the creation of questionnaires that exclusively measure sedentary behaviours (Rivière, Aubert, Omorou, Ainsworth, & Vuillemin, 2015).

Previous research has looked to validate questionnaires that measure sedentary behaviour, to ensure they are measuring behaviours as intended (Clark et al., 2013; Matton et al., 2007; Neilson, Ullman, Robson, Friedenreich, & Csizmadi, 2013; Rosenberg, et al, 2010). Sedentary behaviour questionnaires have in the past been validated against objective measures (Clarket al., 2013; Matton et al., 2007), other previously validated questionnaires (Rosenberg et al, 2010), and cognitive interviewing (Neilson et al., 2013). Results from these validation studies, indicate that questionnaires have inaccuracies, and sedentary behaviours have tended to be underestimated (Matton et al., 2007). Sedentary behaviour recall can be compromised due to problems ranging from; ambiguously worded questions, social desirability, fatigue, acquiescence bias and confirmation bias (Choi, & Pak, 2005). Nevertheless, with the emergence of newly devised objective measures it is recommended that future interventions pair up self-reporting measures in conjunction with objective

measures, in order to increase validity of sedentary scores (Gardner et al., 2016; Hegarty et al., 2016; Rollo, Gaston & Prapavessis, 2016).

1.4.2. Objective measurement

More recently, total time spent sedentary has been captured using objective measures (Kang & Rowe, 2015). The updated definition of what constitutes a sedentary behaviour (Sedentary Behaviour Research Network, 2012) means that objective measures need to be able to meet all three of the following criteria: "(1) waking behaviour characterized by (2) an energy expenditure ≤ 1.5 METs (3) while in a sitting or reclining posture" (Zhu & Owen, 2017, p. 315). At this present time, no single objective measure can simultaneously quantify all three criteria with rigorous precision and accuracy (Healy, Clark, Winkler et al, 2011). Objective sedentary behaviour measures can be separated into two types: those that measure energy expenditure and those that can determine posture (Granat, 2012).

Energy expenditure devices, like heart rate monitors and accelerometers are able to provide sedentary behaviour assessments via quantified low level expenditure thresholds (Biddle et al., 2015). Accelerometers are the most widely used objective sedentary behaviour measure amongst adults in free living conditions (Kozey-Keadle Libertine, Lyden, Staudenmayer, & Freedson, 2011). These devices when worn measure acceleration, relative to free fall, over an axis in order to objectively measure human movement as it happens (Kang & Rowe, 2015). The magnitude of the acceleration, given off by human movement, is continuously calculated within set time periods (epochs) and then converted into an output known as counts per minute (Kang & Rowe, 2015). Counts per minute (cpm) of less than 100 cpm are commonly used by ActiGraph accelerometers like the GT3X and GT3X+ models to classify sedentary time (Matthews et al., 2008), though 150 cpm has more recently been

shown to be more dependable when measuring in free-living conditions (Kozey-Keadle et al., 2011). Inclinometers on the other hand, are able to objectively measure sedentary behaviours by quantifying time spent in different postures (Carr & Mahar, 2011). By distinguishing between sitting, standing, and lying the activPAL device is able to classify sedentary behaviours and provide time-stamp transitions from one postural activity to another (Grant, Ryan, Tigbe, & Granat, 2006).

Recent literature has promoted the use of accelerometers and inclinometers to measure of sedentary behaviour, as opposed to subjective measures, as they are able to provide more valid and reliable results (Atkin et al., 2012). Despite increased validity, these devices still succumb to measurement issues in relation to the conceptualised sedentary behaviour definition (Kang & Rowe 2015). Previous research has seen that accelerometers sometimes wrongly classify certain standing behaviours, which do not expend much energy, as sedentary behaviours when these activities fall below 100 cpm (Granat, 2012; Marshall & Merchant, 2013). Equally, the activPAL suffers from misclassifying behaviours as a result of not measuring energy expenditure (Edwardson et al., 2015). Active sitting activities, such as weightlifting, can be wrongly captured as being sedentary, even though they exhibit high energy expenditure greater than 1.5 METs (Edwardson et al., 2015).

The introduction of the triaxial accelerometer, which includes the inclinometer functionality of measuring posture, reduces some of the misclassification problems. These devices, such as the ActiGraph GT3X, have shown a very strong correlation with directly observed sedentary minutes (r=0.94; Kozey-keadle, Libertine, Lyden, Staudenmayer & Freedson, 2011). Triaxial accelerometers, when used in conjunction with valid subjective

measures, show promise in measuring sedentary behaviours at population level (Gardner et al., 2016; Hegarty et al., 2016; Rollo et al., 2016).

1.5. Sedentary behaviour health risks

The consequences of being sedentary for too long have only recently been recognised as a separate health concern (Sedentary Behaviour Research Network, 2012). Pioneering literature within the field advocate that being sedentary for long periods, exposes adults to a number of increased health risks which contribute negatively towards physical and psychological well-being (Rezende et al., 2014).

1.5.1. Cardiovascular health

With nearly 160,000 deaths each year (British Heart Foundation, 2017) cardiovascular disease proves to be a substantial burden to U.K health. While there are many existing causes that contribute to this figure, the relationship between sedentary behaviour and cardiovascular health in adults has also been investigated (Rezende et al., 2014). Three reviews, which include meta-analysis, argue that there is a positive association between sedentary behaviours and the increased risk of cardiovascular disease (Grøntved, & Hu, 2011; Ford & Caspersen, 2012; Wilmot et al., 2012). Two hours or more of television screen time was shown to be enough to induce a 15% increase in cardiovascular disease (Grøntved, & Hu, 2011; Wilmot et al., 2012) and 5% in cardiovascular events (Ford & Caspersen, 2012). Similarly, strong evidence has been found to support the association between sedentary behaviour and increased cardiovascular related mortality (Proper et al., 2011; Thorp et al. 2011). Both reviews revealed that the findings were independent of how much physical activity was undertaken, (Biddle, Mutrie, & Gorely, 2015) adding support to the notion that

sedentary behaviour is a distinct behaviour. In a follow up meta-analysis, Wilmot et al., (2012) comparatively reviewed the greatest sedentary time against the lowest, and found there was a 90% increase in the risk of cardiovascular mortality.

1.5.2. Type-2 diabetes

Type-2 diabetes is a common health condition in the U.K influenced by genetic, lifestyle and environmental factors (Tuomilehto, et al., 2001). Six reviews have examined the role of sedentary behaviour concluding that there is a significant and positive association with type-2 diabetes in adults, unrelated to physical activity level (Biswas, Faulkner, Bajaj, et al., 2015; Grøntved, & Hu, 2011; Proper, et al., 2011; Thorp et al. 2011; Wilmot et al., 2012; van Uffelen, et al., 2010). Notably, the work conducted by Grøntved and Hu (2011) revealed the risk of type-2 diabetes increased by 20% when sitting to watch television for more than two hours. Furthermore, Wilmot et al., (2012) found the relative risk of type-2 diabetes rose to 112% when comparing adults who exhibited the highest sedentary behaviour against those who exhibited the lowest.

1.5.3. Cancer

The potential association between sedentary behaviour and different types of cancer is of increased interest to researchers, due to the biological plausibility (Zhu & Owen, 2017). Sedentary behaviour is seen as an underlying mechanism in the development and progression of cancer, due to its independent association with adiposity (Blanck, et al., 2007; Wijndaele et al., 2010). Lynch, 2010 hypothesised that "adiposity may facilitate carcinogenesis through a number of pathways, including increased levels of sex hormones, insulin resistance, chronic inflammation, and altered secretion of adipokines" (p. 2701).

Lynch (2010) spearheaded the current literature pertaining to sedentary behaviour and cancer. In her review, a positive and statistically significant association was found in eight of the eleven studies evaluating sedentary behaviour and cancer risk. Results were consistent in studies assessing the association between sedentary behaviour and colorectal cancer (Colbert, et al., 2001; Howard, et al., 2008; Steindorf et al., 2000), ovarian cancer (Patel et al., 2006; Zang, Lee & Binns, 2004), and prostate cancer (Orsini et al., 2009). However, only two of the four studies found a positive association between sedentary behaviour and endometrial cancer (Friberg, Mantzoros, & Wolk, 2006; Friedenreich, et al., 2010) and the association between sedentary behaviour and breast cancer risk were null (Mathew et al., 2009).

Five more recent systematic reviews have explored the association between sedentary behaviour and cancer in adults (Boyle, 2012; Proper et al., 2011; Shen, Mao, Liu et al., 2014; Thorp et al. 2011; van Uffelen, et al., 2010). Further support is given to the association between sedentary behaviour the increase risk of: colorectal cancer (Boyle, 2012; Shen, et al., 2014; Thorp et al. 2011; van Uffelen, et al., 2010), endometrial cancer (Proper et al., 2011; Shen, et al., 2014; Thorp et al. 2011), ovarian cancer (Thorp et al. 2011; van Uffelen, et al., 2010), breast cancer (Shen, et al., 2014; van Uffelen, et al., 2010), and lung cancer (Shen, et al., 2014).

1.5.4. Musculoskeletal disorders

Musculoskeletal disorders (MSD) relate to any damage or injury of the joints or other tissues, affecting mobility in the back, or the upper and lower limbs (Proper et al., 2011). Within the U.K., it is estimated that in 2015/16 MSD's accounted for 41% of all work-related illnesses (Health and Safety Executive, 2017). Lower back pain has been cited as one of the

most common complaints, when sitting for a long time, and this is largely attributable to the way in which we sit (Hamilton et al., 2008). When sitting, the whole of the upper body is concentrated on the lower lumber region of the spine, which results in 30% extra pressure placed on the intervertebral discs, opposed to standing (Andersson 1980, 1981, 1985). Equally, poor posture from sitting has been shown to enact unequal vertebral disc pressure (Tanaka et al., 2001) resulting in; tissue damage, core muscles being disengaged (Nocera et al., 2011; Tomlinson et al., 2014), and thus increasing instances of lower back pain (Lis, Black, Korn & Nordin, 2007).

Four systematic reviews have examined the relationship between sedentary behaviour and musculoskeletal disorders in adults (Chen, Liu, Cook, Bass & Lo, 2009; Ijmker et al., 2006; Proper et al., 2011; Wærsted, Hanvold, & Veiersted, 2010). At present, there is limited evidence to support the association between increased sedentary behaviour and lower back pain (Chen et al., 2009; Proper et al., 2011), neck pain (Ijmker et al., 2006; Wærsted, Hanvold, & Veiersted, 2010), arm pain, shoulder pain and hand pain (Ijmker et al., 2006). Authors have noted, the lack of association between sedentary behaviour and lower back pain may be a symptom of the current literature not possessing a quality measurement, which accurately separates the threshold at which injury occurs from prolonged sitting (Chen et al., 2009; Proper et al., 2011). In spite of the current evidence which is yet to show a strong association with sedentary behaviour and common MSD's, further research is warranted as the mechanics of increased sedentariness are not favourable to the health of the spine (Howarth, Glisic, Lee & Beach, 2013).

1.5.5. All-cause mortality

Available data gathered on 54 countries has attributed sedentary behaviour, in the form of sitting time, to be responsible for 3.8 percent of all-cause mortality (Rezende et al., 2016). This relates to 433,000 deaths per year, when accounting for the populations of each country analysed. Previous reviews indicate that the risk of all-cause mortality associated with sedentary behaviour increases progressively the longer a person is sedentary (Biswas et al., 2015; Chau et al., 2013). This is consistent with findings on TV-viewing which highlighted a 13 per cent increase in all-cause mortality for every two hours sitting watching T.V (Grøntved, & Hu, 2011). A meta-analysis by Chau et al., (2013) which reviewed six studies, including 595,086 participants, quantified the risks associated with prolonged sedentariness. Their findings show that the risk of all-cause mortality, after adjusting for physical activity, increased two percent for every additional hour spent sitting per day. However, the association was found to be non-linear whereby the risk of all-cause mortality worsens when time spent sitting per day exceeds seven hours a day. Indecently, each hour increment of sitting on top of this, was associated with a five percent risk of all-cause mortality (Chau et al., 2013).

1.5.6. Mental health

Besides the rapid growth of evidence regarding high levels of sedentary behaviour on physical health, more researchers within the field are concern that mental health may also be affected (Hamer, Coombs, & Stamatakis, 2014). Mental health is a key component in achieving general health and wellbeing. In the U.K., it is estimated that during an average week at least one in six people experience a common mental health problem (McManus, Bebbington, Jenkins, & Brugha, 2016). The literature examining mental health and sedentary behaviour is still novel, with sparse overarching reviews examining the different associations (Rezende et al., 2014). Instead, research has focused on reviewing the associations separately.

Previous reviews investigating the relationship between sedentary behaviour and risk of depression all found a positive association (Rhodes, Mark, & Temmel, 2012; Teychenne, Ball & Salmon, 2010; Zhai, Zhang & Zhang, 2015). Further findings by Teychenne, Ball & Salmon (2010) suggest increased risk of depression may be dependent on the type of sedentary behaviour an individual is engaged in. This is highlighted in their research, as all four studies resulting in either an inverse or no association where found to have included computer and internet use as a measure of sedentary behaviour. These findings are consistent with Rhodes et al., (2012) systematic review which found time spent viewing TV to be positively associated with depressive symptoms, whilst no association was found for computer use. Social withdrawal hypothesis has been put forward to explain this relationship (Teychenne, Ball & Salmon, 2010), with the verdict that computer use induces more communication and social interaction than TV viewing which help to alleviate depressive symptoms. However, a recent meta-analysis (Zhai, Zhang & Zhang, 2015) combining evidence from twenty-four studies and a total of 193,166 participants found the relative risk of depression was greater for prolonged computer use as oppose to prolonged TV viewing, 1.22 and 1.13 respectively. This goes against the conclusions drawn by previous reviews (Rhodes, Mark, & Temmel, 2012; Teychenne, Ball & Salmon, 2010) but does suggest that the relative risk of depression differs between sedentary behaviours.

To date, only one review has examined the relationship between sedentary behaviour and risk of anxiety (Teychenne, Costigan & Parker, 2015). The analysis found only moderate evidence, with only five of the nine studies included reporting a positive association. More favourable evidence was examined for total sitting time, where all but one of the five studies found a positive association. (Kilpatrick, et al., 2013; Sloan et al., 2013; Rebar et al., 2014;

Uijtdewilligen et al., 2011). However, there were not enough high-quality studies investigating different sedentary behaviours. This resulted in insufficient evidence for the association of both TV viewing and computer use with the risk of anxiety.

1.6. Government guidelines

Despite these concerning findings, the Department of Health guidelines prescribe that people should merely minimise sedentary behaviours for extended periods (UK physical activity guidelines, 2011). This message, unlike the physical activity guidelines, is ambiguous. It is not clear how often periods being sedentary should be broken up, what should be done, or for how long. This vague message is shared by the World Health Organisation. Despite recognising the detrimental health outcomes of too much sedentary behaviour, in their 2010 Global Recommendations for Health Document, they too fail to outline any specific guidelines for people to follow other than to minimise the sedentary behaviour (Word Health Organisation, 2010). It is evident that the dangers of prolonged sedentary behaviours are not widely recognised nor understood (Tremblay et al., 2017). This may in part can be explained by sedentary behaviour only recently being acknowledged as a public health concern within the scientific research community (Tremblay et al., 2017). The avocation for increased breaks in sedentary behaviour should not jeopardise the importance of engaging in longer physical activity bouts, in line with current public guidelines. Rather, a consistent public health message, where the importance of sedentary behaviour breaks supplement physical activity recommendation so that they are taken equally seriously. Until there is an extensive body of experimental evidence that supports initial findings, government guidelines on sedentary behaviours will continue to remain ambiguous (Zhu & Owen, 2017). To this end, more

experimental sedentary behaviour research is needed, in order shape current government guidelines.

1.7. Reducing and breaking up sedentary time

Current research has stated that at least 60 minutes of moderate intensity physical activity a day can alleviate certain risks from prolonged bouts of being sedentary (Ekelund et al., 2016). However, the practicality of individuals implementing this significant behaviour change into daily lifestyles is very low, considering so many already fail to meet the current physical activity recommendations (Hamilton et al., 2008). In addition, this behaviour change approach would not tackle the root of the existing problem, nor does it absolve all the health risks associated with sedentary behaviour (Ekelund et al., 2016), it merely dilutes them and as such should not be recommended. This is shown in the research undertaken by Duvivier et al., (2013) which found that:

One hour of daily physical exercise cannot compensate for the negative effects of inactivity on insulin sensitivity and plasma lipids if the rest of the day is spent sitting. Reducing inactivity by low intensity activities such as walking at a leisurely pace and standing is more effective than physical exercise in improving these parameters in sedentary subjects (p. 7).

Breaking up prolonged sedentary bouts, before they occur, therefore holds greater utility within behaviour change intervention research and should be marked as a priority by health authorities' (Duvivier et al., 2013). Within the scientific research community there is an initial consensus that sedentary bouts should last no longer than 30 minutes, as more prolonged bouts, have been shown to be detrimental to cardio-metabolic health (Healy, Matthews, Dunstan, et al., 2011; Henson, Yates, Biddle et al., 2013). This is supported by

observational data which advocates the need to displace sedentary behaviour, with frequent transitions to a more physical active state ≥ one minute, due to its beneficial associations with metabolic risk (Healy, Dunstan, Salmon et al., 2008).

1.7.1. Effects of displacing time spent sedentary with standing

Experimental studies have examined the effects of breaking-up sedentary time, with frequent transitions from sitting to standing (Bailey & Locke, 2014; Buckley, Mellor, Morris & Joseph, 2014; Miyashita et al., 2013; Thorp, Kingwell, Sethi et al., 2014), with initial evidence showing signs of improvement to metabolic health (Henson, Dunston, Davies, Yates, 2016). Throp et al., (2014) conducted an experiment on 23 overweight and obese office workers to see the effect of disrupting sitting, every 30 minutes with standing. They found that the injection of standing bouts, during an eight hour working day, significantly reduced postprandial glucose response compared to uninterrupted sitting (Thorp, Kingwell, Sethi et al., 2014). Similar benefits from standing are supported in another office based study, which sought to discover if an afternoon of continuous standing was as beneficial to metabolic health (Buckley et al., 2014). When comparing 185 minutes of seated desk work against 185 minutes of work whilst continuously standing, a 43% reduction in glucose levels was found in the standing condition (Buckley et al., 2014). Although the study did not displace time spent sitting, it provides further evidence that standing improves glucose regulation.

Other studies have compared the effects of breaking up sitting time with standing, and light physical activity (Bailey & Locke, 2014; Miyashita et al., 2013). Results showed that light physical activity, but not standing, was able to acutely lower postprandial lipaemia in 15 healthy Japanese men (Miyashita et al., 2013) and postprandial glycemia in 10 heathy adults (Bailey & Locke, 2014). Standing interruptions therefore, have been shown to be beneficial to

metabolic health in an overweight and inactive adult population (Thorp, Kingwell, Sethi et al., 2014), yet the same cannot be said in a healthy adult population (Bailey & Locke, 2014; Miyashita et al., 2013). Emerging evidence that certain metabolic health benefits can be attained within a low activity intensity threshold, is promising. Nonetheless, considerations should be taken, as it appears greater activity intensity is needed, to counteract the detrimental effects of prolonged sitting, in populations with healthy characteristics.

1.7.2. Effect of displacing time spending sedentary with LPA and MVPA

Supplemental research has looked to investigate the effects of displacing prolonged sitting with greater activity intensity, with both LPA and MVPA examined (Benatti & Reid-Larsen, 2015). Available evidence from a review of 16 experimental studies, advocates breaking up prolonged sitting time with LPA, due to beneficial changes in postprandial metabolic parameters (Benatti & Reid-Larsen, 2015), particularly in physical inactive (Bailey & Locke, 2015; Duvivier et al., 2013; Dunstan et al., 2012; Howard et al., 2013) and type-2-diabetes subjects (van Dijk et al., 2013). This is supported in a meta-analysis, which found that LPA breaks were responsible for significant reductions in both blood glucose and insulin levels by 17.42% and 14.92% respectively (Chastin, Egerton, Leask, & Stamatakis, 2015). However, it would appear that these findings do not extended to younger more physical active subjects, with either greater intensity or volume needed in order to extract these positive outcomes (Kim, Park, Trombold, & Coyle, 2014).

Breaking up prolonged sitting, with MVPA also resulted in significant reductions in both blood glucose and insulin levels by 1.40% and 23.84% respectively (Chastin et al., 2015). It was also noted, a single prolonged bout of MVPA was less effective in reducing both blood glucose and blood insulin levels, compared with regular MVPA breaks (Chastin, et al., 2015).

Although previous findings suggest breaking up sitting with MVPA in physically active subjects has a positive, yet delayed effect on metabolic profile, more evidence is required in relation to frequency, intensity and type of physical activity necessary before any association can be made (Benatti & Reid-Larsen, 2015).

Besides metabolic health, interrupting sedentary behaviour with LPA has been shown to reduce lower back discomfort amongst workers (Thorpe, KIngwell, Owen & Dunstan, 2014), reduced reported sick leave attributed to lower back pain (Ljunggren, Weber, Kogstad, Thom, & Kirkesola, 1997), reduced inflammatory responses (Chastin et al., 2015), and reduced all-cause mortality by 30% (Matthews et al., 2015). There is considerable evidence that breaking up sedentary behaviour, with low level movements like standing and light physical activity, represents a realistic intervention tool which can be used to modify health (Benatti & Reid-Larsen, 2015). Despite this, few interventions have been conducted to promote the adoption of these relatively small behaviour change (King et al., 2013).

1.8. Previous interventions to reduce sedentary time

There is currently a lack of published interventions that primarily focus on reducing sedentary behaviours in adults. Therefore, developing successful interventions represents a key challenge for behaviour change researchers and health authorities looking to promote further sedentary behaviour reductions. In order to fulfil this obligation, it is important to have an understanding of what works and why (Michie & Preswich, 2010).

1.8.1. Workplace interventions

Considering a large proportion of adults in developed countries are susceptible to spending hours sitting at a desk, with very few breaks (Ryan et al., 2011), the majority of

sedentary behaviour interventions look to tackle occupational sitting. In a systematic review of workplace interventions, Chau et al., (2010) found none of the six studies reviewed significantly reduced sitting time in the intervention group compared with the control or comparison group. However, it should be noted the primary aim of all six study was to increase physical activity, with reducing sitting time as a secondary aim (Chau et al., 2010). Multiple interventions with a primary aim to reduce occupational sitting time have since been released, yielding more favourable results. This is a timely reminder that an updated systematic review of workplace interventions, incorporating new additions to the literature, is warranted.

More recent intervention strategies, with a primary aim to reduce sitting include; sit-stand desks (Alkhajah et al., 2012; Healy et al., 2013; Neuhuas, et al. 2014; Pronk et al. 2012), treadmill workstations (John et al., 2011), computer software prompts (Evans et al., 2012), and peddle machines (Carr, Karvinen, Peavler, Smith & Cangelosi, 2013). Five of the seven interventions reported significant reductions in sitting time against the control or comparison group (Alkhajah et al., 2012; Carr et al., 2013; Healy et al., 2013; Neuhuas, et al. 2014; Pronk et al. 2012), one observed no significant differences between groups (Evans et al., 2012) and the other was a single group repeated measures (John et al., 2011) but still reported a significant increase in standing. Workstations that are height adjustable, giving employees the option to sit or stand throughout the work day, are the most promising practical solution to break up long periods of sitting (Zhu & Owen, 2017). On average, the introduction of the sit-stand desk induced clinically beneficial reductions in sitting time between 89-143 minutes (Alkhajah et al., 2012; Healy et al., 2013; Neuhuas, et al. 2014; Pronk et al. 2012). In addition, those in the intervention group have reported health benefits which include; increased HDL

cholesterol (Alkhajah et al., 2012), improved mood states, and reduced back and neck pain (Pronk et al. 2012). While the cost and effort of installing sit-stand desks can be high, the health benefits provided should be encouraged within the workplace.

1.8.2. Free living interventions

Outside of the workplace, adults also spend a significant amount of their leisure time engaged in prologue sedentary behaviours (Smith et al., 2015). TV viewing is considered one of the biggest contributors to sedentary lifestyles, with the average U.K person spending over three and a half hours watching TV (Ofcom, 2016). One intervention has actively restricted TV viewing by 50 percent, using lockout devices, in an effort to reduce sedentary behaviours and increase energy expenditure (Otten, Jones, Littenberg & Harvey-Berino, 2009). After three weeks of intervention, they found the intervention group significantly increased energy expenditure compare with control. More recently, interventions have been designed targeting reductions in daily sedentary behaviour across free living conditions (Bond et al., 2012; Gardiner et al., 2011; Thomsen et al., 2016). Strategies employed varied from; smartphone app which allows real time monitoring of behaviours (Bond et al., 2012), face to face consultation with mailed tailored feedback (Gardiner et al., 2011), motivational counselling with SMS-reminders (Thomsen et al., 2016). Results from these interventions highlight that small but significant reductions in daily sedentary time ranging between 3% - 6% are feasible and clinically meaningful (Bond et al., 2012; Gardiner et al., 2011).

1.8.3. Importance targeting sedentary behaviours exclusively

Reductions in sedentary time have been reported in interventions with only some degree of focus on reducing sedentary behaviours. Physical activity promotion,

multicomponent lifestyle approaches, and even dietary techniques have achieved a mean 22.34 minutes per day reduction in sedentary time through intervention (Martin et al., 2015). However, interventions designed with the sole focus on manipulating sedentary behaviours are recommended within the literature, as these have been shown to produce the greatest reductions in sedentary time (Manini et al., 2015). Two separate meta-analysis call attention to this, with specific sedentary behaviour interventions yielding mean difference reductions of 91 minutes per day (Prince et al., 2014) and 41.76 minutes per day (Martin et al., 2015), when compared to the control groups. Reasons put forward by Martin et al., (2015) for the differences in mean scores, were the result of stricter inclusion criteria. Nevertheless, the consensus derived from both reviews, and other studies within the field, is that more interventions focusing solely on sedentary behaviour are needed (Chau, et al., 2010; Manini, et al., 2015; Martin et al., 2015; Prince et al., 2014).

This is further supplemented, as sedentary behaviour is not directly alleviated by effective physical activity promotion (Gardner et al., 2016). Two reviews found no evidence for intervention effectiveness in the six (Chau et al., 2010) and sixteen (Martin et al., 2015) studies designed with a focus on physical activity promotion, stressing the importance of exclusive sedentary behaviour interventions. There is clear grounds for the design and implementation of more experimental interventions that uniquely look to uncover solutions to prolonged sedentary behaviour, with increased activity throughout the day (Manini, et al., 2015).

1.8.4. Importance of theory

Behaviour change theory is strongly emphasised within the frameworks for developing behaviour change interventions (Bartholomew, Parcel, Kok & Gottleib, 2001).

Gardner et al., (2016) support the notion that sedentary interventions should be governed by behaviour change theories, as their review highlighted that those overseen by theory showed more promise than those where theory was omitted. Behaviour change theories that have most commonly been used in previous sedentary intervention research consist of; the theory of planned behaviour, the transtheoretical model and self-efficacy theory (Gardner et al., 2016). Interestingly, Biddle et al., (2015) questions whether these theories, which in the past have been applied to physical activity with varying degrees of success, transfer optimally to explain sedentary behaviour (Biddle, Mutrie & Gorely, 2015). He and other researchers in the field proposes that behavioural choice theory may have greater utility for sedentary behaviour change (Biddle et al., 2015; Epistein, Myers, Saelens, & Vito, 1997; Owen, Leslie, Salmon, & Fotheringham, 2000; Salmon, Owen, Crawford, Bauman, & Sallis, 2003; Zhu & Owen, 2017).

1.9. Behavioural Choice Theory

1.9.1. What is Behavioural Choice Theory?

Behavioural Choice Theory (Epstein, 1998) "based on behavioural economics, is a theoretical approach that attempts to understand how time and resources are allocated given a choice, between two or more alternative behaviours" (Biddle et al., 2015, p374). An individual's choice to be sedentary will be based on a combination of *individual differences:* impulsivity and reinforcement sensitivity, as well as, *environmental modifiers:* accessibility, availability, reinforcement value and time (Epstein, 1998).

The theory denotes that, before engaging in a behaviour, an assessment is made about alternative behaviours and whether there are more desirable ones available. Where

behaviours are equally available, people reliably choose the behaviour that is more reinforced (Epstein, 1998). The reinforcement value is based upon how much appeal or enjoyment a behaviour is given by the individual (Salmon et al., 2003). In order to engage in a particular behaviour, a certain amount of effort or cost will be needed to access it. According to previous research by Epstein (1998), sedentary behaviours are undertaken so regularly, due to the ease of access whereby relatively low cost is needed to engage in them (e.g. sitting). The last consideration of the theory, relates to time. Should there be a delay in which the individual chooses the behaviour and receives the reinforcement, the individual may switch to a more immediately gratifying behaviour (Biddle et al., 2015). This is especially significant in the decision to be sedentary or physically active, as the benefits of undertaken physical activity are often delayed compared to sedentary behaviours which offers immediate appeal (Epstein, 1998).

1.9.2. Why use Behavioural Choice Theory?

The ecological model of sedentary behaviour (Owen, et al., 2011) proposes that a mixture of intrapersonal and environmental determinants are responsible for influencing sedentary behaviour. Behavioural choice theory has face validity with the ecological model, as it explicitly incorporates both intrapersonal and environmental influences, to understand why a specific behaviour is chosen (Rachlin, Kagel & Battalio, 1980; Vuchinich & Tucker, 1983, 1988). This is transferrable in the choice people make between being sedentary and being physically active (Epstein, 1998). Consequently, behavioural choice theory may have unrealised potential within sedentary behaviour interventions (Biddle et al., 2015; Salmon et al., 2003; Zhu & Owen 2017). This is supported by the central tenants of behavioural choice theory, which strongly favour implementation into health behaviour interventions, tasked

with the responsibility of shifting unhealthy behaviours to heathier alternatives (Biddle et al.,

2015).

Using the theory, the reinforcement value can be targeted through appraisal for

choosing alternative behaviours (Epstein, Myers, Saelens & Vito, 1997). This is important as

many individuals hold the view that sedentary behaviours like watching television, and

playing computer games to be more appealing than more physically active behaviours

(Epstein, Myers, Saelens & Vito, 1997). Consequently, identifying alternative behaviours that

can compete with sedentary behaviours that are highly preferred, will be significant in the

effort to reduce sedentary lifestyles (Epstein & Roemmich, 2001; Salmon et al. 2003). Once

identified, interventions can target alternative behaviours that promote more incremental

physical activity, and aim to increase their appeal through positive reinforcement (Epstein et

al., 1999). Interventions can also target the cost, or effort, needed to engage in sedentary and

physically active behaviours. Promisingly, sedentary behaviours have been shown to be very

responsive when manipulated (Epstein, 1998). Research designed to reduce access to highly

preferred sedentary behaviours, has been associated with increases in physical activity

(Epstein & Roemmich, 2001; Epstein & Saelens, 2000). As a result, strategies to reduce

sedentary behaviours need to foster an environment, where alternative behaviours are

perceived to be more enjoyable and accessible (Epstein & Roemmich, 2001; Epstein, Saelens

& O'Brien, 1995).

1.9.3. Previous research on Behavioural Choice Theory

Behavioural choice theory has general applicability examining the adoption of healthy

and unhealthy behaviours, as it considers how individuals frame and execute decisions

(Epstein, 1998). The theory has been utilised in various public health research, which examine

the behaviour modification of: drug use (Bickel & Marsch, 2001; Bigelow, 2001; Vuchinich & Tucker, 1988), gambling (Reynolds, 2006), alcohol consumption (Epstein, Bulik, Perkins, Caggiula, & Rodefer, 1991; Bulik, & Brinded, 1993), smoking (Perkins, Hickcox, & Grobe, 2000), and food choice (De Cock, et al., 2017; Pearson, Atkin, Biddle, & Gorely, 2010). Behaviour choice theory has also been employed to gain further understanding as to why people chose to be sedentary over being physically active (Epstein et al., 1991; 1995a; 1995b; 1997; 1999; 2000; Rayner, Coleman & Epstein 1998; Saelens & Epstein 1998; 1999; Vara & Epstein 1993). Until recently, the literature examining this relationship has been primarily undertaken in laboratory settings. Another criticism is that the majority of the work carried out suffers a large population bias towards children and overweight or obese individuals (Epistein 1995; Epistein et al., 1991; 1995; 1997 1999; 2000; Saelens & Epstein 1999), despite the problem of sedentary lifestyles extending much further. New wearable technology, known as accelerometers, now allow research to be more practical and carry out research outside of the lab in real-world settings. More recent research has incorporated behavioural choice theory into sedentary behaviour interventions aimed at children (Carson et al., 2013; Salmon, et al., 2005), adults with rheumatoid arthritis (Thomsen et al., 2016), and older adults (Gardiner, Eakin, Healy & Owen, 2011).

The theory driven intervention conducted by Gardiner et al., (2011) has revealed encouraging results in adults aged over 60. Their two week study, informed by behavioural choice theory (Epstein, 1998) and social cognitive theory (Bandura, 1986), introduced the intervention after a week of baseline scores were measured. The 45 minute session looked to influence participants': self-efficacy, self-control, reinforcement value, and preference for alternative behaviours. The main aim was to encourage the 59 participants to break up

uninterrupted sitting every 30 minutes, with sedentary time reported via the Actigraph GT1M accelerometer, and defined using <100 counts per minute. During the face to face intervention session participants: reviewed the previous day's sedentary time, received feedback and comparison against the average of similar characteristics, undertook a goal setting programme to displace more sedentary time with more LIPA breaks, and constructed a behavioural action plan. A small but significant reduction in sedentary time of 3.2 percent was observed from the pre- to post intervention. In addition, participants increased their LPA by 2.2 percent, increased their MVPA by one percent, and increase the number of breaks in sedentary time per day (Gardiner et al., 2011).

Another promising intervention, informed by behavioural choice theory (Epstein, 1998) and self-efficacy theory (Bandura, 1977), has previously targeted sedentary behaviour reductions amongst patients with rheumatoid arthritis (Thomsen et al., 2016). The 16 week intervention, used a combination of motivational counselling sessions and text message reminders to enact behaviour change. During the first counselling session at week one, sedentary patterns were identified, behaviour goals were set, and an action plan devised incorporating alternative behaviours. Subsequent sessions, at week three and eleven, reviewed behavioural goals, reiterated health benefits, and used verbal persuasion to boast self-efficacy. Text messages were sent throughout, capped to a maximum of one every weekday, reminding patients of their behavioural goals. Daily sitting time was measured using the ActivPAL3 at baseline and again after the 16 week intervention phase. Although non-significant, a mean reduction in daily sitting time of 30 minutes was found in the intervention group compared with baseline measures.

1.10. Rationale

While the reductions in sedentary behaviours from both of the studies (Gardiner et al., 2011; Thomsen et al., 2016) are encouraging, findings cannot be solely identified as a result of behaviour choice theory. As the interventions incorporated other psychological behaviour change theories, the real impact of behavioural choice theory remains unclear. This presents the rationale for this study, which looks to extend the current literature, by assessing the utility of behaviour choice theory as the sole framework underpinning a sedentary behaviour intervention strategy aimed at a generally healthy adult population.

1.11. Study aims

This study aims to assess the effectiveness of an intervention governed by behavioural choice theory in reducing sedentary behaviours. To do this, the study has eight hypothesises which are as follows:

H1: Participants exposed to the intervention arm will have significantly reduced overall time in sedentary behaviour than the control.

H2: Participants exposed to the intervention arm will have significantly reduced number of sedentary bouts compared to the other group arms.

H3: Participants in the intervention arm will report significantly reduced time in sedentary bouts compared to the other two arms of the study.

H4: Participants exposed to the intervention arm will have significantly greater number of sedentary behaviour breaks when compare to the two other group arms.

2. Method

2.1. Study design

A three-armed randomised controlled trial was devised in accordance with the Consort 2010 checklist (Schulz, Altman, & Moher, 2010), randomising participants into either: a) 'intervention group', receive messages governed by behavioural choice theory and guidance on reducing sedentary behaviour; b) 'prompt', receive neutral messages and guidance on reducing sedentary behaviour; c) 'control', do not receive any messages only instructions at the beginning of the study. To ensure the validity of the trail, participants were blinded as to which group they were assigned to. However due to the design of the study, the researcher was unable to be blinded. There are four dependent variables being studied and analysed separately: 1) objectively measured sedentary behaviour, 2) breaks in sedentary behaviour measured, 3) Self-reported sedentary behaviour, 4) Self-control. The independent variable is the type of stimuli participants will receive, measured by the group they were randomised in; control - no messages, prompt – neutral messages (see Appendix D), intervention - messages governed by behavioural choice theory (see Appendix E).

2.2. Data collection and measures

2.2.1 Objective measures

2.2.1.1. ActiGraph wGT3X-BT

The ActiGraph wGT3X-BT triaxle accelerometer was chosen for its ability to objectively measure sedentary and physical activity intensities (Feng, Wong, Janeja, Kuber, & Mentis, 2017). At 4.6cm x 3.3cm x 1.5cm, the device can easily be worn on the wrist, in conjunction with the wrist straps provided. The back of the device utilises touch technology

in the form of a wear time sensor, detecting when the device has been removed from an individual's wrist, which aids compliance monitoring and data cleaning. The ActiGraph wGT3X-BT comes with 4GB capacity for data storage, and can collect data for roughly 25 days, before it needs recharging.

Before any data collection took place, each ActiGraph wGT3X-BT was connected to a computer via a mini-USB cable where each device was: cleared of all previous data, fully charged, and initialised to incorporate previous sedentary behaviour research recommendations. Initialisation was conducted using Actilife v6.11.9 pro software and included; scheduling the capture day parameters (Healy, Winler, Gardiner et al., 2011, Trost, Mciver, & Pate, 2005), setting the sample rate at 60hz (Donaldson, Montoye, Tuttle, & Kaminsky, 2016; Donath, Faude, Schefer, Roth, & Zahner, 2015; Healy et al., 2011a), and programming each accelerometer to utilise the inclinometer function (Carr & Mahar, 2011; Hamilton et al., 2007). Upon completion of initialisation, the designated wrist bands were attached and at this point were ready to be handed out to participants for data collection.

After data collection, each ActiGraph wGT3X-BT was set up in preparation to download using Actilife v6.11.9 pro software. Before the download could take place, subject information was added. Information included: name, gender, height, weight, date of birth, the limb, side, and dominance. Once added, low frequency extension was marked for inclusion and accelerometers were reintegrated with epochs of 60 seconds, in line with previous research recommendations (Donaldson et al., 2016; Donath et al., 2015). Following this, Actilife v6.11.9 pro software was then able to download all the data from the ActiGraph wGT3X-BT and create an AGD file whereby data could be retrieved later for data analysis. This

allows the ActiGraph wGT3X-BT to be restored, erasing all previous data, so it could be used again during the study.

Objective measures were collected during one week of baseline and one week of intervention. The ActiGraph wGT3X-BT accelerometer was used to objectively measure *time spent in sedentary behaviour* (primary outcome) and physical activity intensity, to measure both *time spent in light physical activity* and *time spent in moderate-vigorous* during the two week study. The ActiGraph wGT3X-BT, worn on the non-dominant wrist, simultaneously assesses acceleration against gravity to objectively measure human movement as it happens. ActiGraph accelerometers have demonstrated excellent classification for low level activities when worn on the wrist (Trost et al., 2014). In addition, the ActiGraph wGT3X-BT also measured *total time in sedentary bouts* and *total time in sedentary breaks* during each week. From this, the *average sedentary bout* and the *average sedentary break*, were calculated by dividing total length of sedentary bouts and breaks separately by the number of valid days during each week. Similarly, the *number daily sedentary breaks* and *the number daily sedentary bouts* were calculated by dividing the total number of sedentary bouts and break separately by the number of valid days during each week.

2.2.2. Self-reported measures

2.2.2.1. SIT-Q-7d

The SIT-Q-7d (Wijndaele et al., 2014) is a self-administered questionnaire, devised of 20 items, which looks to quantify time spent sedentary during the last seven days. Participants were able to recall their sedentary behaviours across five different domains; 1) meals, 2) transportation, 3) occupation, 4) leisure screen time, 5) time spent sedentary in other

activities. This allowed domain specific and total sedentary time can be calculated. Most questionnaires focus on either specific populations (Rosenberg et al., 2010) or specific domains (Healy, Winkler, Gardniner et al., 2011), which limits generalisability. The SIT-Q-7d was chosen having demonstrated fair to good test-retest reliability (ICC=0.68) and high criterion validity (Spearman's rho = 0.52) when total sedentary time is measured in a general adult population (Wijndaele et al., 2014).

2.2.2.2 Self-Control Scale

The Self-Control Scale (Tangney et al., 2004), consisting of 36 items, was administered to measure participants' trait self-control. Self-control is the ability to manage or modify influential response tendencies and to regulate thoughts, emotions, and behaviours (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). Subsequently, participants' ability to manage influential responses (e.g. I get carried away by my feelings) and refrain from behaviours deemed undesirable (e.g. I refuse things that are bad for me) was measured, where possible responses ranged from 1 - not at all, to 5 – very much (Tangney et al., 2004). The Self-Control Scale has demonstrated good reliability (Cronbach's α = .89) and good test–retest reliability (r = .89) in the large development sample (de Ridder et al., 2012). Self-control was chosen as the psychological measurement on the back of the behavioural choice theory's inclusion of impulsivity under individual differences. Recent research suggests that individuals who possess high trait self-control avoid temptation and goal-inhibiting impulses (Ent, Baumeister, & Tice, 2015). Therefore, impulsivity can be operationalised within the study, as those who exhibit low trait self-control and succumb to temptation.

Self-reported measured were recorded at the end of baseline and again after at the end of the intervention. *Self-reported time spent sedentary* was measured via the SIT-Q-7d

(Wijndaele et al. 2014). Sedentary behaviour was calculated in each domain: 1) meals (sum of breakfast, lunch, and dinner), 2) transportation (sum of to and from occupation, as part of occupation and getting about apart from occupation), 3) *occupation* (sum of two occupations), 4) leisure screen time (sum of watching TV/DVDs/videos, using computer apart from work, and playing computer games), 5) time spent sedentary *in other activities* (sum of reading, household tasks, caring, hobbies, socialising, listening to music, and other activities). The times spent sedentary in each domain was then summed to give a total time spent sedentary. Participants' *trait self-control* was measured during the study via the 36-item Self-Control Scale (Tangney et al., 2004). Participant responses, ranging from 1 (not at all), to 5 (very much) were summed to give a single score ranging between 36 and 180. Higher scores demonstrating greater levels of trait self-control (Tangney et al., 2004).

2.2.2.3. Qualtrics

The SIT-Q-7d and the 36 item Self-Control scale were replicated using the experience management website Qualtrics, which allowed the questionnaires to be hosted online. Using Qualtrics, the questionnaires were able to be scheduled and distributed to participants' email at a specific time. After receiving the email, participants would be to access the questionnaire, by clicking a link, and work through it online. Responses to the questionnaires were collected and held in the Qualtrics database, where each participant was given a unique response ID.

2.3. Study eligibility

2.3.1. Participant eligibility criteria

Participant eligibility in the study will depend on the following: (a) are between the ages of 18 and 65; (b) are in generally good physical health and able to stand; (c) own a mobile phone – able to receive SMS text messages; (d) have a working email address.

2.4. Procedure

2.4.1. Recruitment

In line with statistical power analysis, the study aims to recruit 70 participants. As the study did not offer any incentives to take part, convenient sampling was employed to recruit volunteer. University students will be made aware of study on various internal course announcement webpages and told to find out more information via email. Whereas, university staff members will be invited to take part via an email with attached information about the study and how to get involved. Individuals who declare interest in the study will then be administered the participant information sheet (see Appendix A).

2.4.2. Baseline measures

After individuals have fully understood the study and have signed the participant consent form (see Appendix B), participants will then be sent the SIT-Q-7d (Wijndaele et al. 2014) and 36-Item Self-Control Scale (Tangney et al., 2004) via email, to be completed online. Upon completion, participants will be issued an ActiGraph wGT3X-BT accelerometer, and educated on how it works. Participants will be informed that the accelerometer is to be worn on their non-dominant wrist for increased accuracy measuring low level activity (Montoye, Pivarnik, Mudd, Biswas, & Pfeiffer, 2016; Sirichana, Dolezal, Neufeld, Wang, & Cooper, 2017), and reminded it must be worn for a minimum of 10 hours to be considered as part of a valid day of measuring (Ward, Evenson, Vaughn et al., 2005; Healy, Wijndaele, Dunstan et al.,

2008; Healy, Winkler, Gardiner et al., 2011). Participants will wear the accelerometer, every day for 7 days during waking hours, in order to assess sedentary behaviour patterns. Then at the end of the week, participants will be re-issued the SIT-Q-7d (Wijndaele et al., 2014) and 36-Item Self-Control Scale (Tangney et al., 2004) via email, to be completed online.

2.4.3. Randomisation

Randomisation into the intervention arms will not occur until participants have successfully enrolled and completed a week of baseline measures. The randomisation sequence was carried out using Stata 14 statistical software (StataCorp, 2015) with an allocation of [1:1:1] into either; the control, prompt, or intervention arms of the study.

2.4.4. Interventions

The intervention will be delivered over a one week period, after initial one week of baseline measures have been undertaken, and participants have been successfully randomised into the three arms of the study. During the intervention week, participants irrespective of which group they are randomised into will be required to wear the ActiGraph wGT3X-BT accelerometer, every day for 7 days during waking hours. In addition, at the end of the intervention week, all participants will be required to complete the SIT-Q-7d (Wijndaele et al., 2014) and 36-Item Self-Control Scale (Tangney et al., 2004).

a) *Intervention arm*

The intervention arm serves to alter and interrupt prolonged sedentary behaviour patterns. Participants randomised into this arm will receive three text messages; morning – 9:00am, afternoon – 2:00pm, and evening – 7:00pm each day for seven days. These messages will be governed by behavioural choice theory and designed to alter sedentary behaviour

patterns (see Appendix E). The messages were designed by the researcher and a week pilot study was implemented on members of the research team to test the design and delivery of text messages, which were later reviewed following its completion. In keeping with the theory, messages will aim to: make participants aware of alternative behaviours (e.g. try standing up while reading and responding to emails and texts), reduce the perceived effort of these alternative behaviours (e.g. make sure you take the stairs, where possible, it's easier than you might think), make alternative behaviours more appealing though positive reinforcement (e.g. stretching can improve your mood and make you feel more relaxed, try it throughout the day for 1 minute or longer), and also make alternative behaviours be perceived as more instantly gratifying (e.g. drinking water can rapidly reduce pain from headaches, prevent them by getting up and staying hydrated). Each participant assigned to the intervention arm received the same message, derived from the BCT message bank, at the same time in accordance with the text message timetable (see Appendix E).

b) Prompt arm

This arm serves to control for the influence of receiving prompts. Therefore, participants randomised into this arm will also receive three text messages, daily for seven days and will be scheduled at the same time as the intervention arm; morning – 9:00am, afternoon – 2:00pm, and evening – 7:00pm. However, the messages that participants receive will be neutral reminders to reduce sedentary behaviours (e.g. remember to break up long periods of sitting, time to walk around) and will not be governed by any behaviour change theory (see Appendix D). Unlike those in the intervention arm who receive messages designed to enact a conscious response to behaviour change, the prompt arm messages are designed to serve as an unconscious reminder. Those assigned to the prompt condition received the

same messages, derived from the prompt message bank, at the same time in accordance with the text message timetable (see Appendix D).

    c) Control arm

    The control arm of the study serves to provide a benchmark of sedentary behaviour patterns which have not been altered by an intervention. Participants who are randomised into this group will only receive recommendations to reduce sedentary behaviour at the start of the intervention. The group therefore receive no messages during the course of the intervention week, thus controlling for the experimental groups.

2.4.5. Key messages

Participants were made aware of the studies key messages in the participant information sheet, and reaffirmed verbally during a face to face meeting. The intervention three key messages to reduced participants' sedentary time were; 1) sedentary bouts kept to a maximum of 30 minutes, 2) Choose to stand rather than sit where possible, 3) Continuously break up prolonged sitting with standing and other light physical activates for a minimum of one minute.

2.4.6. Intervention delivery method

    Mobile phone text messaging (short message service - SMS) were chosen as the method of intervention delivery, in light of increased evidence for its effectiveness in behaviour change settings (Head, Noar, Iannarino, & Harrington, 2013). With widespread mobile phone use, SMS provides the ability to deliver timey reminders in order to promote behaviour change. Previous research suggests that engagement in mobile phone interventions is high, with the majority of text messages read within a couple of minutes after

being received (Douglas & Free, 2013). Participant mobile phones were checked as part of the study recruitment process, to ensure that the phone was in good working order and able to receive SMS messages. No restrictions were placed on what type or model mobile phone participants used, nor where there any restrictions placed on how participants used their mobile phone once the study was running. This decision was taken in order to replicate natural real world settings, participants would normally be accustom to.

SMS design followed recommended steps by (Abroms et al., 2015) to increase rigour and develop effective behaviour change communication. Frequency of messages was set to three per day and scheduled for 9.00am, 2pm and 7pm. Text messages were designed to be short (<160 characters) so that they could be easily digested and put into action. The style of message differed dependent on the group they were assigned to. A message bank was devised of 21 messages governed by in behavioural choice theory and 21 neutral prompts, then added to an administrative website known as Textlocal. The website was used to automatically send out messages from the bank in accordance with the schedule set out and the group the participant was assigned to. Textlocal, the website used to administer text messages to the intervention arm and prompt arm, was also used to record message receipts. Upon reviewing the message receipts, participants' allocated in the intervention and prompt arms that did not receive all 21 messages, were omitted from the studies data analysis.

2.4.7. Intervention compliance

It is recognised participant compliance during the study will be challenging, and with the knowledge that wear time can significantly influence estimations of sedentary behaviour (Kang & Rowe, 2015), measures were taken in order to increase compliance. For this reason, participant involvement was set at two weeks, to reduce chances of fatigue compromising

results. In addition, the decision was made that participants would wear the accelerometer on their wrist rather than optimal measurements when hip mounted. Despite not being the optimal placement, the Actigraph GT3X+ tri-axial accelerometer has demonstrated acceptable activity type classification accuracy (88.4% +/- 3.0%) when worn on the wrist, compared to (91.0 +/- 3.1%) when worn on the hip (Trost, Zheng, & Wong, 2014). Importantly, wrist placement has excellent classification for low level activities sitting (91.3%), standing (95.8%), and walking (95.8%), previously lacking in older accelerometer models (Trost, et al., 2014). As classification differences between the hip and wrist placement are small, and are unlikely to cause significant differences, the option to use either placement is available when using tri-axial accelerometers (Trost, et al., 2014). As a result, the decision of wrist placement was taken based on its association with increased compliance in population studies (Troiano, McClain, Brychta, & Chen, 2014). On the back of this evidence, it is projected that accelerometer wear time will increase and in turn improve the number of valid wear days which the study can factor into data analysis.

2.5. Ethics

Prior to conducting the study, ethical clearance was obtained from the Research and Ethics Committee at Canterbury Christ Church University, after an ethical evaluation had been conducted. The evaluation consisted of an ethical checklist, in line with the BPS Code of Human Research Ethics (2010) and provided a full ethical review of the study. As the study did not violate any of the pre-existing terms that made up the ethical checklist, the study obtained ethical clearance without the need of a review panel. Before individuals could take part in the study they must have read the participant information sheet, which contains an overview of what is required from them during the study eliminating any potential deception.

Participants were also made aware via the consent form that participation in the study was completely voluntary and they had the right to withdraw at any point. Informed consent was obtained in person by the researcher via the participant consent form during the five months the study ran, between May and September 2017.

Anonymity was granted to participants who took part in the study, with the data collected remaining confidential. For this reason, participants were assigned a numeric code (001, 002, etc.) so as to protect participants anonymity. In addition, data storage procedures were followed to ensure the data was stored securely, and only viewed by the research team. Upon completion of the study, participants received the participant debrief sheet (see – Appendix C). The debrief provided participants the opportunity to learn more about the study they were involved in, ask further questions, and directed to places to get help should they have suffered any emotional issues due to the study.

2.6. Data processing

This study is not able to use the traditional cut points devised by Freedson et al., (1998). These have previously been applied in studies where the accelerometer is hip mounted, and lack precision measuring low level activities in free living conditions (Kozey-Keadle et al., 2011). As Montoye et al., (2016) notes, accelerometer placement effects activity classification sensitivity, and different cut points should be utilised in conjunction with wrist worn accelerometer placement. Kim, Lee, Peters et al., (2014) examined wrist worn accelerometer cut points, concluding 0-1756cpm is optimal to assess sedentary behaviours amongst children. At present however, there are no critically accepted cut points used to identify sedentary behaviours on wrist worn accelerometers for adults (Koster et al., 2016; Montoye et al., 2016). As a result, the decision was taken to devise new cut points.

New activity intensity cut points were established by utilising previous research conducted by Swartz et al., (2000). Their research, performed on 70 healthy adults, measured the accelerometer wrist counts of various leisure activities. Mean wrist counts from Swartz et al (2000) study were recorded and then grouped, in accordance with the most frequently reported MET-defined intensity categories (Tudor-Locke et al., 2010). For example; light intensity (cooking), moderate intensity (gardening), vigorous (doubles tennis). Subsequently, average mean wrist counts were calculated for each intensity group; light (2277 cpm), moderate (3818 cpm), vigorous (5688 cpm). Standard deviation around each of the means was performed, and validated against participants' self-reported sedentary time to give new accelerometer wrist cut points.

Cut points used in Actilife v6.11.9 pro software (ActiGraph, Pensacola, FL) for scoring were as follows: sedentary behaviour (0-1611 cpm), light physical activity (1612-2892 cpm), moderate physical activity (2893 ≥ cpm). Sedentary bouts and breaks were defined based off previous research, conducted by Bankoski et al., (2011), using data from 1367 men and women who participants in the 2003–2006 National Health and Nutrition Examination Survey (NHANES). A sedentary bout was considered a period of time >5 minutes recorded as ≤1611 cpm with a 1 minute drop time, allowable outside this range. A break in sedentary behaviour was defined as an interruption in sedentary time when counts exceed 1612 per minute.

2.6.1. Data Exclusion

Based on research recommendations, a valid day constitutes 600 minutes of non-consecutive wear time (Ward, Evenson, Vaughn et al., 2005; Healy, Wijindaele, Dunstan et al., 2008; Healy, Winkler, Gardiner et al., 2011). For participant data to be included in analysis, participants were required to complete four valid days out of every week (Healy, Wijindaele,

Dunstan et al., 2008; Healy, Winkler, Gardiner et al., 2011; Donaldson et al., 2016). If participants failed to complete four valid days for the week, then their data was excluded from the analysis. Data was also excluded, based on Choi, Liu, Matthews, & Buchowski, (2011) wear time validity recommendations. Should the accelerometer exceed 90 minutes of consecutive counts per minute equal to zero, allowing for a two-minute spike tolerance, then data would be classed as non-wear and removed from analysis (Chio et al., 2011).

2.7. Statistical analysis

Due to a lack of existing research to inform a sample size calculation, a *priori* power analysis using G*power3 (Faul, Erdfelder, Lang, & Buchner, 2007) was used to garner an appropriate sample size to perform a mixed-ANOVA. Based on the number of conditions and outcome variables, a sample size of 70 was deemed necessary to detect differences between groups, with 95% power at $\alpha = .05$ (two-tailed).

All self reported data, entered by the particpants, were stored as an unidentifiable form (using thier assigned participant code) in the Qualtrics database. The scoring of the SIT-Q-7d and the Self-Control Scale was carried out in accordance with the guidelines set by the instrument developers (Tangney et al., 2004; Wijndaele et al., 2014). Data gathered from the Actigraph GT3X+BT accelerometer were processed using Actilife pro software, version 6.11.9. Analysis was conducted using SPSS Statistics for Windows, version 24.0 (SPSS Inc., Chicago, IL). Descriptive statistics were calculated for participant characteristics recorded at baseline, displaying both means (M) and standard deviation (SD) for continuous data and frequencies (%) for categorical data. A mixed analysis of variance was used to determine differences in time spent sedentary, and other outcomes, amongst the three groups (intervention, prompt,

and control) from baseline to post intervention. Statistical significance was set at α= .05 (two-tailed).

3. Results

Participant characteristics

A total of 50 participants were recruited to take part in the study. Three participants did not record ten hours of accelerometer wear time on at least four of the seven days during either week, with two participants not completing the self-report measures on self-control and sedentary time. Thus 45 participants (28 females, 17 males) aged 18 to 65 years old (M = 43.18, SD = 15.56), were included in data analysis (see Table 1 for descriptive statistics). A one way analysis of variance was performed to identify whether participant characteristics' differed significantly between groups. Though the control group differed from both the intervention groups, as it contained more male than female participant's, there was no significant gender differences between groups, p = .07. Similarly, despite a five year mean age range between the control and intervention group, age did not significantly differ between groups, p = .63. Although occupational status varied amongst the groups, it did not influence accelerometer wear time, which did not significantly differ between the three groups p = .80.

Table 1

Participant demographics for control, prompt, and intervention groups.

	Control (N-=15)	Prompt (N=15)	Intervention (N=15)
Male	9	3	5
Female	6	12	10
Age (years)	40 (14.94)	44.33 (14.02)	45.2 (18.03)
Height (inches)	68.20 (3.32)	67 (2.36)	67.27 (2.37)
Weight (lbs)	189 (27.29)	172 (48.27)	157.3 (25.45)

Wear time (%)	57.77	55.27	55.43
Right wrist	3	1	1
Left wrist	12	14	14
Full time	10	10	6
Part time	2	3	5
Student	3	0	2
Unemployed	0	2	2

*Data for age, height and weight presented as the mean (SD)

3.1. Changes in sedentary, LPA and MVPA time

A mixed analysis of variance (group x time) was performed to compare difference between three intervention arms (control, prompt, intervention) on each outcome across two time periods (baseline and post-intervention). Behavioural changes from baseline to post intervention for sedentary and physical activity times are reported (see Table 2). Absolute and relative times were reported, to account for the possible wear time difference between weeks.

Table 2

Absolute and relative time spent sedentary and physically active at baseline and post intervention for control, prompt, and intervention participants

	Control	Prompt	Intervention
	M(SD)	M(SD)	M(SD)
Time spent sedentary (%)			
Baseline	74.34 (8.79)	70.75 (12.9)	70.09 (6.61)
Post intervention	75.11 (9.65)	74.95 (13.27)	69.46 (7.62)
Time spent in LPA (%)			
Baseline	21.83 (8.3)	24.68 (10.89)	26.27 (6.63)
Post intervention	21.17 (9.36)	21.43 (9.71)	26.34 (6.96)

Time spent in MVPA (%)			
Baseline	3.83 (2.08)	4.57 (4.17)	3.63 (2.15)
Post intervention	3.72 (2.2)	3.62 (3.84)	4.21 (2.51)
Minutes sedentary (min/day)			
Baseline	607.19 (202.5)	617.13 (233.74)	617.30 (253.82)
Post intervention	610.43 (166.75)	583.33 (166.96)	550.92 (183.11)
Minutes LPA (min/day)			
Baseline	170.62 (68.73)	241 (182.32)	243.92 (157.48)
Post intervention	164.28 (64.2)	170.33 (91.76)	205.69 (65.78)
Minutes MVPA (min/day)			
Baseline	31.43 (19.51)	42.11 (38.87)	32.37 (23.52)
Post intervention	29.83 (18.22)	27.32 (26.55)	31.84 (18.94)

3.1.1. Time spent sedentary

There was no significant interaction between group and time spent sedentary percentage scores, Wilks Lambda = 0.91, $F(2, 42) = 2.01$, $p = .15$, $\eta_p^2 = .09$. There was no main effect for group differences, $F(2, 42) = 1.03$, $p = .37$. There was no main effect for time, Wilks Lambda = .95, $F(1,42) = 2.02$ $p = .16$, $\eta_p^2 = .05$.

3.1.2. Time spent in light physical activity

There was no significant interaction between group and time spent in light physical activity, Wilks Lambda = 0.94, $F(2, 42) = 1.28$, $p = .29$, partial eta squared = .06. There was no main effect for group differences $F(2, 42) = 1.32$, $p = .28$. There was no main effect for time, Wilks Lambda = .95, $F(1,42) = 2.07$ $p = .16$, $\eta_p^2 = .05$.

3.13. Time spent in moderate-vigorous activity

There was no significant interaction between group and time spent in moderate vigorous activity, Wilks Lambda = 0.90, $F(2, 42) = 2.44$, $p = .10$, $\eta_p^2 = .10$. There was no main

effect for group differences $F(2, 42) = .5$, $p = .95$. There was no main effect for time, Wilks

Lambda = .99, $F(1,42) = .33$ $p = .57$, $\eta_p^2 = .01$.

3.2. Changes in sedentary bouts and breaks

Behavioural changes from baseline to post intervention for sedentary bouts and

sedentary breaks are reported (see Table 3).

Table 3

Sedentary bouts and breaks at baseline and post intervention for control, prompt, and intervention
participants

	Control	Prompt	Intervention
	M(SD)	M(SD)	M(SD)
Number of sedentary bouts (day)			
Baseline	57.6 (12.73)	59.4 (28.51)	64.6 (26.86)
Post intervention	57.4 (13.45)	51.93 (21.61)	53.53 (11.89)
Total time in sedentary bouts (min)			
Baseline	4277.47 (1545.67)	4108.27 (1496.62)	4207.07 (1592.89)
Post intervention	4311.47 (1301.93)	4043.27 (1255.86)	3692.2 (1427.28)
Average sedentary bout (min/day)			
Baseline	75.54 (27.44)	76.1 (31.68)	66.31 (15.38)
Post intervention	78.72 (31.63)	90.15 (53.33)	68.93 (17.61)
Number of sedentary breaks (day)			
Baseline	51.07 (12.26)	52.13 (26.32)	57.33 (24.52)
Post intervention	50.67 (13.11)	45.73 (20.94)	47.13 (11.45)
Total time in sedentary breaks (min)			
Baseline	1523.73 (987.03)	1346.8 (731.41)	1578.2 (614.76)
Post intervention	1468.13 (790.57)	1841.73 (1475.33)	2089.47 (1294.98)
Average sedentary break (min/day)			
Baseline	29.3 (14.91)	35.03 (25.52)	35.54 (12.30)
Post intervention	30.15 (18.67)	28.29 (19.01)	33.73 (10.80)

3.2.1. Number of sedentary bouts per day

There was no significant interaction between group and the number of sedentary bouts, Wilks Lambda = .96 $F(2, 42) = .84$ $p = .44$, $\eta_p^2 = .04$. There was no main effect for group differences, $F(2, 42) = .16$ $p = .86$. There was no main effect for time, Wilks Lambda = .93, $F(1, 42) = 3.21$, $p = .08$, $\eta_p^2 = .07$.

3.2.2. Total time in sedentary bouts

There was a no significant interaction between group and total time in sedentary bouts, Wilks Lambda = .97, $F(2, 42) = .68$, $p = .51$, $\eta_p^2 = .03$. There was no main effect for group differences $F(2, 42) = .28$, $p = .75$. There was no main effect for time, Wilks Lambda = .98, $F(1, 42) = .79$, $p = .38$, $\eta_p^2 = .02$.

3.2.3. Average sedentary bout

There was no significant interaction between group and the number of average sedentary bout, Wilks Lambda = .93 $F(2, 42) = 1.55$, $p = .23$, $\eta_p^2 = .07$. There was no main effect for group differences, $F(2, 42) = .99$ $p = .38$. There was a main effect for time, Wilks Lambda = .90, $F(1, 42) = 4.89$, $p = .03$, $\eta_p^2 = .1$ see Figure 1.
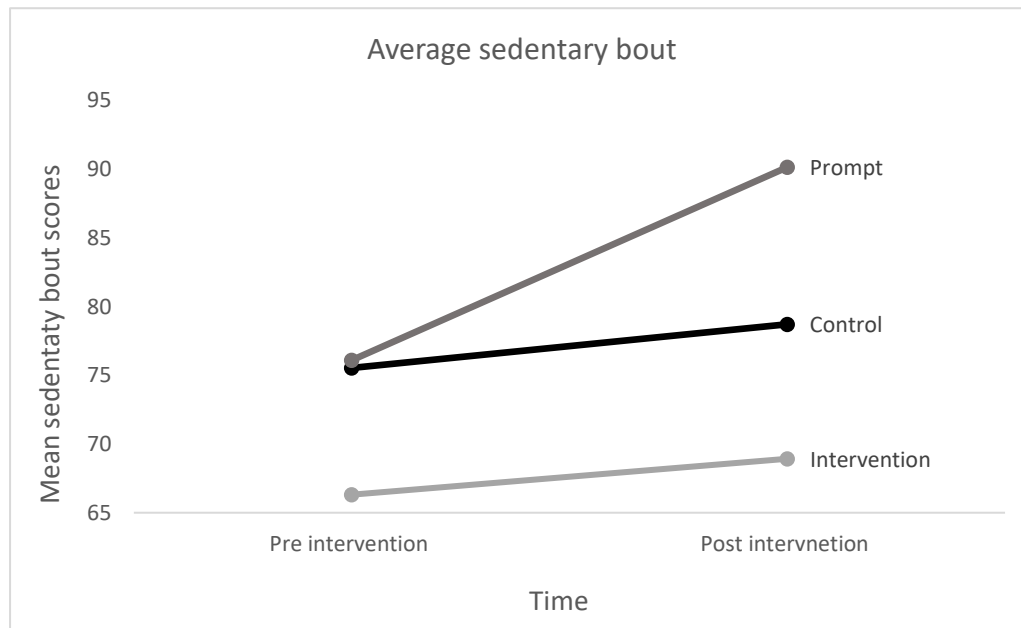
Figure 1: Mean scores in each group for average sedentary bout recorded pre and post intervention

3.2.4. Number of sedentary breaks per day

There was no significant interaction between group and number of sedentary breaks, Wilks Lambda = .96, $F(2, 42)$ = .82, p = .45, η_p^2 = .38. There was no main effect for group differences $F(2, 42)$ = .16, p = .85. There was no main effect for time, Wilks Lambda = .93, $F(1,42)$ = 3.22, p = .80, η_p^2 = .07.

3.2.5. Total time in sedentary breaks

There was no significant interaction between group and total time in sedentary breaks, Wilks Lambda = .93, $F(2 ,42)$ = 1.49, p = .24, η_p^2 = .67. There was no main effect for group differences $F(2 ,42)$ = .98, p = .39. There was a main effect for time, Wilks Lambda = .91, $F(1, 42)$ = 4.31, p = .04, η_p^2 = .09 see Figure 2.
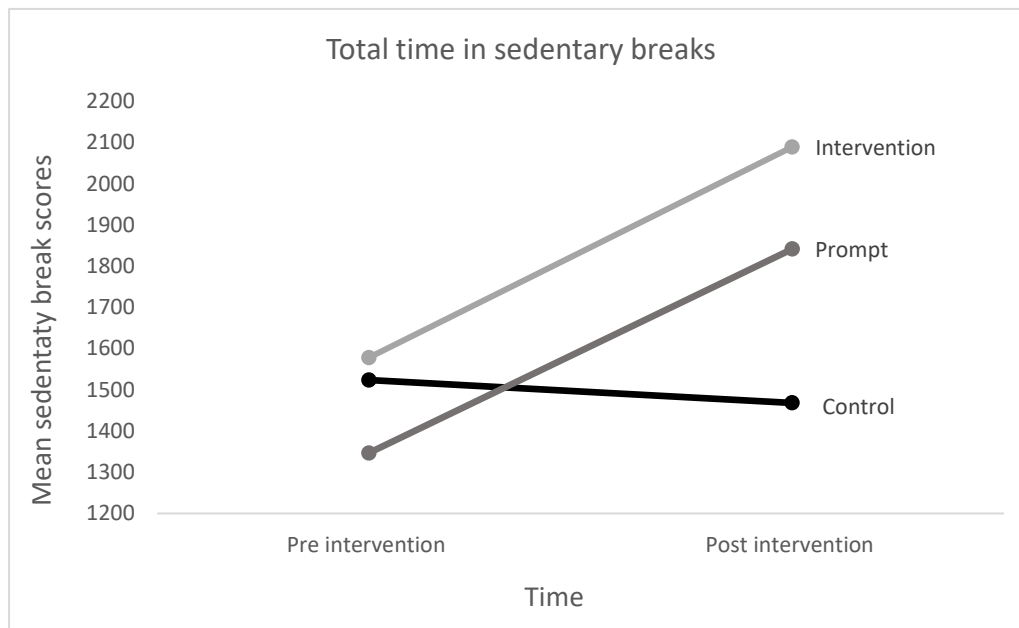
Figure 2: Mean scores in each group for total time in sedentary breaks recorded pre and post intervention

3.2.6. Average sedentary break

There was no significant interaction between group and the number of average sedentary break, Wilks Lambda = .95 $F(2, 42)$ = 1.01, p = .35, η_p^2= .05. There was no main effect for group differences, $F(2, 42)$ = .36 p = .7. There was no main effect for time, Wilks Lambda = .97, $F(1, 42)$ = 1.42, p = .24, η_p^2 = .03.

3.3. Self-Report outcomes

Self-reported outcomes for the self-control scale (Tangney et al., 2004) and the SIT-Q-7d (Wijndaele et al., 2014) are reported (see Table 4). Average self-control scores, as well as domain specific and overall sedentary times can be compared between groups and weeks.

Table 4

Self-reported self-control and time spent sedentary scores at baseline and post intervention for control, prompt, and intervention participants

	Control	**Prompt**	**Intervention**
	M(SD)	M(SD)	M(SD)
Self-Control score			
Baseline	117.87 (18.60)	120.87 (14.29)	122.60 (15.65)
Post intervention	123.47 (18.62)	123.53 (15.97)	122.73 (13.15)
Sedentary time – meals (min/day)			
Baseline	20.14 (8.59)	22.52 (10.06)	23.76 (11.53)
Post intervention	16.86 (8.57)	24.24 (8.83)	24.48 (13.90)
Sedentary time – transport (min/day)			
Baseline	48.36 (55.42)	32.72 (19.92)	34.16 (21.98)
Post intervention	35.33 (40.57)	40.15 (35.34)	29.98 (25.11)
Sedentary time - occupation (min/day)			
Baseline	33.51 (33.43)	36.11 (27.82)	28.16 (30.42)
Post intervention	42.70 (22.46)	45.01 (23.72)	39.57 (45.04)
Sedentary time – leisure (min/day)			
Baseline	88.57 (36.81)	73.43 (46.73)	114.57 (66.75)
Post intervention	86.14 (53.75)	78.71 (43.66)	93.14 (65.70)
Sedentary time other (min/day)			
Baseline	64.71 (55.01)	71.43 (46.09)	74.57 (45.28)
Post intervention	50.86 (50.78)	59.71 (46.84)	73.57 (46.99)
Overall sedentary time (min/day)			
Baseline	255.16 (78.95)	236.22 (66.85)	259.97 (109.28)
Post intervention	231.90 (70.14)	247.83 (86.18)	260.17 (99.41)

3.3.1. Self-Reported sedentary time

There was no significant interaction between group and self-reported time spent sedentary, Wilks Lambda = .94, $F(2, 42)$ = 1.38, p = .26, η_p^2 = .06. There was a main effect for group differences $F(2, 42)$ = 3.86, p = .03. Post hoc comparisons using the Tukey HSD test revealed that the mean score for the intervention group (M = 2149.40, SD = 592.68) was significantly different to the prompt group (M = 1550.33, SD = 362.83) see Figure 3. However, the control group (M = 1759.53, SD = 708.63) did not significantly differ from the intervention and prompt group. There was no main effect for time, Wilks Lambda = .96, $F(1, 42)$ = 1.55, p = .22, η_p^2 = .03.

Figure 3: Mean group differences for self-reported sedentary time recorded at baseline.

3.3.2. Self-Control on sedentary time

There was no significant interaction between self-control (low, moderate, high), intervention group and time spent sedentary percentage, Wilks Lambda = .92, $F(4, 36)$ = .75, p = .56, η_p^2 = .08. There was equally no significant interaction between self-control and time

spent sedentary percentage, Wilks Lambda = .99, $F(2, 36)$ = .25, p = .78, η_p^2 = .01. There was no main effect for time, Wilks Lambda = .95, $F(1, 36)$ = 1.78, p = .19, η_p^2 = .05.

3.3.3. Self-Control on sedentary breaks

There was no significant interaction between self-control, intervention group and number of sedentary breaks. Wilks Lambda = .95, $F(4, 36)$ = .49, p = .75, η_p^2 = .05. There was equally no significant interaction between self-control and number of sedentary breaks, Wilks Lambda = .95, $F(2, 36)$ = .88, p = .43, η_p^2 = .05. There was no main effect for time, Wilks Lambda = .90, $F(1, 36)$ = .88, p = .05, η_p^2 = .1.

4. Discussion

4.1. General discussion

As emerging evidence accumulates on the negative health risks associated with prolonged sedentary behaviour (Rezende et al., 2014), a fundamental goal for researchers is to evaluate promising strategies aimed at reducing time spent sedentary (Owen, et al., 2011). The primary purpose of this study was to examine the utility of behavioural choice theory governing the intervention arm of a randomised control trial which aimed to reduce sedentary time amongst adults. This study evaluated behavioural choice theory by comparing three different conditions which varied in the type of messages received; control - receive no messages, prompt - receive neutral messages, intervention - receive messages based on behavioural choice theory.

The main finding from this study suggests that receiving messages based on behavioural choice theory do not significantly reduce time spent sedentary, compared to receiving neutral messages or no messages, after one week of intervention. Subsequently,

over the same period, receiving messages based on behavioural choice theory do not significantly increase light or moderate-vigorous physical activity. It should be noted, a small (although not significant) reduction in sedentary time is reported in the theory based condition with just one week of intervention. Indeed, the 0.63% reduction, observed in the intervention group, is the only condition to report a reduction in sedentary time (see Table 2). Nevertheless, the observed reduction of 0.63%, produced by the intervention group, is lower than the 3-6% reductions reported in previous sedentary behaviour interventions (Bond et al., 2014; Carr et al., 2013; Gardiner et al., 2011, Otten et al., 2009). Surprisingly, the reduction in sedentary behaviors, seen in the intervention group, were replaced with a greater proportion of moderate-vigorous physical activity as oppose to light physical activity (see Table 2). This is interesting considering the key messages given out at the start of the study and the text messages given out during the intervention, were both designed to promote the increase of light physical activities. These findings build upon previous research which incorporate behavioural choice theory into sedentary behaviour interventions in free living conditions (Carson, et al., 2013; Gardiner et al., 2011; Salmon et al., 2005; Thomsen, et al., 2016), and addresses the current population bias within the literature by objectively measuring a generally healthy adult population.

Similar outcomes, to that of our main finding, have been observed in two studies which measured the interventions to reduce daily sitting time against control groups (Evans et al., 2012; Thomsen et al., 2016). Both studies, reported no significant between-group differences in objectively measured sitting time after; five days of programmed software reminders (Evans et al., 2012), and 16 weeks of motivational counselling and text message reminders (Thomsen et al., 2016). Nevertheless, six studies have reported the intervention

group had a significant greater reduction in time spent sedentary than the control group (Alkhajah et al., 2012; Carr et al., 2013; Healy et al., 2013; Neuhuas, et al. 2014; Otten et al., 2013 & Pronk et al., 2012). Four of the six interventions used sit-stand workstations (Alkhajah et al., 2012; Healy et al., 2013; Neuhuas, et al. 2014 & Pronk et al., 2012), one incorporated a peddle machine (Carr et al., 2013) and the other used lock out boxes to restrict TV viewing Otten et al., 2013). This is important as it reveals that interventions that incorporate environmental modifications, may be more effective at producing significant reductions in sedentary behaviour than individualised programmes that place heavy emphasis on the use of message reminders. The use of text messages as a delivery method has previously demonstrated efficacy amongst physical activity interventions (Head, Noar, Iannarino, & Harrington, 2013). However, this study lends support to (Thomsen et al., 2016) findings that the use of text messages are ineffective at promoting significant sedentary behaviour reductions. While additional interventions are necessary to confirm this finding, this study adds to the literature as only the second study to implement the use text messages in a sedentary behaviour intervention.

This study also found that receiving messages based on behavioural choice theory do not significantly reduce the time in sedentary bouts or the number of daily sedentary bouts, compared to the other two conditions. Again, it should be noted small (although not significant) reductions in the number of and the total time in sedentary bouts are observed in the two conditions which received messages during the intervention (see Table 3). Without accounting for weekly differences in wear time, these changes are greater in the theory based condition as a 12.24% and a 9.4% reduction in total time in sedentary bouts and number of sedentary bouts are observed respectively. However, average sedentary bouts significantly

differed from pre to post intervention, with increases observed across all three conditions after one week. While the increase in the theory based condition of 3.95% is lower than the other two conditions, this finding is unexpected, and goes against the hypothesis that receiving messages based on behaviour choice theory would reduce average sedentary bouts. One possible explanation for this unexpected finding is potential intervention effects at the start of the study which were uncontrolled for. Receiving information about the health consequences of prolonged sedentary behaviour at the start of the study, and the initial wearing of the accelerometer, may have produced short term intervention effects of their own. Alternatively, research suggests that receiving health messages, which contradict ones beliefs, are often met with resistance (Falk et al., 2015). This lack of openness to change, may in part explain why the average sedentary bout increased in both conditions which received messages after intervention.

This study also found that receiving messages based on behavioural choice theory do not significantly increase the number daily sedentary breaks or average or sedentary break, in comparison with the prompt and control conditions. Surprisingly, all three conditions reported small (yet not significant) reductions in the number of daily sedentary breaks after one week of intervention while, both the experimental conditions reported small (yet not significant) reductions for average sedentary break (see Table 3). The theory based condition reported a 17.79% reduction in the number of daily sedentary breaks and a 5.09% reduction in the average sedentary break. These findings are unexpected and do not support our hypothesis. Previous research has shown a 4.5% increase in the number of daily sedentary breaks is possible during a one week intervention period in older adults (Gardiner et al., 2011). Such a large disparity between results, raises the question whether wrist worn

accelerometers are able to effectively capture transitions from a sedentary bout into a sedentary break. Further research examining the effectiveness accelerometers to measure these transitions while wrist worn is warranted. Although no between group differences were reported, total time spent in sedentary breaks differed significantly from pre to post intervention (see Figure 3). Both conditions receiving messages during the intervention saw total time in sedentary breaks increase after one week of intervention, compared to the control condition which decreased (see Table 3). Interestingly, the prompt group saw a larger increase in total time spent sedentary breaks of 36.75% compared the increase in the intervention group of 32.40%. However, these findings do not correspond with the observed reductions in light and moderate-vigorous physical activity after intervention (see Table 2). As such, these results should be interpreted with caution. If this study were to be replicated, working alongside a trained statistician with experience using accelerometer data and Actilife v6.11.9 pro software may provide useful to assist in the analysis. This is strongly recommended to uphold greater statistical rigour and provide more meaningful results (Walters, 2006).

It appears the sample size was too small to draw valid conclusions about the effects of receiving behavioural choice theory messages on sedentary behaviours. Nevertheless, the aforementioned findings are suggestive and warrant further investigation. Alternatively, one possible explanation for the findings reported in this study, is that sedentary behaviours are habitual and thus harder to alter. Habits are formed through the repetition of a behaviour within a specific context (Lally, van Jaarsveld, Potts & Wardle, 2010), and are prompted automatically by situational cues (Woods & Neal, 2009). Research suggests the action to carry out sedentary behaviours are regulated by automatic and controlled processing (Conroy,

Maher, Elavsky, Hyde, & Doerksen, 2013). As such, the degree to which sedentary behaviours are performed automatically, with minimal conscious forethought, determines the strength of the habit (Gardner, 2015). Where habit strength increases, behavioural control is transferred to environmental stimuli (Lally, Wardle & Gardner, 2011), and alternative options become less accessible (Danner, Aarts & de Vris, 2008). This study, in keeping with behavioural choice theory (Epstein, 1998), aided those in the intervention group with messages designed to increase awareness of alternative behaviours and make them more accessible. However, it is theorised that in specific contexts associated with the repetition of a behaviour, habit will override conscious counter-habitual intentions and will elicit the behaviour anyway (Hall & Fong, 2007; Traindis, 1997). So while messages based on behavioural choice theory may have helped consciously form better sedentary behaviour intentions, these would have been overridden by unconscious automatic processing. Similarly, this highlights the importance of removing environmental stimuli associated with sedentary behaviour and supports the notion that environmental modifications are key to producing sedentary behaviour reductions. As such, it is recommended that future sedentary behaviour interventions take a dual process models approach, which targets both automatic and control processing.

4.2. Strengths

This study has several strengths. This study puts theory into practise, by evaluating the utility of behavioural choice theory as the sole framework informing a sedentary behaviour intervention. The inclusion of two experimental conditions, one of which serves to control for the influence of receiving prompts, allows for the direct effect the behavioural choice theory

intervention to be examined. This plus the randomised control design, represents the gold standard for evaluating intervention effectiveness (Schulz, Altman, & Moher, 2010).

Another key strength, is that the study objectively measures sedentary behaviours across free living conditions. The 10 hours minimum wear time, advocated within the literature (Ward, et al., 2005; Healy, Dunstan, Salmon et al., 2008; Healy,Winkler, Gardiner et al., 2011), gives a better reflection of daily behaviours compared to previous interventions which have largely focused on measuring occupational behaviours (Alkhajah et al., 2012; Healy et al., 2013; Neuhuas, et al., 2014; Pronk et al., 2012). In addition, this study is the first to use the ActiGraph wGT3X-BT accelerometer to measure behaviours while worn on the wrist. In doing so, this study also establishes new cut off points for scoring wrist worn accelerometer data in adults. This allows future studies to replicate wrist worn accelerometer scoring using these cut points, and provides a foundation, to establish more optimal cut points which are critically accepted. Overall, the decision to wear the ActiGraph wGT3X-BT on the wrist was well received by participants. Compliance was very high, as 90% of recruited participants' recorded ten hours of recorded accelerometer wear time on at least four days during each week.

4.3. Limitations

This study also has certain limitations. Due to the lack of existing research to inform sample size, priori power calculations revealed 70 participants would be needed to attain observed power level at 95%. Unfortunately, participant recruitment to take part in the study proved challenging. One of the reasons for this, was that the mass email campaign, which advertised the study to university staff and students, had a lower response rate than expected. The 50 participants recruited, and the subsequent 45 used in data analysis were

lower than intended, and may have resulted in confounding. Nevertheless, it appears this study is underpowered to detect between-group differences in each of the outcomes measured. Therefore, a follow up study with a greater sample size is warranted.

At present the design of sedentary behaviour interventions are constrained to current technology. This study is no different. The ActiGraph GT3X-BT is limited to roughly 25 days of continuous data collection before it needs recharging (ActiGraph, Pensacola, FL,). This decreases the feasibility of conducting long term interventions, or conducting a follow up due to how labour and time intensive collecting, charging then redistributing the accelerometers is. Therefore, this study was restricted to a transient evaluation of behavioural choice theory over just a one week intervention period. Future studies may wish to examine the long term effectiveness of behavioural choice theory, as soon as technological advances allow objective measures greater feasibility when recording behaviours over an extended period.

Due to its analytical complexity, working with and interpreting accelerometer data has been recognised as challenging (Broderick, Ryan, O'Donnell, & Hussey, 2014; Lawman, Van Horn, Wilson, & Pate, 2015). Due to a lack of in-house accelerometer expert, no training to become certified for accelerometer initializing, screening or scoring was provided, which goes against accelerometer scoring protocol recommendations (Cain, 2014). If this study were to be replicated, and funding allowed, certified accelerometer training would be pursued. Alternatively, previous research has demonstrated instances where the researcher has outsourced accelerometer data processing to a trained research statistician who has previous experience working with this type of data (Cooper, Bassett & Falk, 2017; Napolitano et al., 2010).

While previous ActiGraph accelerometers have demonstrated excellent classification for low level activities while worn on the wrist (Trost, et al., 2014), no critically accepted cut points are available to identify sedentary behaviours in adults (Koster et al., 2016; Montoye et al., 2016). Therefore, the cut points devised in this study to classify activity intensity, are not yet optimal. Consequently sedentary behaviours may have been misclassified. Future studies are needed to clarify whether the cut points used in this study are appropriate, and determine critically accepted cut points for adults when accelerometers are worn on the wrist.

Prior to conducting the study, SMS text messages were chosen to deliver sedentary behaviour reduction stimulus to participants due to engagement in mobile phone interventions being high (Douglas & Free, 2013), and increased evidence for its effectiveness in behaviour change settings (Head, Noar, Iannarino, & Harrington, 2013). However, the study was not able to control for how many text messages participants received overall, not just those on behalf of the study. In accordance with the Stimulus Response Theory (Suppes, 1969), the volume and the frequency of text messages received by participants independent of the study would have influenced the effectiveness of the sedentary behaviour reduction stimulus. As a result, automatic learned responses to receiving a text message would likely override any sedentary behaviour intervention, due to stimulus being delivered via the same method.

4.4. *Future implications*

While the literature on sedentary behaviour increasingly develops, it is important to recognise it is still in its infancy. The ability to objectively measure sedentary behaviours simultaneously across the three criteria laid out by the conceptualised definition, with

rigorous precision and accuracy, remains elusive (Healy, Winkler, Gardiner et al, 2011). Until then, future studies have a responsibility, not only strive towards greater precision, but also capitalise on emerging technologies that show promise assessing sedentary behaviours (Atkin et al., 2012). It should be noted, advancement in this area of research will only occur in line with participant compliance. Nevertheless, improvements in objective measures may allow future researchers to measure sedentary behaviours over a longer periods. This would allow interventions to be scaled up and measure the potential for further reductions over time, as well as, give researchers the opportunity to include follow up measures to examine if behaviour changes have been maintained after intervention ceases.

Extracting significant reductions in sedentary time through feasible intervention trials, in different populations and settings, remains a top priority within the field (Owens et al., 2011). Interventions that feature environmental modifications are promising (Alkhajah et al., 2012; Healy et al., 2013; Neuhuas, et al. 2014; Pronk et al. 2012). While research has explored areas in the office that can be modified, the chair permeates all domains. Redesigning the chair, which induces the repetitive automatic process, is essential to overcome strong habits and promote more incremental physical activity. New chair designs are being to emerge, with considerations to physical and cardiometabolic health in mind (Zhu & Owen, 2017). Future research should look to examine new designs in different settings to evaluate the feasibility of implementation and the effects on health.

An interdisciplinary approach with the field of neuroscience, could prove useful in the efforts to predict sedentary behaviour. Exploring brain-behaviour responses, using fMRI scanners, provides greater understanding of how key brain regions interact during exposure to different sedentary behaviour interventions. This type of research has shown early signs of

promise. Copper, Basset & Falk (2017) found a strong relationship between brain activity in the ventral striatum and future behaviour. Interestingly, the ventral striatum is central to the treatment of reward (Copper, Basset & Falk 2017), a key aspect of behavioural choice theory. Future intervention may look to unpack this discovery and operationalise behavioural choice theory differently in line with technologies advances to investigate the theories utility further.

5. Conclusion

In conclusion, this randomised control trial provides a methodological framework to evaluate the utility of an intervention underpinned by behavioural choice theory which aims to reduce time spent sedentary in adults. It is recommended that future interventions build on this research with a randomised controlled trial powered to detect between group differences. In addition, research looking to replicate this study are made aware of the pitfalls faced when conducting this study so that they can be avoided. Nevertheless, this is first study to assess the direct effectiveness of a popular behaviour change theory. Similarly, this is the first study to devise new cut points to classify different activity intensities amongst adults when worn on the wrist.

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Appendix A: The Participant Information Sheet

Participant Information Sheet

Study Title: Standing up to sedentary behaviour

Lead investigator: Mathew Westrep

Contact number: 07463388215   Email: m.westrep420@canterbury.ac.uk

You are invited to participate in a study that looks to explore sedentary behaviour patterns. Participation in the study is voluntary so taking part is your choice. Therefore, if you do not want to take part, you do not have to give a reason. There is also the option to withdraw from the study at any point so, if you decided to take part but later change your mind, you are free to stop.

This Participant Information Sheet will guide you through the study and help you decide if you would like to take part. It sets out why we are doing the study and what your participation would involve.

If you agree to take part in this study, you will be asked to fill out and sign the Consent Form before your involvement starts.
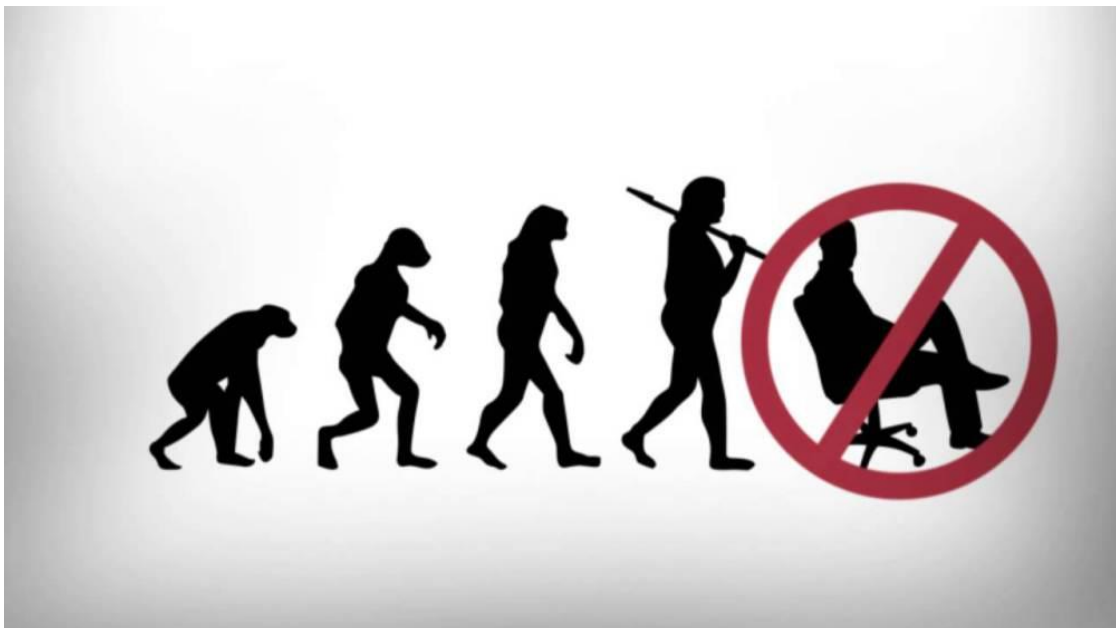
Background Information – Did you know?

- Sedentary behaviour is distinctly different from physical inactivity.
  - It is defined as activities that are done sitting or reclining during waking hours (does not include sleep) with low levels of energy expenditure.
- Common sedentary behaviours include:
  - Watching T.V, reading, using a computer, playing inactive video games, sitting while in a car, as well as any other low energy emitting behaviour spent sitting, reclining or lying down.
- Being sedentary for long uninterrupted periods, exposes adults to number of increased health risks.
  - Potential health risks include: cardiovascular disease, type 2 diabetes, metabolic syndrome, all- cause mortality, and obesity.
- It is commonly mistaken that the risks of prolonged sedentary behaviours can be alleviated by being physically active later.
  - Research has shown the risks associated with prolonged sedentary behaviour are independent of how much physical activity is undertaken later on.
- Reducing prolonged sedentary behaviour bouts is increasingly important in order to minimise the exposure to health risks.

  - Simple 1 minute transitions, or breaks, from sitting down to standing up every 30 minutes has been shown to reduce the onset of health risks.

What is the purpose of the study?

This study will fundamentally be examining a behaviour change theory known as 'Behavioural Choice Theory'. The utility of this theory, in relation to reducing people's sedentary behaviours, remains untested to date. This intervention, which has been grounded in the Behavioural Choice Theory, looks to extend our current knowledge about its effectiveness with sedentary behaviour reductions.

The first week of the study serves to measure your normal sedentary behaviours. The second week of the study introduces the intervention where you will be randomised into one of three groups.

1) The intervention group: receive messages grounded in Behaviour Choice Theory
2) The prompt group: receive neutral messages
3) The control group: receive no message.

This MSc by research study has been deemed worthy of further investigation by the Research Panel at Canterbury Christ Church University and has received full clearance from the Ethics Committee.

What will you be required to do?

Before participating please ensure that you have signed the participant consent form. This will ask for a few details: age, height, weight, email address, and whether you own a mobile phone. Once enrolled, you will be given an ACTi graph accelerometer (a device, that measures time spent sitting – via a combination of the angles from your posture and physical exertion).

You will be required to wear the accelerometer every day, for at least 10 hours, for the entire 2 weeks of the study. The accelerometer is to be worn on either the wrist or ankle during the waking hours of the day, and is to be removed at night before you go to sleep or in any event that brings it into contact with water. For optimal measurement, the study prefers you wear the accelerometer on your non-dominant wrist, and only switch between wrist and ankle if you feel 10 hours of wear time will not be met that day.

This study asks that you also keep a mental note of your daily sedentary behaviour patterns yourself as you will be required to self-report these at the end of week 1 and 2 via the SIT-Q-7d questionnaire.

In addition, the study will be assessing participant's self-control. For this reason, you will also be required to fill out the Self-Control Scale questionnaire at the end week 1 and week 2.

Both these questionnaires will be hosted online for you to fill out. At the end of each week (Sunday) you will be emailed with the link to complete the two online questionnaires.

Dependant on the group that you are placed in, will determine whether or you receive 3 daily text messages (9am, 2pm and 7pm) during the second week of the study. Texts received by participants are prompting in nature, however it is your choice whether act on what the messages say.

Confidentiality

All data and personal information will be stored securely within CCCU premises in accordance with the Data Protection Act 1998 and the University's own data protection requirements. The study is looking for completely honest feedback and as a result it should be recognised that any information obtained during the study will be kept confidential. It should be noted that this study is completely voluntary and you have the right to withdraw at any point.

Participant Weekly Checklist:

Before participating:

- ❖ Read Participant Information Sheet ☐

- ❖ Fill out Consent Form ☐

- ❖ Receive an ACTi graph accelerometer ☐

Week 1:

- ❖ Wear accelerometer (Mon-Sun) during waking hours ☐

- ❖ Fill out SIT-Q-7d ☐

- ❖ Fill out Self-control questionnaire ☐

Week 2:

- ❖ Wear accelerometer (Mon-Sun) during waking hours ☐

- ❖ Fill out SIT-Q-7d ☐

- ❖ Fill out Self Control questionnaire ☐

Any questions?

Should you require any additional information or would like to take part in this study feel free to contact me via email: m.westrep420@canterbury.ac.uk

Appendix B: The Participant Consent Form

CONSENT FORM

Canterbury
Christy Church
University

Study Title: Standing up to sedentary behaviour

Lead investigator: Mathew Westrep

Contact number: 07463388215   Email:

matwest31@gmail.com

Gender

Date of Birth (dd/mm/yyyy)

Height (in feet and inches)

Weight (optional)

Dominant Hand

Do you own a mobile phone?

I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions.

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

I understand that any personal information that I provide to the researchers will be kept strictly confidential

I agree to take part in the above study.

_____   _____
Email   Mobile number

_____   _____   _____
Name of Participant   Date   Signature

_____   _____   _____
Researcher   Date   Signature

Appendix C: The Participant Debrief Sheet

Participant Debrief Sheet

Study Title: Standing up to sedentary behaviour

Lead investigator: Mathew Westrep

Contact number: 07463388215   Email: matwest31@gmail.com

Your cooperation throughout the last two weeks is greatly appreciated, we thank you for giving up your time to take part in this study. This study is an initial investigation into adult sedentary behaviours. The purpose, is to assess the utility of a sedentary behaviour intervention grounded in Behavioural Choice theory. This was achieved by two methods. Firstly, everyone wore an ACTi-graph wGT3x-BT accelerometer for at least 10 hours every day, for the duration of the two week study. Secondly everyone self-reported time spent sedentary, at the end of each week, via the SIT-Q-7d questionnaire.

There were 3 manipulations in the overall design of the study which took place in the second week. Participants were assigned to either:

1) 'Intervention group', receive messages grounded in Behavioural Choice Theory and guidance on reducing sedentary behaviour

2) 'Prompt, receive neutral messages and prompts to reduce sedentary behaviour

3) 'Control', receive no messages to reduce sedentary behaviour

We anticipate that those put in the 'Intervention group' would show lower overall time spent sedentary, and a higher frequency in the number of sedentary behaviour breaks. Sedentary behaviours from week 1 can then be compared to the manipulations in week 2, in order to assess the effectiveness of the intervention.

If you would like to read more about the health risks of being sedentary for long periods and potential solutions, check out the websites below.

http://www.getbritainstanding.org/   http://activeworking.com/

If you have any further questions about the study or would be interested in seeing the results once completed feel free to get in touch via email.

Appendix D: Text Message Timetable - Prompt Group (Neutral messages)

Monday

9am Remember to break up long periods of sitting
2pm Time to move
7pm It's not too late to stretch those legs

Tuesday

9am Remember to stretch throughout the day
2pm Have you stood up regularly throughout the day?
7pm It's not too late to break from sitting

Wednesday

9am Remember to get up every 30 minutes
2pm Time to stretch
7pm Have you managed to walk around often throughout the day?

Thursday

9am Remember to stand up instead of sitting down
2pm Time to walk around
7pm Have you been sitting for too long?

Friday

9am It's not too late to sit less and move more
2pm Time to stand
7pm Have you been regularly breaking up sitting?

Saturday

9am Remember to go for a stroll
2pm Have you been stretching at various points in the day
7pm It's not too late to change your behaviours

Sunday

9am It's not too late to get up and move around
2pm Time to get up
7pm Don't forget to fill out the two questionnaires – I have sent these to your email

Appendix E: Text Message Timetable - Intervention group (BCT Messages)

<u>Monday</u>

9am: Substituting sitting with short periods of standing and walking about can make you feel more awake and alert, try it now.

2pm: Drinking 2 litres of water a day is associated with increased weight loss and flushing out bad toxins, so why not get up every hour and stay hydrated.

7pm: Try taking the stairs where possible, it can easily be built into your daily life.

<u>Tuesday</u>

9am: Going for a brisk walk can help lower stress levels straightaway, test it out

2pm: Try standing up while reading and responding to emails and texts

7pm Keep stretching different body parts throughout the day, it's simple and your body will feel the benefits.

<u>Wednesday</u>

9am: Try and implement getting up to get a drink of water at the start of each hour.

2pm: Did you know, taking the stairs can burn more calories than jogging. Keep climbing those stairs

7pm: Standing is rewarding, it increases energy levels, tones muscle and improves posture. Allocate more time to standing up.

<u>Thursday</u>

9am: Drinking water can rapidly reduce pain from headaches, prevent them by getting up and staying hydrated.

2pm: If you're ever on the phone, try pacing around instead of sitting.

7pm: Breaking up your sitting time can reduce the risk of developing certain types of cancer. You have more control over our health than you think!

<u>Friday</u>

9am: If you're struggling to stay awake, a few stretches can immediately improve your energy levels.

2pm: Stretching can improve your mood and make you feel more relaxed, try it throughout the day

7pm: Remember to go for a stroll outside, some fresh air will help clear your mind

<u>Saturday</u>

9am: Weekends generally mean a lot more sitting, break it up as much as possible, it is not as hard as you think

2pm: Make sure you take the stairs, where possible, it's not too strenuous.

7pm Talking breaks from sitting to stand up every half an hour will instantly improve blood circulation and make you less stiff, give it a go

Sunday

9am: Try parking further away or taking a longer route walking to your destination.

2pm: Don't forget to go for walks throughout the day, it's easy.

7pm: Remember to complete the two questionnaires – why not try doing them whilst standing