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The Creation and Application of a Validated Tool to Measure the Impact of Mobile Standing Desks on Undergraduate Students' Sedentary Time

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Abstract

Undergraduate students (UGS) are highly sedentary, which may elevate their health risks. However, before the effectiveness of an undergraduate sedentary time (ST) intervention can be assessed, accurate and applicable measurement tools need to be identified. The overall purposes of this research program were to first, evaluate the validity of two weekly ST questionnaires compared with criterion data in homogenous samples of UGS (Studies 1 and 2); and second, to measure the effect of providing UGS with mobile standing desks for one-week (Study 3) and one-month (Study 4), while also exploring students' perceptions about using the desks. Each study built on the findings of the study that came before it, with Studies 1 and 2, and Studies 3 and 4 presented together.

In Study 1, UGS wore the activPAL4^{TM} for one week and then completed the PAST-WEEK-U (PWU). In Study 2, UGS wore the activPAL4^{TM} for one week and simultaneously completed the NIGHTLY-WEEK-U (NWU). The agreement between the self-report and criterion measures were assessed via Bland-Altman plots. In Study 3, UGS were provided with a mobile standing desk for one week and their ST was measured using the activPAL4^{TM} and NWU. In Study 4, UGS were provided with a mobile standing desk for one month and their ST was measured with an online version of the NWU. Semi-structured interviews (Study 3) and online opened-ended questions (Study 4) explored participants' experiences with the desks.

The results of Studies 1 and 2 revealed that the NWU outperformed the PWU with much tighter limits of agreement (-1.75 to 2.17 vs. -5.38 to 5.55 hours), making it better suited for use in future intervention studies. In Studies 3 and 4, mobile standing

desks were associated with a significant reduction in one-week (objective: p= 0.0045; self-report: p= 0.0005) and one-month (self-report: p= <0.0001) ST, with the greatest reductions occurring within the 'study' domain. Qualitative analyses revealed facilitators (e.g., enhanced productivity) and barriers (e.g., cumbersome to carry) to using the desks.

This dissertation's studies are valuable for future intervention research aimed at UGS ST, and may contribute to future health gains for an expanding and important population.

Keywords: sedentary, undergraduate, university, college, self-report, questionnaire, accelerometer, Bland-Altman, standing desk

Summary for Lay Audience

The daily sedentary time (ST) of undergraduate students (UGS) is too high and could negatively affect their health. This research program had two main objectives: (1) to establish a questionnaire that could accurately estimate the daily ST of UGS; and (2) determine the impact of mobile standing desks on the daily ST of UGS, while also understanding their experiences with the desks. These two objectives were divided into four research studies.

Study 1 compared the accuracy of a past-week ST questionnaire, the PAST-WEEK-U (PWU), to a device capable of near perfect ST measurement, the activPAL4^{TM}. The daily ST measured by the PWU was compared to the daily ST measured by the activPAL4^{TM}. The comparison was not favorable as many participants under- and over-estimated their ST by large amounts.

Study 2 compared the accuracy of a week-long ST questionnaire, the NIGHTLY-WEEK-U (NWU), with the activPAL4^{TM}. Participants completed the NWU on each day of the week, instead of at the end. Daily ST was compared between the NWU and the activPAL4^{TM}. The NWU was much more accurate than the PWU from Study 1 and was deemed acceptable for use in future studies.

In Study 3, UGS were provided with mobile standing desks for one week to test the usefulness of the desks and asked questions about their experience immediately afterwards. Daily ST from one week without the desk (baseline) was compared to daily ST of a week with the desk (intervention), measured using the activPAL4^{TM} and the NWU. Students mostly enjoyed the desks and reduced their ST significantly.

Study 4 involved providing UGS with the mobile standing desks for one month to test the long-term suitability of the desks and asking them questions online following the intervention. Daily ST from a baseline week was compared to that of an intervention week, which occurred one month after students received their desk. Students mostly enjoyed using the desks and reduced their ST significantly, but some became bored with the desks.

This research program could help future researchers measure and intervene with the ST of UGS, ultimately improving student health.

Co-Authorship

While the contents of this dissertation are my original work (study design, data collection, data analysis, overall manuscript preparation), major contributions were made by several co-authors. I would like to thank my graduate supervisor, Dr. Jennifer Irwin (study design, overall manuscript preparation), and my advisory committee members, Drs. Trish Tucker and Harry Prapavessis (manuscript preparation) for their co-authorship contributions on all four studies. I would also like to thank Dr. Chris Lee (a co-author on Studies 1 and 2, statistical analysis, manuscript preparation) for his statistical expertise. The four studies have been organized into two manuscripts. The first, '*Weekly recall of sedentary time: validity of two weekly self-reported measures in undergraduate students'*, and the second, '*Using mixed method feasibility studies to examine the impact of a mobile standing desk on undergraduates' sedentary time'*, have been submitted for publication.

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Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

Abbreviation	Meaning
GPAQ	Global Physical Activity Questionnaire
IPAQ	International Physical Activity Questionnaire
PA	Physical Activity
SB	Sedentary Behaviour
SBRN	Sedentary Behaviour Research Network
ST	Sedentary Time
UGS	Undergraduate Students

Chapter 1: Introduction

The creation of a modern society and advances in technological innovations have led to global improvements in health status and life expectancy. Throughout the 1900's, high income countries such as the United States experienced unprecedented increases in life expectancy of almost 30 years (Cutler, Deaton, & Lleras-Muney, 2006). Although the life expectancy of those in poorer countries remains much lower than the rich, they too experienced major increases in life expectancy in the second half of the twentieth century (Cutler, Deaton, & Lleras-Muney, 2006). While there are many determinants of decreased mortality, these health gains can be attributed to increases in knowledge, science, and technology (Cutler, Deaton, & Lleras-Muney, 2006). However, the recent boost in life expectancy experienced throughout the world is now being eroded by the very mechanisms that contributed to its rise, and the children of this modern era could experience shorter lives than their parents (Olshansky et al., 2005). The industrialization of daily life has led to a decrease in energy expenditure and an increase in sedentary behaviour (SB) (Kruk, 2014).

SB has been studied across the entire lifespan, from children (Tremblay et al., 2011), to working aged adults (Mummery, Schofield, Steele, Eakin, & Brown, 2005), to the older generation (Harvey, Chastin, & Skelton, 2003). There is a general consensus that each of these populations has become sedentary to the point of endangering their health, evidenced by numerous interventions attempting to reduce their SB (Copeland et al., 2017; Gardner, Smith, Lorencatto, Hamer, & Biddle, 2016; Marsh, Foley, Wilks, & Maddison, 2014). Significantly less consideration has been given to the SB of undergraduate students (UGS) (Buckworth & Nigg, 2004), although more attention has

been directed to this important and growing population (National Centre for Education Statistics, 2018) in recent years (Moulin, Truelove, Burke, & Irwin, 2019). Undergraduate populations have been found to be highly sedentary (Moulin et al., 2019), as well as physically inactive (Irwin, 2004; Irwin, 2007), resulting in high risk for a multitude of negative health outcomes including obesity (Shields & Tremblay, 2008), diabetes, cardiovascular disease, and overall death (Wilmot et al., 2012). As such, like the rest of the population, interventions are needed to reduce the SB of UGS. However, before interventions can be developed and directed towards UGS, accurate measurement tools that are appropriate for distribution amongst large numbers of students need to be evaluated and identified. In an effort to contribute to the improvement of health outcomes among future undergraduate populations, this dissertation is built on a collection of studies that created and compared two sedentary time (ST) questionnaires designed for and validated in UGS. The most valid questionnaire was then applied to measure the impact of mobile standing desks on undergraduate ST, while exploring students' perceptions to using the desks for the duration of one-week and one-month interventions.

The Definition of Sedentary Behaviour and Other Key Terms

There have been many definitions of SB throughout the years (Tremblay et al., 2017), but the recently completed Sedentary Behaviour Research Network's (SBRN) Terminology Consensus Project solidified that SB is "any waking behaviour that is characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Tremblay et al., 2017, p. 9). An important caveat of SB, ST, has been defined as "the time spent for any duration (e.g., minutes per day) or in any context (e.g., at school or work) in sedentary behaviours" (Tremblay et al., 2017, p.

9). Comparatively, physical activity (PA) has been defined as any movement of the body that is produced by skeletal muscles and requires energy expenditure, (World Health Organization [WHO], 2019). This should not be confused with 'exercise' which is a division of PA that is purposeful and planned movement with the goal of improvement in physical fitness (WHO, 2019).

To be considered physically active, an adult (> 18 years old) needs to accumulate at least 150 minutes of moderate to vigorous aerobic PA a week with muscle strengthening exercises completed at least two days a week (Tremblay et al., 2011; WHO, 2010). Conversely, physical inactivity has been defined as a level of PA that is insufficient in meeting current PA guidelines (Tremblay et al., 2017). Very importantly, this definition of physical inactivity allows distinct PA guidelines to be set, and prevalence data to be collected, providing context on the health of populations. Unfortunately, a definition mirrored in physical inactivity does not yet exist in SB research. As of now, it is unclear what amount of daily or weekly ST is safe for human health, as there is insufficient evidence to establish clear-cut SB guidelines (Young et al., 2016). Quite possibly, future guidelines for PA and ST may work alongside each other, as recent evidence suggests a strong dose-response relationship between these two states of activity (Ekelund et al., 2016). Currently, while very distinct and quantitative guidelines exist for PA (WHO, 2010), SB guidelines have only been developed in a limited number of countries, and are broadly stated and vague (Young et al., 2016).

Current Sedentary Behaviour Guidelines

In 2012, the Canadian Society of Exercise Physiology released initial SB guidelines for children and youth. The guidelines state that any amount of screen time is

not recommended for children under the age of two, and that screen time should be limited to under one hour a day for children between the ages of two and four, noting that less is better. For children ages five to 11 and youth aged 12 to 17, recreational screen time should be no more than two hours a day while limiting motorized transport, ST, and time spent indoors. In Canada, there are no current SB guidelines for adults (18 to 64 years old) or older adults (65 years and older), with a 'less is better' approach being all that is available. Similarly, Australia and the United Kingdom recommend that adults limit the amount of time spent sitting and break up extended periods of sitting (Australian Government Department of Health, 2019; UK Department of Health and Social Care, 2011). Young and colleagues (2016) contend that such broad sedentary guidelines are warranted as evidence remains to be collected regarding the strength of associations, causation, and the support for dose-response relationships for SB as an independent risk factor for negative health outcomes. However, a dose-response relationship has been found between PA and sitting time (Ekelund et al., 2016), which could provide a road map to understanding the healthy limits of ST as it interacts with an individual's commitment to PA.

Ekelund and colleagues (2016) conducted a meta-analysis of the association between sitting time and all-cause mortality in more than one million men and women and stratified the results by quartiles of PA. Sitting time was divided into four sections: <4 hours/day; 4-<6 hours/day; 6-8 hours/day; and >8 hours/day. The quartiles of PA were divided into: ~5 minutes/day (Q1); 25-35 minutes/day (Q2); 50-65 minutes/day (Q3); and 60-75 minutes/day (Q4). The authors found that the hazard of sitting for >8 hours/day decreased dramatically from the lowest activity quartile to the highest (Q1= 27%, Q2=

12%, Q3= 10%, Q4= 4%). Comparatively, for individuals who sat between 6 and 8 hours per day, the hazard of sitting was substantially lower across all activity quartiles (Q1= 9%, Q2= 6%, Q3= 3%, Q4=1%), demonstrating the potentially profound effect that reducing daily ST can have on health at equal levels of PA. Although the work of Ekelund and colleagues (2016) cannot provide concrete sedentary guidelines, it suggests that healthier limits for daily sitting time could fall within six and eight hours, particularly for individuals who are physically active. The dose-response relationship between ST and PA suggests that future guidelines should not be prescribed independent of each other, as the effects on human health are inherently linked.

The division of future SB guidelines into cohorts of children and youth, adults, and older adults is needed based on the differing physiological needs of each separate cohort. Adolescence is a period of constant extensive physiological and emotional changes (Ortega et al., 2013), and older adults may experience a diminished physical capacity as they age (Lord et al., 2011). Although it may be appropriate to group all adults (18 to 64 years old) together based on their physiological needs regarding ST, the contribution of individual SBs to overall ST may be drastically different within unique subgroups of the adult population. The determinants of SB vary based on what environment they occur in (Owen et al., 2011). Therefore, it is most appropriate to study these subgroups separately from each other to inform interventions tailored to each unique subgroup. An adult's typical day occurs in three domains: the workplace, leisure, and transportation (Chau et al., 2010). However, for one unique subgroup of the adult population, UGS, the workplace domain, or for most full-time UGS, the 'study' domain, is spread across multiple environments ranging from lecture halls, to libraries, and

various private studying areas. The determinants of SB and the intervention needs of this distinct population could be entirely different from the rest of the adult population based on the ST they accumulate in numerous academic sedentary environments.

The Importance of Undergraduate Students in Sedentary Behaviour Research

The transition from high school into university or college can be one of the most positive and memorable stages in life as students form new friendships and develop social patterns (Macneela et al., 2012). During these years, young adults enter a formative stage and will develop lifestyle behaviours that may track into adulthood (Irwin, 2004), quite possibly impacting them for the rest of their lives. Healthy behaviours that are practiced and established early in life will have a greater chance of being carried forward (Jones, Hinkley, Okely, & Salmon, 2013), positively impacting the individual and potentially influencing the social and cultural norms of the entire population (Leslie et al., 1999). Unfortunately, the opposite is also true as students may experience adjustment difficulties and the establishment of negative health behaviours (Macneela et al., 2012). The transition from high school to post-secondary education has been associated with an abandonment of routines and habits, and the adoption of new lifestyles (Deforche, Van Dyck, Deliens, & De Bourdeaudhuji, 2015) that for some UGS is associated with a decline in PA and considerable health challenges such as those associated with weight gains (Deforche et al., 2015).

Compounding the negative effects of a decrease in PA is the possibility that in addition to be being physically inactive (Irwin, 2004, Irwin, 2007), students may be highly sedentary. The university environment is inherently sedentary, and while resources may exist to increase or maintain PA through exercise (i.e., campus recreational center,

intramural sports leagues, etc.), there are significantly fewer resources available to reduce SB (i.e., standing desks). UGS have reported that their main occupation of studying, on campus and off campus, creates barriers to them engaging in a less sedentary lifestyle (Moulin & Irwin, 2017). Arguably, no other adult population will have more sedentary hours committed to the 'study' domain, uniquely separating UGS from their working-adult counterparts. Furthermore, UGS may have less control over their study environments, unlike older graduate students who may primarily work in personalized on-campus labs, with less time in classroom settings. While the focus of UGS in SB research is relatively new (Buckworth & Nigg, 2004), recent investigations into the daily ST of UGS has confirmed that some UGS are sedentary to the point of endangering their health (Moulin et al., 2019) and at levels that cannot be offset by any realistic amount of PA (Ekelund et al., 2016).

Undergraduate Sedentary Time

Moulin and colleagues (2019) recently conducted a systematic review to identify a range of daily ST of UGS throughout the world. Studies were included in the review if they (a) were written in English, (b) had a study population that consisted entirely of UGS, (c) reported a daily or weekly ST, and (d) included a measure of ST using an accelerometer (a device designed to measure physical and SBs) or validated ST questionnaire consisting of at least three domains from the comprehensive SIT-Q Sedentary Time Questionnaire. The SIT-Q was chosen as the model questionnaire for the review as it was identified as one of the most comprehensive ST questionnaires available (Rivere, Aubert, Omorou, Ainsworth, & Vuillemin, 2018), and was most appropriate for the undergraduate population (Moulin et al., 2019). In an attempt to avoid the inclusion of

a study that drastically underestimated daily ST, the assessment of at least three domains was required.

A total of 23 studies, across seven countries consisting of over 6,500 participants was included in the review. The authors reported a wide range of daily ST among UGS from 0.75 to 14.35 hours per day, with 22 out of 23 articles (95.7%) published in the last five years, demonstrating the recent interest in the undergraduate population. To make better sense of such a wide range, average daily ST was calculated from each measurement tool used. Measurement tools for included studies consisted of accelerometers, domain-specific questionnaires, and single/double item questionnaires. Domain-specific questionnaires ask a participant to report the time they spent sitting or lying down in separate domains (i.e., watching TV, computer use, work, school etc.) with each domain having its own questionnaire item. Comparatively, a single/double item questionnaire has respondents report daily ST across just one or two items, without organizing total ST into individual domains. Moulin et al. (2019) found that studies using accelerometers reported an average daily ST of 10.69 hours per day, compared to 11.10 hours per day for domain-specific questionnaires, and 6.39 hours per day for single/double item questionnaires.

This systematic review was the first of its kind, quantifying the daily ST of UGS around the globe. It confirmed that on average, UGS are highly sedentary, and depending on their commitment to PA, they may be on an early path to disease. For UGS who meet currently prescribed PA guidelines (WHO, 2010), these high amounts daily ST could be negating the health benefits of PA (Ekelund et al., 2016). Furthermore, for those students who are physically inactive, they are quite possibly one of the most inactive and highly

sedentary subgroups of the adult population, with the greatest risk of poor health (van der Ploeg & Hillsdon, 2017). In both cases, interventions are needed to effectively reduce the daily ST of UGS, and interrupt these negative lifestyle behaviours before they are carried forward into adulthood. In addition to the main findings of high amounts of ST among UGS, the authors discussed the measurement issues of certain types of questionnaires that potentially led to such a wide range of reported ST.

The single/double item questionnaires included in the review, the International Physical Activity Questionnaire (IPAQ) (Booth, 2000; Craig et al., 2003) and the Global Physical Activity Questionnaire (GPAQ) (Armstrong & Bull, 2006), met inclusion criteria for the review as these questionnaires ask respondents to report their ST across multiple domains in one or two items. However, some researchers have demonstrated that the IPAQ has low to moderate correlations with criterion measures (Craig et al., 2003; Rosenberg, Bull, Marshall, Sallis, & Bauman, 2008), and single item ST questionnaires have a pattern of underreporting overall ST compared to domain-specific questionnaires (Healy et al., 2011). The average daily ST of single/double item questionnaires (6.39 hours/day) in the review was substantially lower than that of accelerometers (10.69 hours/day) and domain-specific questionnaires (11.10 hours/day), and carried a range of 0.75 to 14.35 hours. These secondary findings illustrate the importance of methodologically sound measurement techniques for undergraduate ST. Researchers rely on accurate assessments of ST to inform the development of interventions. Each ST measurement tool has strengths and weaknesses, with some that are more appropriate and better suited to measure the daily ST of UGS.

Measuring Undergraduate Sedentary Time

ST is often measured by the means of objective measures, such as accelerometers/inclinometers, or self-report instruments (Young et al., 2016). Accelerometers/inclinometers have been found to provide more accurate assessments of ST compared to questionnaires (Boyle, Lynch, Courneya, & Vallance, 2015), but are costly, place a greater burden on participants, and most importantly, cannot provide context on the allocation of overall ST into SBs. Without understanding the behaviour setting in which SBs take place, relevant guidelines cannot be developed, well-informed interventions cannot be designed, and broad-based environmental policy initiatives cannot be put in place (Young et al., 2016). The latter limitation is also true of single/double item questionnaires such as the IPAQ and GPAQ, in addition to low to moderate correlations (Craig et al., 2003; Rosenberg et al., 2008) and a trend of underestimating ST (Healy et al., 2011). These facts in combination with the results of the previously mentioned systematic review (Moulin et al., 2019) and findings detailing the shortcomings of these types of questionnaires (Rivere et al., 2018) suggest that their use should be reconsidered when domain-specific questionnaires are available (Moulin et al., 2019).

The downfalls of accelerometers/inclinometers are the strengths of domain-specific questionnaires as they are more affordable, place a minimal burden on participants, are better suited for larger epidemiological studies (Blair, Czaja, & Blair, 2013), and provide a breakdown of daily ST into individual domains (Young et al., 2016). Unfortunately, their subjective nature makes them less accurate than accelerometers/inclinometers as they rely on a participant's memory of their past SBs and

are negatively impacted by recall bias (Castillo-Retamal & Hinckson, 2011). For this reason, it is critical for researchers to utilize a domain-specific questionnaire that has been validated against a trusted criterion measure, and has been validated for use in the targeted population.

There are currently a limited number of domain-specific ST questionnaires that are appropriate for the undergraduate population as many questionnaires for adults do not contain a domain for 'study' (Sedentary Behaviour Research Network [SBRN], 2017), and even less have been validated for use in UGS. One questionnaire has been partly designed and validated in a population consisting of UGS, but has been found to systematically under/overestimate self-reported daily ST (Clark, Pavey, Lim, Gomersall, & Brown, 2016), and uses a past-day format that limits the intra-individual variability the questionnaire is able to capture compared to longer recall timeframes such as one week (Wijndaele et al., 2014). In general, the accuracy of self-report measures of ST is poor, with most questionnaires grossly underestimating ST (Chastin et al., 2018). There is a need for validated, appropriate self-report measures for all populations, including UGS, as emerging evidence (Chastin et al., 2018) suggests that SB researchers utilizing ST questionnaires have been shooting in the dark, and measures of ST may not be as accurate as once thought. It may be time to implement a new strategy for the design of domain-specific ST questionnaires - one that is able to reduce the recall bias of participants, while maintaining the intra-individual variability (Wijndaele et al., 2014) captured by the questionnaire. Nonetheless, initial objective measures of UGS daily ST suggest that this unique subgroup of the adult population is highly sedentary (Moulin et al., 2019), and interventions are needed to improve their health outcomes.

Previous Interventions Targeting Undergraduate Sedentary Time

Interventions aimed at reducing the ST of UGS have ranged from text message-based interventions (Cotton, 2015), to library pedal machines (Maeda, Quartiroli, Vos, Carr, & Mahar, 2014), and internet-based motivational interventions (Miragall, Dominguez-Rodriguez, Navarro, Cebolla, & Baños, 2018). However, it is surprising that very few interventions have attempted to explore the effectiveness of standing desks on the ST of UGS, considering logical comparisons between the work of undergraduates and desk-based workers, the popularity of standing desk interventions in the workplace (MacEwen, MacDonald, & Burr, 2015), and their effectiveness at reducing the ST of office workers (Alkhajah et al., 2012). Preliminary investigations into the use of standing desks in the university classroom setting have shown promise for the acceptance of the intervention, the reduction of classroom ST, and the improvement of associated health outcomes.

Jerome, Janz, Baquero, and Carr (2017) tested the effectiveness of standing desks on the classroom ST of UGS in a six-week cross-over design. The study took place over 12 weeks, within two university classrooms – Classroom A and Classroom B. At the beginning of the study, 25 height adjustable sit-stand desks replaced traditional seated desks in Classroom A, while traditional seated desks remained in Classroom B. Each classroom setting lasted six weeks. At the six-week mark, first observations of sitting and standing were conducted via direct observations of students' sitting and standing behaviours using a video camera that was placed in the front corner of each classroom. Standing and sitting behaviours were observed for the full class period and to reduce the expectation effects, the video cameras remained in the classrooms on days in which

observations did not occur. The time spent standing and walking was subtracted from the total class duration to calculate a total class sitting time independently by two researchers. Immediately following this first observation, the sit-stand desks were moved to Classroom B and the traditional seated desks returned to Classroom A for the next six weeks.

Utilizing the same protocols as the first six weeks, upon the conclusion of week 12, classroom observations were conducted and standing and sitting time were once again calculated. Participants completed post-intervention online surveys that collected participants' responses on their acceptability of using the sit-stand desks, whether they would like to take another class with the desks, their reasons for why they did or did not use the desks, etc. The results of the intervention were quite favourable as the participating students stood significantly more minutes per hour per student (7.2 minutes/hour/students) and for a larger percentage of class time (9.3%) when given access to a sit-stand desk compared to when they were limited to a seated desk (0.7 minutes/hour/student, 1.6% of class time spent standing). Post-intervention responses revealed that 69% of students would be willing to take another class that provided sit-stand desks, 71% would support the addition of sit-stand desks to other classrooms on campus, and when asked about strategies that might encourage them to stand more with the desks, the most common answer was "seeing other students stand" (Jerome et al., 2017, p. 235).

In 2018, Butler, Ramos, Buchanan, and Dalleck conducted a similar type of study to investigate the effect that providing college students with standing desks had on their cardio-metabolic health. To be included in the study, students had to be at least 18 years

old, and be enrolled in at least two classes in a single specified building on the Western State Colorado University campus in which standing desks had been installed. In a randomized cross-over design, participants were randomized into Group One or Group Two. For the first three weeks, Group One was required to sit in two classes while Group Two was required to stand in a minimum of two class periods per week, which totaled five hours per week of standing during the intervention stage. During week four of the study, both groups were required to sit to effectively 'washout' the effects of the first three weeks of the trial. In weeks five to seven, the conditions of the first three weeks were reversed for Groups One and Two. Throughout the entire trial, with the exception of the washout occurring in week 4, a number of cardio-metabolic related measures were taken including: lipid profile, fasting blood glucose, and resting blood pressure. The mean measurements of all cardio-metabolic risk factors between three weeks of sitting and three weeks of standing showed significant improvements (p= <0.05), demonstrating that standing desks in university classrooms have the potential to improve student health, even over a short time span. In addition to improved health outcomes, the authors note that the intervention was widely accepted, suggesting that standing desks in university classrooms could be a promising and effective solution for students who participate in high levels of SB (Butler et al., 2018).

These above-noted investigations on standing desks in the university setting have provided SB researchers with two key findings: providing students with a standing desk during class time can reduce their classroom ST, and these reductions are associated with improvements in multiple cardio-metabolic risk factors, which can lead to health improvements. However, the aforementioned interventions were limited to the classroom

setting, and therefore were not able to intervene in other study environments that UGS frequent. Undergraduate study occurs in multiple environments, and Macneela and colleagues (2012) have reported that while 62% of academic study occurs in classes and tutorials, the remaining 38% occurs in private study areas that could range from libraries to individual homes to coffee shops. During certain times of the academic year, such as midterm or exam periods, these numbers could shift dramatically. Without targeting all study environments, it is not possible to grasp the true potential of standing desks for the reduction of total daily ST. Such an intervention would need to be available in all study environments, located on and off the university campus.

Purpose of Dissertation

The information above provides direction and focus for the research studies contained within this doctoral dissertation. The following chapters outline four studies, presented in two separate research projects. Study 1 and Study 2 are presented together and titled '*Weekly recall of sedentary time: validity of two weekly self-reported measures in undergraduate students*', with the overall purpose of validating a ST questionnaire appropriate for use in the undergraduate population and in subsequent studies. The most valid questionnaire was carried forward and used in Study 3 and Study 4, presented together and titled '*Using mixed method feasibility studies to examine the impact of a mobile standing desk on undergraduates' sedentary time'*, with the overall goals of measuring the impact of mobile standing desks on the ST of UGS, and understanding their perceptions to using the standing desks.

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Chapter 2: Weekly Recall of Sedentary Time: Validity of Two Weekly Self-Reported Measures in Undergraduate Students (Studies 1 and 2)

Excessive SB increases the risk of multiple chronic diseases and overall mortality (Patterson et al., 2018). An accurate assessment of a population's ST is important for understanding their level of associated health risks. While accelerometer/inclinometer devices provide the most accurate measure of ST (Boyle, Lynch, Courneya & Vallance, 2015), more economical tools are required to get an accurate assessment of ST among larger groups and populations, as well as estimates of domain specific ST. UGS are a unique population that will develop into the leaders and decision makers of tomorrow; they are expected to contribute to the establishment of social and cultural norms for the entire population (Leslie, 1999). Academic/study-related tasks are inherently sedentary, and a considerable amount of undergraduate ST is spent in study-related pursuits (Moulin & Irwin, 2017). Reducing ST during these formative years may help these young people to establish healthier lifestyles throughout their adult lives (Moulin & Irwin, 2017).

To date, UGS have been largely absent from SB research (Buckworth & Nigg, 2004). While increased attention has been paid to this important population in recent years (Choi, Chang, & Choi, 2016; Driller, Dixon, & Clark, 2017; Moulin & Irwin, 2017), there is a paucity of tailored, validated ST questionnaires (SBRN, 2017) that are appropriate for investigating UGS. Furthermore, these ST questionnaires have not been validated in UGS. With students spending a substantial amount of time engaged in academic work, the domain of 'study' is a necessary component of a student-focused questionnaire as it typically separates undergraduates from their working adult counterparts. One tool that has been designed and validated for populations that include

undergraduates is the Past-day Adults' Sedentary Time-University (PAST-U) questionnaire (Clark, Pavey, Lim, Gomersall, & Brown, 2016). The PAST-U, a previous-day ST questionnaire, was validated for use on university campuses via a sample of university students (n = 37) and staff (n = 20), with the majority of university students being enrolled at the post-graduate level (92%) (B. Clark, personal communication, April 11, 2018). Clarke and colleagues (2016) addressed a gap in the literature by validating a ST questionnaire in the university population. However, a very low percentage of the students were undergraduates and although the past-day recall timeframe reduces recall bias among participants, Wijndaele and colleagues (2014) contend that a past-day recall timeframe is not able to capture as much intra-individual variability in SB compared to longer memory timeframes, such as 7 days. In an attempt to build on the strengths of the PAST-U (Clark et al., 2016), the researchers assessed the validity of two modified, weekly versions of the PAST-U, the PAST-WEEK-U (Study 1), and the NIGHTLY-WEEK-U (Study 2). The questionnaires were validated with two separate, homogenous groups of UGS.

Methods

Study 1 – The PAST-WEEK-U. The original PAST ST questionnaire (Clark et al., 2013) was previously developed to measure previous-day ST of an adult population and was validated using a sample of women with a history of breast cancer. Clark and colleagues (2016) noted the narrow focus of the questionnaire and strived to develop a ST questionnaire that would be appropriate for a more general segment of the population. This lead to their subsequent creation of the PAST-U (Clark et al., 2016), which when validated using an activPAL3^{TM} inclinometer (PAL Technologies Ltd, Glasgow, UK),

demonstrated a reasonable correlation between the two measures (r= 0.63) in a sample of university students and staff. The average daily ST calculated using the PAST-U was 10.72 hours. This is 0.08 hours higher than the ST obtained using the inclinometer, with a 95 percent limit of agreement (Bland & Altman, 1986) ranging from -3.91 to 4.1 hours. The PAST-U (Appendix A) asks respondents to report their ST in multiple domains over the past day including study, work, transportation, meals, television viewing, leisurely computer use, leisurely reading, socializing, and other purposes. Time spent sleeping was excluded from the PAST-U. The PAST-WEEK-U (Appendix B) utilized in this study was directly adapted from the PAST-U (Clark et al., 2016).

The PAST-WEEK-U utilized the same domains as the PAST-U (Clark et al., 2016). However, revisions were made to the PAST-U questions to reflect a past-week format to better account for the intra-individual variability of UGS' daily activities (Wijndaele et al., 2014), which may differ significantly based on their lecture and work schedules throughout the week. For example, in the 'study' domain, the PAST-U (Clark et al., 2016) asks "How long were you sitting while ***studying yesterday***? (include the time at university, during lectures, tutorials, meetings, group discussions, self-study, study from home, etc.)" and the PAST-WEEK-U asks "How long did you sit or lay down while ***studying on each of the previous 7 days***? (include the time at university, during lectures, tutorials, meetings, group discussions, self-study, study from home, etc.)". Unlike other past-week ST questionnaires (Lynch et al., 2014; Rosenberg, Bull, Marshall, Sallis, & Bauman, 2008; Wijndaele, 2014) that separate weekdays and weekend days, the PAST-WEEK-U asks respondents to report ST in each domain on each specific day of the week. While this increases the burden on participants, it better accounts for the heterogeneous

nature of an undergraduate's typical week (L. Hardy, personal communication, February 12, 2018) and it is more in line with the past-day format of the original PAST-U.

Prior to the start of Study 1, approval was received by the University's Office of Research Ethics (Project ID# 110847) (see Appendix C). To determine the number of participants needed for recruitment, the method described by Shoukri, Asyali, and Donner (2004) was used. A sample of 23 participants was deemed sufficient assuming a reliability ICC= 0.85 which represents a 15 percent level of disagreement between the two methods. However, 25 participants were recruited to account for participant drop out and missing data. This sample size is comparable to other methodologically similar studies which used the Bland-Altman method of agreement to validate a self-report measure against a criterion measure (Busschaert et al., 2015; Fowles, O'Brien, Wojcik, d'Entremont, & Shields, 2017; Igelström, Emtner, Lindberg, & Åsenlöf, 2013). Consequently, in February 2018, 25 full-time UGS were recruited from the Faculty of Health Sciences at the host university in Ontario, Canada, through e-mails sent to professors (see Appendix D) and Faculty of Health Sciences Facebook pages (see Appendix E). The recruitment e-mail contained the letter of information and requested permission to allow recruiters to make a short in-class announcement (see Appendix F) to their UGS regarding their participation in the study. Part-time undergraduate and graduate students were excluded to ensure a homogenous sample of full-time UGS.

Interested participants emailed the research team to schedule an initial meeting. Forty-five participants made contact. Participants were chosen on a 'first come, first served' basis and then based on their schedule aligning with the schedule of the co-investigator and the research assistant. Twenty interested participants were excluded due

to scheduling conflicts with the co-investigator and the research assistants. Participants were made aware that their enrollment in the study would be set to begin at the end of this initial meeting and would conclude exactly one week later and as such, they were required to confirm that they would be available one week later for their follow-up meeting. The initial meetings entailed participants reviewing the letter of information, signing a consent form (see Appendix G for letter of information and consent form), and completing a demographic questionnaire (see Appendix H). Participants then received a waterproofed activPAL4^{TM} inclinometer (PAL Technologies Ltd, Glasgow, UK) and were verbally instructed on how to best attach the device to their upper thigh using transparent film dressings (Tegaderm^{TM} Roll, 3M^{TM}. Each participant received three additional dressings to allow them to change the dressing every two to three days, as necessary. They were also given an activPAL4 log sheet (see Appendix I) that they were instructed to fill out daily over the next seven days. The log asked participants to report the time each day that they went to sleep and awoke, as well as daily non-wear time lasting more than 10 minutes. The activPAL4^{TM} devices were set to begin recording activity data approximately 30 minutes after the initial meeting concluded. Participants were instructed to wear the device 24 hours a day for the next seven days and only remove the device if they were experiencing irritation. If irritation persisted, they were instructed to contact the co-investigator. One day prior to their follow-up meeting, participants were sent a reminder email that instructed them to return the device, the log sheet, and any unused materials. At the follow-up meeting (Day 7), participants completed the PAST-WEEK-U. Data collection for Study 1 was completed in March 2018.

The activPAL^{TM} monitor differentiates between SB, standing, and free moving activity using propriety algorithms (Intelligent Activity Classification, PAL Technologies) (Clarke, Holdsworth, Ryan, & Granat, 2013). The activPAL^{TM} has been utilized in numerous research studies and experienced increased use of 460% in physical activity and sedentary behaviour research between 2008 and 2014 according to the Scopus citation database (Edwardson et al., 2016). Aminian and Hinckson (2012) observed a perfect correlation between the activPAL^{TM} monitor in time spent sitting/lying, standing and walking with direct observation, making it an excellent tool for measuring various active and SBs. The activPAL4^{TM} is worn on the midline anterior aspect of the thigh (right or left), switching legs throughout a study if one thigh gets irritated (Edwardson et al., 2016). One distinct advantage of the activPAL4^{TM} device over other accelerometers it that the activPAL4^{TM} can be waterproofed, allowing a participant to simply attach the device and forget about it for the duration of a study. This could improve device compliance and therefore improve accuracy. The activPAL4^{TM} default settings were used and data was downloaded via activPAL Professional Software (Version 7.2.37) (see Appendix J for an example of activPAL4^{TM} software analysis).

All data was transferred to Microsoft Excel (Version 15.32.). Average daily ST (hours per day) was calculated from the activPAL4^{TM} and the PAST-WEEK-U. Daily sleep time recorded with the activPAL4 log was subtracted from daily sit/lie time recorded with the activPAL4^{TM} activity monitor (derived from event file). Each daily ST from the activPAL4^{TM} was totaled and averaged to calculate average daily ST. Average daily ST was calculated from the PAST-WEEK-U by totaling the sedentary hours within each domain over the entire week, dividing by seven, and then adding each domain

together. The Bland Altman Method of Agreement (Bland & Altman, 1986) was used to compare the differences (Y) between the activPAL4^{TM} and PAST-WEEK-U average daily STs and the averages of the two measurement methods (X). Mean difference (bias) and upper (+1.96 SD) and lower (-1.96 SD) levels of agreement were also reported.

Study 2 – The NIGHTLY-WEEK-U. The NIGHTLY-WEEK-U (see Appendix K) was directly adapted from the PAST-U (Clark et al., 2016). The NIGHTLY-WEEK-U retained the original domains of the PAST-U (Clark et al., 2016) and aimed to collect weekly STs of UGS. However, the NIGHTLY-WEEK-U collected ST each day throughout the week, rather than retrospectively at the end of the week. This was decided, in part, based on testimony from participants in Study 1 who expressed frustration with the memory demands of the past-week format of the PAST-WEEK-U, and a preference to provide STs each day, rather than at the end of the week. The NIGHTLY-WEEK-U was designed into a paper-copy questionnaire booklet containing eight pages. The first page was an instruction page that outlined how to successfully complete each of the next seven pages, one for each day of the week. Each included domain was described and participants were instructed to return to this page as needed, to confirm that they were delegating a block of ST into the correct sedentary domain. In the original PAST-U, these instructions were given next to every question. Further separating the NIGHTLY-WEEK-U from the PAST-U (Clark et al., 2016) is the time at which participants are instructed to complete each individual day. The NIGHTLY-WEEK-U instructs participants to complete each individual day, as close to them falling asleep or 12am midnight, whichever event occurs first. The researchers theorized that by having participants recall their ‘past day’ at the end of the day before falling asleep, recall time would be

diminished and the accuracy of the questionnaire would improve. Additionally, at the end of each day's page, the participant is prompted to add up their ST for that day across each of the domains, and double check if that amount of ST makes sense based on how long they slept the night before.

Prior to the start of Study 2, approval was received by the University's Office of Research Ethics (Project ID# 112232) (see Appendix L). Sample size, recruitment strategies (see Appendices M-Q for letter of information and consent, invitations to course instructors, demographic questionnaire, in-class verbal announcement, and activPAL4^{TM} log sheet for Study 2), the criterion measure, and data storage were uniform with Study 1. Fifty-eight interested participants made contact and again 25 full-time UGS were chosen on a 'first come, first served' basis. The protocol remained the same as Study 1 with the exception of participants receiving the NIGHTLY-WEEK-U at the start of the week rather than the end. Data was analyzed by calculating a daily ST for each day of the week, and averaging each day into an average daily ST. The Bland Altman Method of Agreement (Bland & Altman, 1986) was used to compare the differences (Y) between the activPAL4^{TM} and NIGHTLY-WEEK-U average daily STs and the averages of the two measurement methods (X). Mean difference (bias) and upper (+1.96 SD) and lower (-1.96 SD) levels of agreement were also reported.

Results

Descriptive participant data for Study 1 (*N= 25*) and Study 2 (*N= 23*) can be found in Table 1.

Table 1

Demographic Information

Characteristic	Study 1 (*N= 25*) PAST-WEEK-U	Study 2 (*N= 23*) NIGHTLY-WEEK-U
	n (%)	*n* (%)
Sex		
Male	3 (12%)	1 (4%)
Female	22 (88%)	22 (96%)
Age		
19 years and under	16 (64%)	11 (48%)
20-24	9 (36%)	12 (52%)
Ethnicity		
Caucasian	18 (72%)	11 (48%)
Middle Eastern	1 (4%)	6 (26%)
African	1 (4%)	0 (0%)
South Asian	4 (16%)	1 (4%)
East Asian	1 (4%)	4 (17%)
Hispanic	0 (0%)	1 (4%)
Year of Enrollment		
1st	11 (44%)	3 (13%)
2nd	9 (36%)	9 (39%)
3rd	3 (12%)	7 (30%)
4th	2 (8%)	3 (13%)
5th	0 (0%)	1 (4%)
Employment		
Unemployed	11 (44%)	15 (65%)
Part-Time	14 (56%)	8 (35%)
Full-time	0 (0%)	0 (0%)

Twenty-five separate UGS consented to participate in each study; however, two participants were excluded from Study 2 due to malfunctions with the activPAL4™ equipment. Participants in each study wore the activPAL4™ for 24 hours a day for the entire week with no participants reporting removal of the device for more than ten minutes a day.

In Study 1, the activPAL4™ reported an average daily ST of 11.34 ± 1.36 hours per day, accounting for 69.9% of total waking time. Comparatively, the PAST-WEEK-U reported an average daily ST of 11.25 ± 3.32 hours per day and a mean difference of 0.09 hours. In Study 2, the activPAL4™ reported an average daily ST of 10.50 (±1.17) hours per day, accounting for 64% of total waking time. Comparatively, the NIGHTLY-WEEK-U reported an average of 10.29 (±1.79) hours per day and a mean difference of 0.21 hours. The greatest contribution to average daily ST in Study 1 and Study 2 was derived from the 'study' domain, at 5.03 and 5.55 hours per day, respectively. The comparisons between the mean STs of each tool, the mean difference between them, and their limits of agreement from the Bland Altman analysis can be found in Table 2.

Table 2

Statistical Comparisons Between Measurement Tools

Measurement Tool	Mean ST ActivPAL (Hrs/day)	Mean ST Questionnaire (Hrs/day)	Mean Difference Between ActivPAL and Questionnaire	LOA (Hrs/day)
PAST-U	10.64	10.72	5 minutes	-3.91 to 4.1
PAST-WEEK-U	11.34	11.25	5 minutes	-5.38 to 5.55
NIGHTLY-WEEK-U	10.50	10.29	13 minutes	-1.75 to 2.17

Notes.
ST: Sedentary time, Hrs/day: Hours per day, LOA: Limits of agreement

The PAST-WEEK-U performed significantly worse than the NIGHTLY-WEEK-U. Although the clear majority of participants (23/25 or 92%) fell within the upper and lower levels of agreement, only 56% of self-reported STs were within a two-hour difference of the criterion measure activPAL4^{TM}. The NIGHTLY-WEEK-U showed significant improvement with 100% of participants self-reported ST falling within the upper and lower levels of agreement and 91% within 1.5 hours of the criterion measured ST. The Bland-Altman plots conducted in Studies 1 and 2 are illustrated in Figure 1.

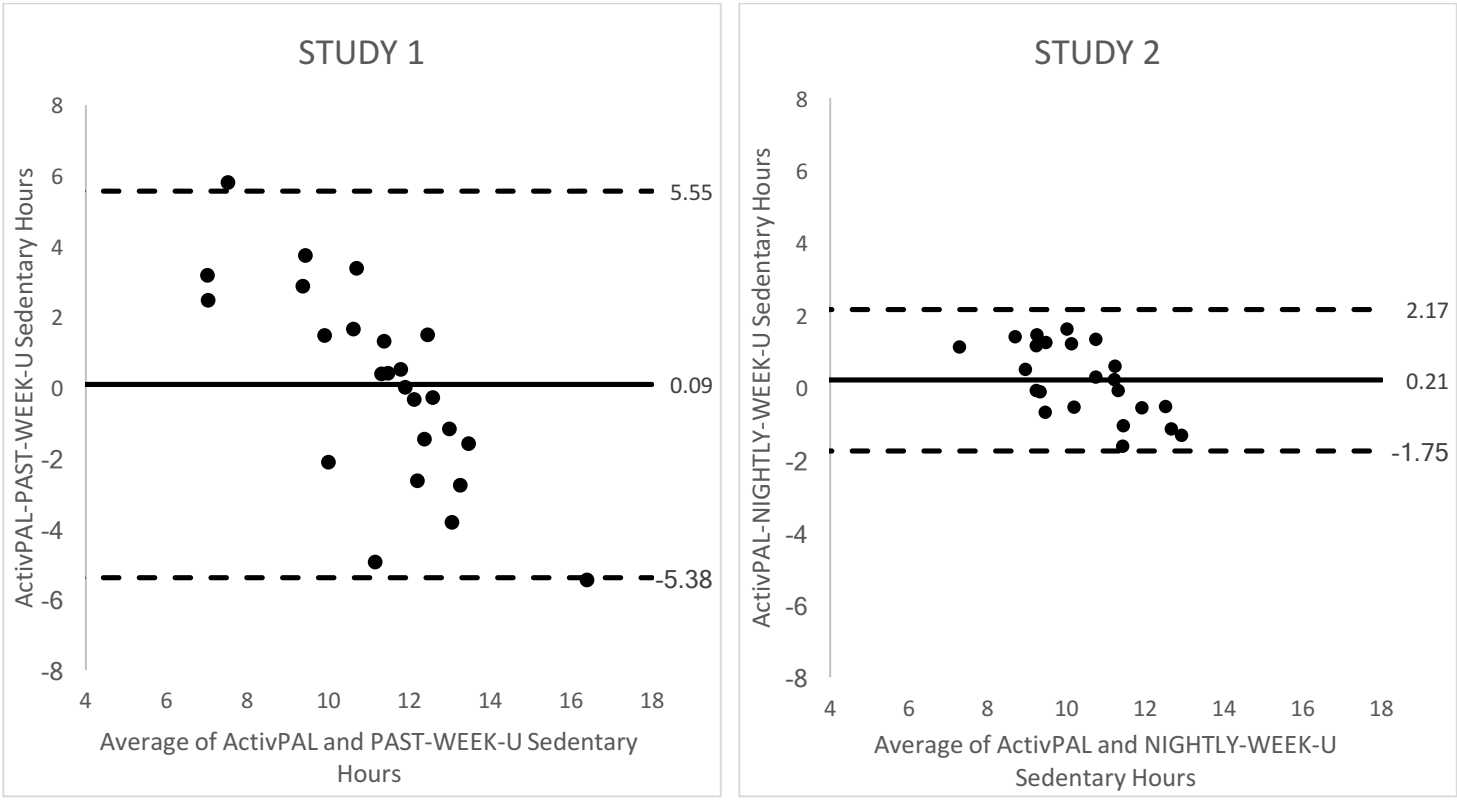

Figure 1. Agreement between activPAL4^{TM} and modified weekly versions of the PAST-U for average daily ST. The solid line represents the mean difference (bias) between the two measurement tools and the dashed lines represent the upper and lower 95% limits of agreement. The X axis is the average of the activPAL4^{TM} and the weekly questionnaire. The Y axis is the difference between the activPAL4^{TM} and the weekly questionnaires.

Discussion

The purpose of this study was to evaluate the validity of two weekly ST questionnaires in UGS using criterion data obtained via an activPAL4^{TM} inclinometer. The PAST-U (Clark et al., 2016) provided a blue print for the creation of ST questionnaires designed for, and validated among UGS, a unique sub-group of the adult population. However, it is that distinction that lead to the hypothesis that a past-day recall timeframe may not be appropriate for a population whose day-to-day lives can differ significantly based on class schedules, private study demands, and part-time work schedules.

In Study 1, the PAST-WEEK-U had problematic levels of agreement compared to the activPAL4^{TM} demonstrating a systematic under/overestimation of ST and large limits of agreement (-5.38 to 5.55 hours). Although the mean bias was very impressive (0.09 hours, ~5 minutes), the Bland Altman plot illustrates how this is a result of under/overestimation and not due to the accuracy of the PAST-WEEK-U. The mean difference between measurement tools was similar to the mean difference of 5 minutes reported by Clark and colleagues (2016), demonstrating a consistency between the questionnaires. The limits of agreement reported by Clark and colleagues (2016) were also quite large (-3.91 to 4.1 hours), yet smaller than the limits of agreement in Study 1. This may be explained by the increased recall bias attributed to a past-week questionnaire compared to a past-day questionnaire. Clarke and colleagues (2016), as well as Study 1, were able to report a minimal bias between the two measurement methods because a larger sample size allowed for a 'cancellation' of inaccurate STs across the sample. This may become especially problematic when researchers use either the PAST-U or the

PAST-WEEK-U to measure ST during an intervention study. The systematic under/overestimation of ST does not allow a correction factor to be added to the results and is unclear if the self-reported ST reported on the questionnaires would provide an accurate assessment of the impact of future sedentary interventions. The findings of Study 1 suggest that the PAST-WEEK-U should not be used in large epidemiological studies or intervention studies, and not for individual assessment of ST, conflicting with that reported by Clarke and colleagues (2016). The accuracy of recall in research participants is highly impacted by the time interval between the event and the time of assessment: as time increases, memory decreases, and recall bias occurs (Margetts, Vorster, & Venter, 2003). Although the PAST-WEEK-U can account for more intra-individual variability in SB (Wijndaele et al., 2014) than a questionnaire with a past-day recall timeframe, perhaps the negatives of increased recall bias of a past-week recall timeframe outweighs the benefits. In Study 2, the PAST-U was modified to reduce a participant's recall timeframe to the lowest possible levels, while maintaining the ability to account for more intra-individual variability in SB that a weekly sedentary questionnaire can provide.

The Bland-Altman analysis of the NIGHTLY-WEEK-U showed significant improvements compared to the PAST-WEEK-U. The NIGHTLY-WEEK-U reported a small mean difference with the activPAL4^{TM} (0.21, ~13 minutes), and much tighter limits of agreement (2.17 to -1.75) than the PAST-WEEK-U. Logically, this increase in accuracy is attributed to the decrease in memory demands for the participants, as the domains remained the same. Additionally, the limits of agreement are much narrower than the limits of agreement of the original PAST-U (Clark et al., 2016) (-3.91 to 4.1),

suggesting that having participants complete a past-day questionnaire at the very end of their day (either right before they go to sleep, or 12am midnight, whichever event comes first), can increase the accuracy of the past-day questionnaire. Although there were some changes to the language of the PAST-U (e.g. 'Reading' changed to 'Leisurely Reading' to help distinguish study-related reading from leisurely reading), it is unlikely that these changes attributed to the increased accuracy more than the decreased recall timeframe. Like the PAST-WEEK-U, the Bland-Altman plot illustrates systematic under/overestimation of ST, although on a much smaller scale. A correction factor cannot be applied to individual participant data, but correction is less important with much narrower limits of agreement.

The results of Study 1 bring into question the legitimacy of other past-week ST questionnaires widely used in SB research. Remembering ST across multiple SBs appears to be quite difficult after just one day (Clark et al., 2016), and Study 1 demonstrated that some participants were unsure up to ±5 hours over the past-week. In recent, similar studies, the inaccuracy of other weekly sedentary questionnaires has been demonstrated using the Bland-Altman analysis. The IPAQ was found to have innate measurement error with most participants under-reporting past-week ST on weekdays (mean difference of 2.81 hours) and weekends (mean difference of 2.90 hours) with limits of agreement ranging from -7.53 to 1.91 hours and -7.36 to 1.56 hours, respectively (Cleland, Ferguson, Ellis, & Hunter, 2018). Additionally, the same inaccuracies may exist for questionnaires asking respondents to report on their 'typical' weekday. The GPAQ was found to have systematic measurement errors with wide limits of agreement ranging from -7.8 to 5.8 hours (Gibbs et al., 2015). Similarly, a modified version of the Sedentary

Behaviour Questionnaire reported limits of agreement ranging from -4.9 to 11.9 hours (Gibbs et al., 2015). These results further strengthen the results of Study 2, suggesting that the most accurate measures of weekly ST may come from a questionnaire that has participants report daily ST across multiple sedentary behviours sequentially, in more of a 'log' format, rather than retrospectively, such as the PAST-WEEK-U. Furthermore, to maximally reduce recall bias, the 'past-day' reporting of ST should be done at the end of the day in question, and not on the following day after a participant has fallen asleep.

It is possible that continuous reporting of past-day ST over a week could make a participant aware of how much sitting they are participating in, and as a result, begin to limit their daily ST. The downside of this limitation will need to be weighed against the demonstrated inaccuracies of past-week or typical week ST questionnaires (Cleland et al., 2018; Gibbs et al., 2015). A further limitation of the NIGHTLY-WEEK-U is the increased burden displaced on both the participant and the researcher. More data and time are required from the participant, and as a result, there is more data to be analyzed by the researcher.

As stated in other comparable methodologically similar studies (Busschaert et al., 2015; Fowles, O'Brien, Wojcik, d'Entremont, & Shields, 2017; Igelström, Emtner, Lindberg, & Åsenlöf, 2013), the small sample size of Study 1 and Study 2 limits the generalizability but not the validity of the findings. The small sample size of Study 1 and Study 2 closely resembled, and improved upon the results of the validation of the original PAST-U (Clark et al., 2016), suggesting that a larger sample size may not be warranted. The study sample in both studies consisted primarily of women and therefore, comparisons between men and women were not possible. It was very difficult to recruit

men to participate in Studies 1 and 2. In addition to recruiting from a female dominant faculty, for full-disclosure of the risks involved with participating in these studies, students were made aware during the in-class announcements that the dressings that attach the activPAL4^{TM} to the thigh can be uncomfortable to remove from the skin when the area of attachment is covered in hair. Future studies may want to explore other attachment methods for the activPAL4^{TM} where significant pulling of body hair with device removal is not a factor in male participation. In addition to the above-noted limitations, both studies enrolled students from classes in the Faculty of Health Sciences only. It is unclear whether UGS from other faculties would have had similar results to the students who participated in these studies (e.g., completed the log with the same level of accuracy or engaged in similar ST).

Conclusion

The PAST-WEEK-U demonstrates questionable criterion-related validity at the group level for estimating daily ST when compared to the activPAL4^{TM} in the undergraduate population. The NIGHTLY-WEEK-U demonstrates superior criterion-related validity at the group level for estimating daily ST when compared to the PAST-WEEK-U and potentially other validated weekly ST questionnaires.

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Chapter 3: Using Mixed Method Feasibility Studies to Examine the Impact of a Mobile Standing Desk on Undergraduates' Sedentary Time (Studies 3 and 4)

The nature of UGS' learning often necessitates sitting at desks in lecture, at the library, and/or in their own homes. In fact, researchers have estimated that some UGS spend a total of 17.3 hours a week in classes and tutorials, with another 10.6 hours in private study time, excluding exam periods (Macneela et al., 2012). For students in some faculties, such as engineering, attending university may require a similar number of hours to a full-time job, and does not necessarily provide the option of standing while at 'work'. UGS' objectively measured ST has been found to be very high. Clemente, Nikolaidis, Martins, and Mendes (2016) reported objectively measured undergraduate ST at 12.61 hours per day, while others reported it to be as high as 13.03 hours per day (Driller, Dixon, & Clark, 2017). Lectures and private study time have been identified, by UGS themselves, as barriers to engaging in a less sedentary lifestyle (Moulin & Irwin, 2017). As a result of their high levels of ST, the large and growing adult population of undergraduates (National Center for Education Statistics, 2018) is at an increased risk of all-cause and cardiovascular mortality, as well as an increased incidence of type 2 diabetes (Patterson et al., 2018). One possible intervention to help UGS reduce their ST is the provision of standing desks. The standing desk has become a popular intervention for desk-based workers (MacEwen, MacDonald, & Burr, 2015) and has been deemed highly effective at reducing their ST. For instance, Alkhajah and colleagues (2012) found that providing office workers with a standing desk for one week reduced their total waking ST by 97 minutes per day and other researchers have found a reduction of 87 minutes per day

after three weeks of intervention (Chau et al., 2014), potentially resulting in substantial health improvements.

Logical comparisons exist between desk-based workers and UGS in terms of how they accomplish their daily work (i.e., sitting at a desk). One difference between the two groups might be the environment(s) in which they work (i.e., office versus lecture hall, library, home). Jerome, Janz, Baquero, and Carr (2017) tested the effect of introducing standing desks into university classrooms and examined average minutes of standing per hour per student, average percent of class time spent standing, and number of sit-to-stand transitions. The authors found that students responded positively to the introduction of the standing desks and spent 9.3% of class time standing (Jerome et al., 2017). This study set the stage for the development of more interventions involving standing desks aimed at reducing the ST of UGS. However, the intervention was limited to a single classroom and the study was unable to provide information about the intervention's impact on the entire 'study' domain which includes multiple classrooms and private study environments.

UGS may spend time in daily academic study at home, in numerous lecture halls, and/or at the university library. As such, to measure the effect of providing UGS with a standing desk on overall ST, the intervention must meet this multi-environment need. Large scale renovations and the installation of standing desks campus-wide would be costly and time consuming. A viable alternative might be for UGS to use a more affordable and mobile standing desk, thus allowing them to manipulate various sedentary environments at home and on campus. A first step is needed to determine the feasibility of such an intervention. If proven feasible and effective (Bowen et al., 2009), the longer-

term suitability can then be explored. Lifestyle interventions often follow a distinct pattern of initial success followed by diminished adherence over time, leading to underwhelming long-term outcomes (Middleton, Anton, & Perri, 2013). Therefore, two mixed method feasibility studies were executed to measure the effect of a one-week (Study 3) and one-month (Study 4) mobile standing desk intervention on the ST of UGS. We also wanted to determine any domain-specific impacts on ST (Study 3 and 4) and gain an understanding of students' initial experiences with using the desks (Study 3) as well as their experiences of using this desk for an extended period of time (Study 4).

Methods

Measurement tools.

Objective assessment of sitting time: The AcitvPAL4™. The activPAL4™ (PAL Technologies Ltd., Glasgow, UK) is a light-weight, accelerometer/inclinometer that attaches to the midline, anterior aspect of either thigh, with the ability to change legs if one leg becomes irritated during a study (Edwardson et al, 2016). The activPAL™ monitor differentiates between SB, standing, and free movement activities using propriety algorithms (Intelligent Activity Classification, PAL Technologies) (Clarke, Holdsworth, Ryan, & Granat, 2013). A perfect correlation has been found between direct observation and the activPAL™ inclinometer in time spent sedentary (sitting and lying down), standing, and walking (Aminian & Hinckson, 2012), making it an ideal measurement tool for many active and SBs. The activPAL4™ software breaks down participants' ST into daily totals of sitting/lying time for up to 14 days, allowing an average daily ST to be calculated.

Subjective assessment of sitting time: The NIGHTLY-WEEK-U. Although the accelerometer/inclinometer device is the most valid and accurate measurement tool available (Boyle, Lynch, Courneya, & Vallance, 2015), it cannot provide information on the break-up of overall ST into individual sedentary domains, and the context of average daily ST cannot be fully understood. The use of a subjective, multi-domain ST questionnaire can provide researchers with information on what domains contributed most to overall ST, and for intervention studies, which domains either increased or decreased following intervention. For both Studies 3 and 4, The NIGHTLY-WEEK-U, a modified, weekly version of the PAST-U (Clarke et al., 2016) was used to provide a self-report assessment of sitting. The NIGHTLY-WEEK-U has been validated in a homogenous sample of UGS (Moulin, Lee, Tucker, Prapavessis, & Irwin, 2019) and has respondents self-report their daily ST at the end of each day (as close as possible to them falling asleep, or 12 am) for an entire week within the following domains: study, work, transport, television, computer and internet use, eating, leisurely reading, socializing, and sitting for other purposes (Moulin et al., 2019). For reasons of increased ease and environmental responsibility, the NIGHTLY-WEEK-U was transferred to the Qualtrics™ online platform for electronic completion by participants in Study 4.

Procedure. Prior to recruitment, approval was received by the University's Non-Medical Research Ethics Board (Project ID#: 112232-Study 3 and Project ID#: 112737-Study 4) (see Appendices L and R). For Study 3, full-time UGS were recruited from one school from the Faculty of Health Sciences (Health Studies) at the host university in Ontario, Canada. E-mails requesting permission for the co-investigator to make an in-class announcement (see Appendix P) inviting students to participate in the study were

sent to professors in the Faculty (see Appendix N). If a participant was to use the standing desk during one of their classes, there was the possibility of it causing a small distraction to the professor and the other students; the research team reasoned that professors within the health-focused Faculty might be more inclined than those in other units to allow a student to stand during their classes. Part-time undergraduate and graduate students were excluded.

Fifty-eight students made contact and the first 25 who met the inclusion criteria of being full-time UGS taking a health sciences' course were enrolled in the study. The initial meeting consisted of participants reviewing the letter of information, signing a consent form (Appendix M), and completing a demographic questionnaire (Appendix O). Participants then received a waterproofed activPAL4^{TM} activity monitor and verbal instructions about how to best attach the device to their upper thigh using 3M Tegaderm Film Dressing. Each participant received three additional dressings in case any dressing changes were needed. They were also given an activPAL4^{TM} log sheet (Appendix Q) that they were instructed to fill out daily over the next seven days. The log asked participants to report the time each day that they went to sleep and awoke, as well as daily non-wear time lasting more than 10 minutes. The activPAL4^{TM} devices were set to begin recording activity data for the next two weeks approximately 30 minutes after the initial meeting concluded. Participants were instructed to wear the device 24 hours a day for the next seven days and only remove it if they were experiencing irritation. They were instructed to contact the co-investigator if irritation persisted. Participants were also given the NIGHTLY-WEEK-U and were instructed to complete it at the end of each day, as close as possible to them falling asleep or 12 am.

Immediately upon completion of the one-week baseline period, participants returned to the research lab where the co-investigator changed the waterproof dressings on the activPAL4™ and again instructed the participants about wearing the device 24 hours each day for the next seven days. Participants were given a week two activPAL4™ log and the NIGHTLY-WEEK-U and were instructed to complete them as they did for week one. Participants were also given a mobile standing desk to use in whichever environments they chose for the next week. The T-Zone Vibration 4MT Standing Desk Top Extender (see Appendix S for picture) is a light-weight, foldable standing desk that can be placed on top of any traditional work space and can theoretically be moved from location to location (i.e., campus library to home, home to lecture hall, etc.). All that is required for set up is an existing flat surface. Participants were briefed on how to set up the standing desk and were encouraged to use the desk as much as they were comfortable doing so. At the third and final meeting (exactly one week after the second meeting), participants returned all week two materials and participated in a short, one-on-one semi-structured interview (see Appendix T for interview guide) about their experiences with the standing desk (i.e., what they liked and disliked about it and the challenges and facilitators associated with using it). The interviews lasted 10 to 20 minutes and were audio-recorded and transcribed verbatim. For their participation, participants were entered into a draw to win one of two 50$ Visa Gift Cards.

For Study 4, participants were recruited from two schools in the Faculty of Health Sciences (Health Studies and Kinesiology) with the same strategies outlined in Study 3 (see Appendices U-X for invitation email to course instructors, letter of information and consent, demographic information, and in-class announcement script for Study 4), as well

as recruitment messages posted to school-specific Facebook pages (see Appendix Y). Additionally, participants received an email welcoming them to the study with a link to the letter of information and consent (see Appendix Z), and when completed, another email containing a link to the demographic questionnaire (see Appendix AA). Forty-one participants made initial contact. Thirty participants consented to participate in the study and completed a demographic questionnaire. Rolling enrollment allowed for participants to start the study at their own convenience, with the understanding that they would need to be available for a short meeting with the co-investigator at the start of week two, and that the five-week study would need to conclude before the beginning of the winter exam schedule to keep the intervention uniform for all participants. On their first day of the study, participants were emailed seven links. Each link took the participants to an online version of the NIGHTLY-WEEK-U (via Qualtrics™) for that particular day, and participants completed one per day, for each day of the first week. On Day 8 of the study, each participant met with the co-investigator to receive a mobile standing desk. Participants were told to use the desk as much as they were comfortable doing so over the next four weeks. Three weeks after this meeting, participants were sent an email containing links to the NIGHTLY-WEEK-U for the fifth and final week of the study. Again, participants completed one NIGHTLY-WEEK-U per day, each day of the final week. Additionally, participants were provided with another link to the open-ended questions used in Study 3, which also included a new question that focussed on the impact of the standing desk over the duration of the intervention (see Appendix AB for open-ended online questions). Participants were required to answer a question before moving on to the next. The online platform of the NIGHTLY-WEEK-U allowed for the

co-investigator to monitor when and if participants had completed each daily section of the NIGHTLY-WEEK-U. When a participant missed a section, the co-investigator sent a reminder email to the participant asking them to complete the missed section as soon as possible. For their participation, participants were entered into a draw to win one of two 50$ Visa Gift Cards.

Power and sample size. For both studies, a minimum sample size (N) of 20 individuals was calculated to be sufficient to detect the hypothesized effect (d= .800) of a two-level within-subject independent variable 81.8% of the time using a .05 alpha level, assuming a within-subject correlation of .30. An additional five (Study 3) and ten (Study 4) participants were recruited to account for participant attrition and missing data. A sample size of 25 participants in Study 3 would allow for up to a 20% error rate with the activPAL4^{TM} while retaining the necessary 20 participant sample size. An additional 10 participants were recruited in Study 4 to allow for more activPAL4^{TM} malfunctions, but also based on the increased study duration. The researchers theorized that it was more likely to lose participants in a study with a five-week timeline.

Statistical analysis.

Quantitative analysis. Participants' schedules determined what day and time the initial meeting took place and which day of the week they started the study. In Study 3, participants began the study at various times, with all participant activPAL4^{TM} recordings starting between 10am and 5pm. For those who started the study later in the day, their Day 1 daily sit/lie time derived from the activPAL4^{TM} was heavily impacted by their late start time. For this reason, Day 1 ST was excluded from data analysis. Additionally, participants received their standing desk at various times on Day 8, and the total sit/lie

time for that day was divided up between not having access to the standing desk, and having access to the standing desk. For this reason, Day 8 was excluded from data analysis. The same exclusions were applied to the NIGHTLY-WEEK-U for consistent comparisons. The resulting data analysis for both the activPAL4^{TM} and the NIGHTLY-WEEK-U included six, 24-hour baseline week days (4 weekday and 2 weekend days), and six, 24-hour intervention week days (4 weekday and 2 weekend days). This allowed for uniform observations across all participant data, regardless of what time they started the study.

Average daily ST was calculated from both measurement tools separately for week one and week two of Study 3. The activPAL4^{TM} does not distinguish between ST and sleeping, and therefore the activPAL4^{TM} log sheet was needed to calculate how long participants slept each night. For each day of the week, participants' nightly sleep time was subtracted from the activPAL4^{TM} derived total sitting/lying time to calculate daily ST. Daily STs were added together and divided by six to calculate average daily ST for each week. For the NIGHTLY-WEEK-U, individual domains for each day were added together to calculate daily ST, and then each daily ST was added together and divided by six to calculate average daily ST. To determine the domains that had the greatest effect on average daily ST, domain-specific ST was calculated by adding individual domains together throughout the week and dividing by six. Average weekday and average weekend day STs were also calculated from the NIGHTLY-WEEK-U. For Study 4, quantitative data analysis was uniform with Study 3, with the exception that no days were removed from analysis because an objective measure was not used for data collection. All statistical analyses were performed using the Statistical Package for the Social Sciences

(SPSS) program (version 25). Average daily ST data were analyzed using paired t-tests (week one to week two-Study 3 and week one to week five-Study 4). All reported t-tests were accompanied by corresponding effect sizes and percent change scores.

Qualitative analysis. For both the semi-structured interviews (Study 3) and open-ended online questions (Study 4), the transcriptions underwent inductive content analysis by question (Patton, 2015). Qualitative analysis was completed by hand, and no qualitative analysis software was used. To support data trustworthiness, the researchers adhered to quality assurance protocols during data collection and analysis (Guba & Lincoln, 1989), including: (1) *credibility* – member-checking participant responses to confirm answers were fully understood (Study 3 only), (2) *confirmability* – analysis was completed by two researchers independently, (3) *dependability* – researchers summarized and debriefed findings to protect against bias, and (4) *transferability* – methods, procedures, and analyses were documented to allow other researchers to determine whether findings are transferable to other settings. The interview transcriptions (Study 3) and online answers (Study 4) were first read through in their entirety, one participant at a time. In a second read through, the responses were coded to identify key themes. The co-investigator and a research assistant independently identified which themes were most present in the responses, and then met to compare possible themes. The final themes were decided upon with the co-investigator and the research assistant having equal decisional control. This avoided any bias and maintained the integrity of the qualitative analysis. In a final read through, supporting quotations for each theme were identified.

Results

Study 3. From the 25 UGS recruited, two participants were excluded due to malfunctions with the activPAL4^{TM} devices, and two participants dropped out of the study (during the intervention week), citing personal reasons. The largest percentage of participants identified as female (n = 20, 95%), Caucasian (n = 8, 38%), and enrolled in their second year of undergraduate study (n = 7, 33%).

Quantitative results. Comparisons between the baseline week and the intervention week for activPAL4^{TM} derived ST are illustrated in Table 3.

Table 3

ActivPAL4 Derived Average Daily ST (Hours/day)

	Baseline Mean (± SD)	Intervention Mean (± SD)	% Change	Cohen's *d*	*p* Value
Total ActivPAL4	10.96 (± 1.14)	9.99 (± 1.85)	-8.9%	0.71	0.0045
Weekday ActivPAL4	11.31 (± 1.37)	10.17 (± 2.01)	-10.1%	0.77	0.0025
Weekend ActivPAL4	10.26 (± 1.49)	9.62 (± 1.76)	-6.2%	0.33	0.1515

At baseline, participants were sedentary for almost 11 hours per day. The paired sample t-test revealed a significant reduction ($p = 0.0045$, $d = 0.71$) in activPAL4^{TM} derived total ST (0.97 hours, ~ 58 minutes/day) between the baseline and intervention weeks. This reduction was more attributed to a reduction of ST on weekdays than weekend days, as UGS reduced their ST on weekdays by 1.14 hours/day, compared to 0.64 hours/day on weekend days. The greatest reduction in total daily ST was by 3.53 hours/day, and one participant experienced an increase of ST of 1.45 hours/day. The NIGHTLY-WEEK-U derived STs broken down by domains are provided in Table 4.

Table 4

NIGHTLY-WEEK-U Derived Average Daily ST (Hours/day)

	Baseline Mean (± SD)	Intervention Mean (± SD)	% Change	Cohen's *d*	*p* value
Total ST	10.44 (± 1.72)	8.85 (± 2.27)	-15.2%	0.92	0.0005
Weekday ST	10.98 (± 2.09)	9.20 (± 2.46)	-16.2%	1.03	0.0001
Weekend ST	9.24 (± 1.69)	8.09 (± 2.32)	-12.4%	0.43	0.0589
Domain-Specific ST					
Study	5.21 (± 1.78)	4.29 (± 2.22)	-17.7%	0.36	0.1210
Work	0.19 (± 0.42)	0.18 (± 0.59)	-5.3%	0.02	0.8931
Transport	0.67 (± 0.52)	0.52 (± 0.41)	-22.4%	0.26	0.2116
Television	0.27 (± 0.44)	0.23 (± 0.38)	-14.8%	0.10	0.6345
Computer	1.27 (± 0.97)	1.25 (± 0.87)	-1.6%	0.03	0.8756
Reading	0.06 (± 0.19)	0.07 (± 0.13)	+16.7%	0.05	0.9286
Eating	0.77 (± 0.44)	0.73 (± 0.53)	-5.2%	0.16	0.4241
Socializing	1.29 (± 0.78)	1.14 (± 0.81)	-11.7%	0.21	0.3640
Other	0.67 (± 0.66)	0.50 (± 0.57)	-25.4%	0.36	0.1319

Notes. SD = Standard Deviation

Similar to the activPAL4^{TM} derived data, the results from the NIGHTLY-WEEK-U show a significant reduction in overall ST (1.59 hours/day), with a greater reduction on weekdays (1.78 hours/day) than weekend days (1.15 hours/day). However, these self-reported results highlight that, when compared to the results from the objective measure, participants underestimated their daily ST at baseline by 0.52 hours/day, and believed the intervention was more effective than it was by 0.62 hours/day. Baseline domain-specific data revealed that participants spent most of their ST engaged in study-related behaviours (5.21 hours/day, 50% of average daily ST), followed by socializing (1.29 hours/day, 12.4%), and leisurely computer time (1.27 hours/day, 12.2%). As expected from an intervention designed to target the reduction of study-related SBs, the greatest reduction of ST -- of approximately 55 minutes/day (0.92 hours) -- was found within the domain of 'study'. However, this reduction was not statistically significant ($p = 0.12$, $d = 0.36$). With the exception of reading, all other domain-specific ST decreased. The effects of these reductions were small-to-medium in size and non-significant.

Qualitative results. All 21 participants completed semi-structured interviews. Participant responses revealed several facilitators and barriers to using the standing desks. Three facilitators were identified that aided the participants' use of the standing desk: (1) a desire to stand/enjoyed having the option to stand, (2) a previous knowledge of the dangers of sitting, and (3) increased productivity. Three barriers were identified that hindered participants' use of the standing desk: (1) the social norms of sitting, (2) it was difficult to carry desk between environments/size of the desk, and (3) the lecture halls' design. Tables 5 and 6 provide illustrative quotations for each identified facilitator and barrier to using the standing desk.

Table 5

Facilitators to Using the Standing Desk

1) Desire to Stand/Enjoyed Having the Option to Stand
"Yeah I prefer to stand especially because it is so much better than sitting. Like I was in- and you'll see on this sheet I was in [university library] one day for like ten hours studying just sitting and then if I had the option to stand not awkwardly I would've done it"
"I like standing…, after midterm season especially I liked standing. It's good to be able to not only like do this all the time it was nice to be able move around…it just makes you feel better I would say"
"I sit a lot when I study, like writing notes and I have a back injury from dance so sometimes sitting for long periods of time really hurts so I have to get up…. [b]eing able to constantly stand in a comfortable position writing -- that was really awesome for the couple weeks I had it."
2) A Previous Knowledge of the Dangers of Sitting
"Especially those who aren't in Health Science, they wouldn't really know what a standing desk is. Whereas, we've kind of talked about it in other Health Science classes, so maybe [health-related students] be more understanding [of the need to not sit all the time]…"
"I know researchers, or students in health sciences or kin are more aware, but other people or other faculties that don't learn about health could be more aware of [the dangers of prolonged sitting] and [using a standing desk] could become more normalized"
"*Yeah, I don't see why a lot of people wouldn't [use a standing desk] especially in Health Sciences, because we talk about sedentary behaviour."*
3) Increased Productivity
"…if I'm sitting for too long I get tired because I'm not moving around as much. But when I'm standing I can shuffle around if I wanted to and that keeps me more active, I guess. More energized."
"I think it would increase the productivity, because sometimes where you're sitting for a certain amount of time, you start to doze off, but if I was standing, then if you doze off [you'd] fall… so it made you more alert and focused."
"On-campus I just found it easier to … pay attention. In class I found I wasn't falling asleep or having trouble focusing because you are standing, and I find that I'm not as susceptible to slouching or not paying attention."

Notes. This table contains the most relevant quotations; some phrases such as 'like', 'um', and 'I mean' were removed from quotations to increase the readability of the quotations; names and locations have been removed for confidentiality purposes as discussed by Corden and Sainsbury (2006).

Table 6

Barriers to Using the Standing Desk

1) The Social Norms of Sitting
"… it's that feeling of standing out or breaking the social norm of the professor standing at the front speaking to students that are sitting. It's almost like a power dynamic there, I think. I would feel awkward to break it."
"I don't think the social environment would make it easier because sometimes people are like 'what is that' or I don't think [the standing desk is] used as much so it's kind of an abnormal thing to certain people"
"… standing up where everyone else is sitting down is probably the hardest and then just because there isn't a lot of areas, there is [a] few, but there isn't a lot of areas that you can stand and it won't be strange"
2) Difficult to Carry Desk Between Environments/ Size of the desk
"… I've got my lunch in my hand, a heavy backpack, I really don't want to carry another thing, so it's not like super heavy but [the standing desk is] not light either."
"On campus I didn't use the [standing]desk much because [the standing desk] was just awkward to bring around and definitely to carry too."
"… the [standing desk] is too long. I wish it would fold in half maybe just once more, it if it was like that somehow than I would be more motivated to bring it with me. But it's just too bulky to carry."
3) Lecture Hall Design
"… most of the lecture halls have the weird slide tables… so it's hard to fit the[standing] desk on it."
"… depending where you're sitting in class, it's hard to use [the standing desk] if you're standing in front of other people."
"… I usually study in [university library], so I probably would only been able to use [the standing desk] in private study instead of lecture halls that have the flip desk, that doesn't really work"

Note. This table contains the most relevant quotations; some phrases such as 'like', 'um', and 'I mean' have been removed from quotations to increase the readability of the quotations; names and locations have been removed for confidentiality purposes as discussed by Corden and Sainsbury (2006).

Study 4. Thirty full-time UGS participated in this study. Two participants were lost at follow-up, leaving a final sample size of 28 participants. Most participants were female (n = 23, 82%) and Caucasian (n = 17, 61%), with almost half enrolled in their third year of undergraduate study (n = 13, 46%).

Quantitative results. The results from the NIGHTLY-WEEK-U illustrate a significant reduction in total average daily ST (1.93 hours/day, p = <0.0001, d = 0.98), weekday ST (1.69 hours/day, p = 0.0001, d = 0.85), and weekend ST (2.52 hours/day, p = 0.0001, d = 0.85). At baseline, participants spent most of their ST engaged in 'study' (5.83 hours/day, 49.5% of average daily ST), followed by 'computer use' (1.60 hours/day, 13.6%), and 'eating' (1.14 hours/day, 9.7%). Results also show a significant reduction in domain-specific ST of study (1.41 hours/day) and computer (0.51 hours/day). With the exception of television and socializing, all other domain-specific ST decreased. The effects of these reductions were small-to-medium in size and non-significant. The greatest reduction of ST in a single participant was by 6.22 hours/day, while one participant increased their ST by 1.23 hours/day, demonstrating large variability in the changes. During the baseline week, 118 out of 196 (60.2%) total NIGHTLY-WEEK-U entries were completed on time across the 28 participants (7 entries in a week). During the intervention week, this dropped to 90 out of 196 (45.9%). Average daily ST and the breakdown of ST into individual domains between baseline and intervention weeks derived from the NIGHTLY-WEEK-U can be found in Table 7.

Table 7

NIGHTLY-WEEK-U Derived Average Daily ST (Hours per day)

	Baseline Mean (± SD)	Intervention Mean (± SD)	% Change	Cohen's *d*	*p* Value
Total ST	11.77 (± 2.17)	9.84 (± 1.81)	-16.4%	0.98	< 0.0001
Weekday ST	11.69 (± 2.03)	10.0 (± 1.85)	-14.5%	0.85	0.0001
Weekend ST	11.99 (± 2.93)	9.47 (± 2.31)	-20.1%	0.85	0.0001
Domain-Specific ST					
Study	5.83 (± 2.21)	4.42 (± 1.45)	-24.2%	0.83	0.0002
Work	0.10 (± 0.27)	0.08 (± 0.27)	-20.0%	0.23	0.1567
Transport	0.56 (± 0.51)	0.52 (± 0.49)	-7.1%	0.09	0.6545
Television	0.72 (± 0.77)	0.87 (± 0.88)	+20.83	0.22	0.2864
Computer	1.60 (± 1.14)	1.09 (± 1.05)	-31.9%	0.47	0.018
Reading	0.18 (± 0.54)	0.10 (± 0.22)	-44.4%	0.21	0.3016
Eating	1.14 (± 0.42)	1.11 (± 0.47)	-2.6%	0.09	0.6745
Socializing	1.05 (± 0.59)	1.19 (± 0.74)	+13.3%	0.19	0.3162
Other	0.65 (± 0.98)	0.36 (± 0.43)	44.6%	0.27	0.1622

Qualitative results. Twenty-six (92.9%) participants completed the online qualitative questions. Two facilitators were identified that aided participants' use of the standing desk: (1) a strong desire to sit less during academic study, and (2) feeling positively impacted by the physical and mental increases in productivity received from standing during study. Four barriers were found to hinder participants' use of the standing desk: (1) the social norms of sitting, (2) it was difficult to transfer/size of the desk, (3) the lecture halls' design, and (4) a loss of interest in the intervention. The facilitators and barriers of Study 4 were overlapped with the facilitators and barriers of Study 3 due to the responses between the studies being extremely similar. Table 8 provides supporting quotations for the identified facilitators and Table 9 provides supporting quotations for identified barriers.

Table 8

Facilitators to Using the Standing Desks

A Desire to Stand/Enjoyed Having the Option to Stand
"I can't stand siting in lectures, even for the hour."
"*I would use the[standing]desk for every class if it was available in all of my classes"*
"It was very nice to be able to stand up. I've been doing a lot of studying and I am very glad I have not had to sit this whole time."
Experienced an Increase in Productivity
"I enjoyed that I could stand comfortably and I feel like I was more productive when I used a combination of sitting and standing. I like that I felt I was making a healthier choice."
"It is harder to focus on studies when sitting down for a long time. The desk helped solve the problem."
"*[The standing desk] really helps during prolong study sessions, as with sitting I get back pain. [The standing desk] was a good way to change positions while also continuing to be productive"*

Notes. This table contains the most relevant quotations; In some responses, spelling and/or grammatical errors were edited to increase the readability of the quotations as discussed in Corden and Sainsbury (2006).

Table 9

Barriers to Using the Standing Desks

The Social Norms of Sitting
"I believe that other students would be rather judgmental towards me, especially if I was the only person using the desk."
"[Using the desk would be awkward] on campus since people are not used to [the standing desk] so they stare. Some students may have looked at you funny for a second."
"…I was the only one standing and people stared at me."
Difficult to Transfer/ Size of the Desk
"The size made it hard to carry to/from campus as [the standing desk] was awkward and didn't fit into my backpack"
"[The standing desk] is cumbersome and difficult to lug around (considering I have my bag and gym-bag to carry as well)."
"I only used [the standing desk] off campus because it was not very portable and I didn't feel comfortable bringing it to class"
Lecture Hall Design
"If the desk was optional, and positioned at the back of the class, I would not use it as I value being at the front of the class more as the back of the class is hard to hear, and there is too much stimulus."
"A lot of the lecture halls don't have much [room], so fitting the desk there was a bit difficult on top of my other stuff."
"most of my classes have very small desks and not much space in between desks so I wasn't able to use it anywhere aside from my desk in my room [at home]."
A loss of Interest
"[The standing desk] helped me to sit less. The first week I barely sat at all and then I got a bit lazy to use it."
"[I]tried to use the desk more at the beginning but gave up [using the standing desk] a bit towards the end."
"I used [the standing desk] a lot the first week I had it, but set it aside and ended up forgetting about it"

Note. This table contains the most relevant quotations; In some responses, spelling and/or grammatical errors were edited to increase the readability of the quotations as discussed in Corden and Sainsbury (2006).

Discussion

To our knowledge, the studies described above are the first that investigated the effect of standing desks on UGS' average daily ST, targeting both their private and public study environments. In Study 3, the undergraduate participants were sedentary at baseline (objectively measured) for almost 11 hours per day, underscoring the need for ST interventions within this population. Furthermore, self-report baseline data from the NIGHTLY-WEEK-U identified that the most significant allocation of undergraduate ST was within the 'study' domain (5.21 hours/day, 50% of average daily ST). This was confirmed with results of Study 4 as participants reported that the study domain contributed to 49.5% of their average daily ST at baseline, suggesting that an intervention targeting the 'study' domain could offer the most effective change in ST. The findings from Study 3 suggest that providing UGS with an option to stand while engaging in study-related behaviours in multiple environments for one week is associated with reductions in average daily ST. The standing desk intervention was statistically significant for objectively and self-reported average daily ST, although surprisingly, the reduction in the 'study' domain was not independently statistically significant.

Similar results occurred in Study 4, as average daily ST was reduced significantly from baseline by almost two hours, suggesting that the impact of the intervention was sustainable over the course of one month for at least some participants. The increased length of the intervention in Study 4 was associated with an improved reduction of average daily ST, and a statistically significant reduction within the 'study' and 'computer' domains. However, the intervention week measurements of average daily ST in Study 3 (objective: 9.99 hours/day, self-report: 8.85 hours/day) and Study 4 (9.84

hours/day) remained at unhealthy levels, unless offset by an impressive amount of PA (Ekelund et al., 2016). Ekelund and colleagues (2016) estimated that individuals who sit for more than eight hours a day would need to participate in moderate intensity activity for 60 to 75 minutes per day to completely attenuate the negative health risks of sitting. Such a high level of PA may be unattainable for some UGS, as previous research has demonstrated that UGS commonly come up short on recommended PA guidelines (Irwin, 2004; Irwin, 2007). Furthermore, Chau and colleagues (2013) identified that for each additional hour of sitting time greater than seven hours per day, there is a 5% increased risk of all-cause mortality, even after accounting for physical activity. As such, average daily ST will likely need to be further reduced for most students. Nonetheless, the collective results of Studies 3 and 4 suggest that mobile standing desks could make an important contribution toward resolving the problem of excessive ST among UGS.

The reduction of average daily ST over one week (Study 3) and one month (Study 4) is encouraging. Further, the qualitative analysis from both studies suggest that there could be room for even greater improvements. Specifically, participants in both studies noted that they did not transfer the desk to the classroom environment due to its inconvenient size (i.e., would not fit easily into a backpack or other book bag) coupled with lecture halls filled with rows of closely situated chairs with flip-up arms. For the participants in these studies, their class time may account for approximately 15 hours of ST that might have been reduced had the mobile desks been slightly smaller and classroom seating more amenable; with some design alterations, more potential for healthy change could be possible. Jerome and colleagues (2017) found that providing university students with standing desks exclusively in a small classroom setting increased

standing to 7.2 minutes per hour per student. When that result is applied to the average lecture schedule of UGS in these studies (i.e., typically 3 hours per day), a meaningful reduction in ST is possible. That is, more conveniently-sized desks used exclusively in smaller classrooms that are better suited to their use could be associated with an additional reduction in ST equaling up to 21.6 minutes a day for some individuals. With continued access to standing options in private study environments and improved access to in-class standing options, the results of this study suggest that there is significant potential for further reduction of ST in this highly sedentary population. Qualitatively, the findings of Studies 3 and 4 provide insight and understanding pertaining to the barriers and facilitators students experienced in using the desks and can inform future intervention work of this nature.

Participants in Study 3 identified that their enrollment in a health-focused faculty provided them with previous knowledge of the dangers of increased SB, potentially motivating them to stand more during the study, and creating a positive attitude towards using the standing desk. Although this facilitator was not identified as a theme for the participants in Study 4, it is likely that they too had previous knowledge of the dangers of SB given their recruitment from health-related programs. This discrepancy between the two samples is possibly the result of the change in qualitative methodologies from Study 3 to Study 4 as participants in Study 3 were not limited to the strict structure of online questions and were able to speak more freely in semi-structured interviews. Further impacting the participants' ability to use the standing desk was likely the social norms associated with standing during 'study'. Participants in both studies identified that the norms of sitting while engaged in study-related pursuits, particularly during class time,

prevented them from using the desk as desired. For those students who used the standing desk in class and other public spaces such as the library, they were quite literally 'standing out' and expressed feeling a social pressure to sit like everyone else. Other sedentary-related studies have also identified that there is a social component to the determinants of SBs among university students (Jerome et al., 2017; Deliens, Deforche, De Bourdeaudhuij, & Clarys, 2015). This identified barrier may prove to be the most challenging to eliminate -- even if students are provided with the perfect standing desk product in terms of size and functionality, the social awkwardness of using the desk is likely to remain.

Participants in Study 4 reported having an initial excitement towards using the standing desk, which they explained resulted in early and significant reductions of their ST. Unfortunately, for some participants, this enthusiasm faded over the month-long intervention making them believe that the intervention was not as effective at its conclusion. However, this did not seem to have a large impact on the overall effect of the intervention, as average daily ST was reduced substantially from baseline to intervention weeks. This could be explained by those participants who remained consistent and interested in using the standing desk compensating for those who lost interest, or those who lost interest finding alternative ways to reduce their ST. It is possible that the identified barriers (size of the desk, lecture hall design, social norms of sitting) to using the standing desks contributed to a loss of interest, although the identified barriers had an influence on public and on-campus study only, and does not explain a loss of interest in the intervention while at home. Further research into understanding students' personal agency to utilize available mobile standing desks is warranted.

Limitations

The findings for the present studies must be considered in light of the limitations. First, self-selection bias may have been present with only those UGS who were motivated to reduce their ST volunteering to participate in a standing desk study. Second, participants were recruited from the Faculty of Health Sciences only, limiting the generalizability of the findings. Future interventions should attempt to recruit a more heterogeneous sample. Third, the standing desks did not fit easily into most bags, making them less mobile than desired; size issues impeded the goal of targeting 100% of the 'study' domain. Future interventions should aim to provide students with a light-weight collapsible desk that conveniently fits into the average bag of choice for UGS, and when unfolded, maintains a workable surface area. Fourth, participants acted as their own controls and therefore, it is not possible to determine if other factors influenced their behaviour during the intervention week. Finally, Study 3 and Study 4 consisted of two observation points across a two-week and five-week timeline, respectively. Although Study 3 verified the feasibility of the intervention, and Study 4 demonstrated that the impact of the intervention could be sustained for one month, it is unclear how long it takes an individual to maintain certain behaviours, or form a habit, such as using a standing desk; the maintenance of a behaviour can occur anywhere within 18 and 254 days (Lally, Van Jaarsveld, Potts, & Wardle, 2010). Future investigations should increase the number of observation points across a longer timeline of one semester and/or up to an entire undergraduate academic year.

Conclusion

Providing full-time UGS with mobile standing desks for one week and one month was associated with a statistically significant and meaningful reduction of average daily ST. The 'study' domain contributed most to average daily ST, and the greatest reduction occurred within this domain. Participants responded positively to the mobile standing desk intervention and reported a desire to stand more during 'study', although they were negatively influenced by the social norms of sitting, the size of the desk, and the design of large university classrooms. A larger and longer randomized control trial is warranted.

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Chapter 4: Summary of Findings, Limitations and Future Directions, and Conclusions

Objective ST measurement tools are the most accurate tools available when measuring ST (Chastin et al., 2018), but they are unable to provide key information on the break-up of average daily ST into individual SBs, and are expensive and inconvenient when used in large epidemiological studies. To inform future interventions aiming to reduce undergraduate average daily ST, more affordable, domain-specific ST questionnaires that can provide context on average daily ST are needed. Unfortunately, recent investigations into the true accuracy of ST questionnaires has revealed that self-report measures of ST exhibit poor accuracy, low correlation, and large bias with objective measures, resulting in grossly underestimated STs (Chastin et al., 2018). Furthermore, very few ST questionnaires have been developed for, validated specifically in a population of UGS (SBRN, 2017), and are capable of capturing the intra-individual variability of an UGS' typical week (Wijndaele et al., 2014). These gaps in UGS SB research gave rise to the first half of this dissertation (Studies 1 and 2), in which the researcher (and his colleagues) sought to validate a ST questionnaire that was appropriate for UGS, outperformed previously validated ST questionnaires (Clark et al., 2016), and could be utilized in future intervention research involving UGS.

Researchers utilizing objective measurement tools have found that UGS are highly sedentary (Moulin, Truelove, Burke, & Irwin, 2019), putting them on an early path to a multitude of chronic diseases, and death (Patterson et al., 2018; Shields & Tremblay, 2008, Wilmot et al., 2012). To improve the health status of a population that has long been known to be physically inactive (Irwin, 2004; Irwin, 2007), and now highly

sedentary, effective interventions are needed. Logical comparisons between UGS and desk-based workers' typical work day, and the effectiveness of standing desks in the workplace (Alkhajah et al., 2012) provide justification for the use of standing desks to reduce undergraduate ST. The standing desk has been found to be effective for reducing sitting time and improving cardio-metabolic risk factors over a short time span within the university classroom (Butler, Ramos, Buchanan, & Dalleck 2018; Jerome, Janz, Baquero, & Carr, 2017). However, no intervention to date has targeted the entire 'study' domain, which exists in multiple academic environments, on and off the university campus, and could provide a profound reduction in average daily ST. The second half of this research program (Studies 3 and 4), demonstrated that it is possible to make an impact on the 'study' domain, with an intervention that may be more affordable than the retro-fitting of university common areas, libraries, and classrooms.

Findings

There are some common findings that exist in each of the independent research studies contained within this dissertation that confirm patterns previously demonstrated in the small body of undergraduate SB research currently available. Although it was not the main objective of the research studies, secondary findings from the first three studies demonstrated that objective measurements of average daily ST (pre-intervention for Study 3) was quite high at about 11 hours per day when averaged together. Based on the work of Ekelund and colleagues (2016), the dangers associated with this level of average daily ST cannot be offset by the current PA guidelines (WHO, 2010), meaning that these samples of UGS are most likely at risk for negative health outcomes without intervention. Domain-specific data from each of the four studies, in line with previous research

(Deforche, Van Dyck, Deliens, & De Bourdeaudhuij, 2015; Moulin & Irwin, 2017), suggests that the 'study' domain is the greatest contributor to undergraduate ST and interventions should be directed to the academic domain to have the greatest impact on undergraduate ST. Neither of these findings are very surprising considering the university environment and the sedentary nature of undergraduate work, but nonetheless are confirmed with the completion of this dissertation.

The individual studies that make up this dissertation, although presented together, have the ability to stand on their own in SB research, each with their own unique findings. Study 1 found that homogenous samples of UGS have a very difficult time recalling their ST within multiple SBs when completing a past-week ST questionnaire. The PAST-WEEK-U performed worse than the original PAST-U (Clark et al., 2016) when analyzed with the Bland-Altman method of analysis, with very wide limits of agreement despite showcasing an impressive mean bias. Considering that the domains of the PAST-WEEK-U were virtually the same as the PAST-U (Clark et al., 2016), it is likely that the decrease in accuracy is attributed to the increase in memory demands (past-day vs. past-week), as discussed by previous researchers (Clark et al., 2013; Matthews et al., 2013). Further, some participating students provided unsolicited testimonies that they found the memory demands of the PAST-WEEK-U irritating, and would prefer to complete a weekly ST questionnaire on a daily basis to improve their recall. Although it is unclear whether a participant's level of enjoyment while filling out a questionnaire has an impact on the accuracy of their responses, it is easy to surmise that if a participant is irritated with a questionnaire, they may rush through its completion, which could lead to inaccurate or missing data. Moving forward, it seemed critical to make a change to

reduce the memory demands of the questionnaire, and make the experience more enjoyable for participating students.

The findings of Study 2 demonstrated the success of reducing the memory demands of participants when recalling weekly ST, while maintaining the intra-individual variability of a past-week questionnaire (Wijndaele et al., 2014). Although not perfect, the format of the NIGHTLY-WEEK-U significantly improved the limits of agreement when compared to the objective measure. Participants were able to better provide estimates of average daily ST for an entire week. Again, because the questions, language, and domains of the NIGHTLY-WEEK-U were virtually the same as the PAST-WEEK-U, it appears that the increase in accuracy is due to the decrease in memory demands. Although no self-report measure will likely ever be as accurate as an objective measure (Chastin et al., 2018), the NIGHTLY-WEEK-U significantly improves on the original PAST-U (Clark et al., 2016), and the comparable domain-specific questionnaires explored by Chastin and colleagues (2018). The findings of Study 2 suggest that the NIGHTLY-WEEK-U is appropriate for use in large epidemiological studies, as its strengths appear to outweigh its weaknesses. Researchers cannot solely rely on objective measures for the advancement of SB research, and weekly ST questionnaires structured like the NIGHTLY-WEEK-U may be the most accurate weekly self-report option moving forward.

The findings of Study 3 indicated that mobile standing desks are associated with a reduction in the average daily ST of UGS. Intervention measurements, objective and self-report, demonstrated a significant reduction in average daily ST, with the greatest reductions occurring in the ‘study’ domain. Overall, the intervention was successful, but

certain modifications should be made to the mobile standing desks to increase its use on the university campus. This was made evident with the analysis of student responses following semi-structured interviews pertaining to their experiences with the desks. The student interviews revealed that the size of the desk made it difficult to conveniently transfer it to campus, and therefore, most students kept the desk at home for use during private study. Additionally, the use of the desk within certain large university lecture halls was not possible as these rooms did not provide a suitable surface for use with the mobile standing desk. These identified barriers prevented the desk from being used in 100% of academic study environments. Furthermore, as reported by Jerome and colleagues (2017), students revealed that they felt a social pressure to sit like the majority of their peers, and felt awkward using the desk in class and public study areas. The findings from Study 3 suggest that for on-campus standing desk interventions to be successful, modifications need to be made to the physical and social environments. However, despite these barriers, mobile standing desks for the reduction of undergraduate ST appears to be a feasible intervention in the short-term, with room for further improvement.

Study 4 found that the mobile standing desk was associated with reductions in average daily ST for the longer period of one month. Similar to Study 3, these reductions were most associated with a reduction in the ‘study’ domain. Furthermore, student responses to online, open-ended questions indicated that the desks were used mostly at home, as their design made it difficult to transfer from place to place. The social awkwardness of standing while others sit did not seem to diminish with an increased intervention duration, as many students reported social pressure to fit and conform to the

behaviour of their peers. However, the longer duration did bring about a new barrier to using the standing desk – a loss of interest in the intervention. Some students reported that although they were interested in using the desk at the beginning of the study, their enthusiasm soon wore off. The findings of Study 4 suggest that modifications will need to be made to the mobile standing desk to make it more transferrable, the social acceptance of standing during 'study' will need to be increased, and the motivation for using a standing desk will need to be explored.

Limitations and Future Directions

A collective limitation of the research studies within this dissertation is the overwhelmingly female study populations. Each of the study samples were recruited entirely from the Faculty of Health Sciences, an inherently female-dominated faculty at Western University. Further impacting the majority of female participants could have been the attachment protocol of the activPAL4^{TM} activity monitor, which required attachment to the upper thigh. Participants in each study utilizing the activPAL4^{TM} device were made fully aware of the risk of pulling of leg hair when removing the device. The percentage of participating males for Studies 1, 2, and 3 were 12%, 4%, and 5%, respectively. The percentage of males for Study 4, which did not utilize the activPAL4^{TM} for measuring ST, jumped to 18% suggesting that the pulling of body hair may have deterred some males from participating in Studies 1-3. Due to this collective limitation, the results of this dissertation are limited mostly to females within the Faculty of Health Sciences and not representative of the entire undergraduate population. Future studies should attempt to recruit from various academic disciplines, and perhaps create a study

protocol that requires participants to shave their upper thigh before attachment of the activPAL4^{TM} takes place.

For each study that used it (Studies 3 and 4), the structure of the NIGHTLY-WEEK-U could serve as an intervention itself. That is, the daily tracking of ST could make a participant aware of how much daily sitting they accumulate, and could cause them to consciously or subconsciously limit their sitting times for the remainder of the week in question. This atypical change in SB could have led to an underestimation of their typical/true average daily ST. Moving forward, this potential limitation will need to be weighed against the proven strengths of the NIGHTLY-WEEK-U. Future researchers are advised to use a combination of objective and subjective measurement tools when the resources are available. An objective tool, such as the activPAL4^{TM}, provides an accurate assessment of ST, and a domain-specific questionnaire provides context to the objective data. As mentioned earlier in this dissertation, both measurement tools have their strengths and weaknesses, and greater confidence can be ensured when they are applied together.

A limitation affecting the results of Studies 3 and 4 was the potential self-selection bias during recruitment. It is possible that only students who were interested in reducing their average daily ST volunteered to participate in studies that attempted to reduce the average daily ST of UGS. It is not clear how the mobile standing desk intervention would have fared in a real-world setting, and how effective the intervention would have been in a random sample of university students across disciplines. Future studies should attempt to use a randomized control protocol, and if ethical guidelines allow for it, obtain samples of entire university classrooms to allow for positive and

negative perceptions to using the mobile standing desk at the start of a study. Participating students who are given access to a standing desk but choose not to use it could be interviewed at follow-up regarding their perceptions on the standing desk, and the analyzed data could be used to inform future interventions.

The design of the mobile standing desk was not ideal for the majority of participating students. The large size of the desk prevented students from using the desk in all study environments as originally planned. Despite significant reductions to average daily ST, even greater reductions could have been made with a smaller standing desk. Future researchers should use a mobile standing desk that is collapsible and can fit into a typical school bag/backpack, and maintains a workable surface area.

Studies 3 and 4 were limited to two observation points across short intervention timelines of one and four weeks, respectively. Study 3 confirmed the feasibility of the intervention, and Study 4 indicated that the impact of the intervention could be sustained, but it is unclear how long it would take to maintain the behaviour of using a standing desk. Future research should test the effectiveness of a mobile standing desk intervention over an entire academic semester (four months), or an entire academic year (eight months). These longer durations would enable the researchers to account for the changing demands and commitments to schoolwork that occur during different times of year. Each of the measurements of average daily ST across the four studies in this dissertation occurred toward the end of the semester when students may have been gearing up for final assignments and exams. As such, the amount of average daily ST, and estimates of ST attributed to ‘study’ could have been experiencing an increase. Future research in this

area should investigate how the average daily ST of UGS changes throughout a semester, as well as the daily ST time spent in 'study'.

Conclusions

The findings of Studies 1 and 2 provides SB researchers with a ST measurement tool that can be used in the undergraduate population and capable of capturing the full intra-individual variability (Wijndaele et al., 2014) of their average week, without unrealistic memory demands. With the creation and successful validation of the NIGHTLY-WEEK-U, a domain-specific questionnaire designed for and validated entirely in UGS (rather than in a mix of university employees and student types), a gap has been filled in undergraduate SB research. The contents of this dissertation have demonstrated that mobile standing desks are a feasible intervention for the significant reduction of undergraduate ST from one week to one month. It could be a long time before universities take the required steps to provide their students with standing options while on campus, and students will need an alternative until, and if such options are provided to them. UGS currently have little to no control over their study environments, especially if a student engages in private study exclusively on campus. At this moment, to succeed, students are required to sit. Ideally, future university administrators will act as health promoters, enabling UGS to increase control over, and improve their health (WHO, 1986) by providing UGS the option to stand when on campus. Academic time commitments in sedentary environments are putting UGS' health at risk, and compact and mobile standing desks for use in the majority of study environments appears to be an effective and viable option for reducing ST.

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Appendix A

PAST-U: Past-day Adults' Sedentary Time - University

ID:

Yesterday's date: _____

Yesterday's day: Monday Tuesday Wednesday Thursday Friday Saturday Sunday

I am going to ask you about particular activities you did yesterday while sitting down or lying down. Please note that this does not include sleeping, either in bed or if you fell asleep while doing another activity, for example watching television.

I am going to ask you about different times when you may be sitting or lying down: when studying, working, travelling, watching TV, using the computer, and doing other activities. For each of these, only count the time this was your main activity. For example, if you watched TV and ate dinner at the same time, this might be TV or meal time, but not both. Your answers can be given in hours and minutes. Try to report only the time you spent sitting or lying down and do not take into account the time you spent getting up for breaks (e.g. coffee, bathroom).

Sitting for study

ST 1. **How long** were you **sitting** while studying yesterday? (include the time at university, during lectures, tutorials, meetings, group discussions, self-study, study from home, etc.)

		hours			minutes

Interviewer: if the respondent has difficulty, you can reassure them that their best estimate will be OK.

Sitting for work

ST 2. **How long** were you **sitting** at your workplace or working from home in a paid position yesterday? (Examples: babysitting, sitting at the reception, minding a stall/shop, data entry/administrative paper work, tutoring, etc.)

		hours			minutes

Sitting for Transport

ST 3. Thinking again of yesterday, please estimate the **total** time that you spent **sitting** to travel from one place to another. Please **include sitting and waiting** for transport. Do **not** include any time you were standing up while travelling or waiting.

☐☐ hours ☐☐ minutes

Interviewer clarification: transport includes public and private, waiting for any type of transport and travel to all locations. This would not include time spent travelling as part of work which was reported in ST2 e.g. taxi driver

Television Viewing

ST 4. Please estimate the **total time** you spent sitting or lying down to watch TV or DVDs or play games on the TV, such as PlayStation/Xbox yesterday? This includes if you watch TV in bed.

☐☐ hours ☐☐ Minutes

Computer, Internet, Electronic Games

ST 5. Please estimate the total time yesterday that you spent sitting or lying down and using the computer. (For example, include time spent playing games on you Iphone/Ipad/tablet, using the internet or activities that **were not for studying or working purposes**, like Facebook, Twitter, Skype, YouTube, online-shopping, etc.)

☐☐ hours ☐☐ minutes

Sitting for reading

ST 6. Please estimate the total time yesterday that you spent sitting or lying down while reading **during your leisure time**. Include reading in bed but do not include time spent reading for paid work or for study.

☐☐ hours ☐☐ minutes

Sitting for eating

S7. Please estimate the total time yesterday that you spent sitting down for eating and drinking, including meals and snack breaks.

☐☐ hours ☐☐ minutes

Sitting for socializing

ST8. Please estimate the total time yesterday that you spent sitting down to socialize with friends or family, regardless of location (at university, at home or in a public place). Include time on the telephone.

		hours			minutes

Sitting/lying for other purposes

ST 9. We are interested in any other sitting or lying down that you may have done that you have not already told us. For example this could include; hobbies such as doing art and craft, playing board games; listening to music or for religious purposes.
Again thinking of yesterday, please estimate the **total time** that you spent sitting or lying down **NOT** including time that you have told us about in the previous answers.

		hours			minutes

Interviewer: if the respondent has difficulty, you can reassure them that their best estimate will be OK.

That's all the questions we have for you about the time you spent sitting or lying down yesterday. Thinking back on your answers, is there anything you would like to change?

Interviewer: This will give the participant an opportunity to confirm that they have given an accurate response to each question. Please change responses as required.

If the participant has reported sitting for over 16 hours in the day prompt them to consider their answers by saying 'I've got here that you spent ….. sitting yesterday. Are there any times where you might have over-estimated or doubled up on reporting sitting time?'

Appendix B

PAST-WEEK-U Sedentary Time Questionnaire

ID:

Week start date: _____ Week end date: _____

I am going to ask you about particular activities you did over the past week while sitting down or lying down. Please note that this does not include sleeping, either in bed or if you fell asleep while doing another activity, for example watching television.

I am going to ask you about different times when you may be sitting or lying down: when studying, working, travelling, watching TV, using the computer, and doing other activities. For each of these, only count the time this was your main activity. For example, if you watched TV and ate dinner at the same time, this might be TV or meal time, but not both. Your answers can be given in hours and minutes (Ex. Watching TV from 2:00pm to 3:45pm would be written as 1 hour and 45 minutes). Try to report only the time you spent sitting or lying down and do not take into account the time you spent getting up for breaks (e.g. coffee, bathroom).

Keep in mind that when the total hours of sitting time per day are added together, the total should not equal more than the number of hours you sleep per night subtracted from 24. For example, if you slept on average for 8 hours per night, the total number of sedentary hours each weekday should not be greater than 16 hours.

Think about what last week looked like. What happened on each individual day? Think about what days and times you had classes, what your work schedule looked like, and any social events you may have attended. What miscellaneous activities filled in the rest of those days? How much sitting or lying down did you do during each of these activities?

Sitting for study

ST 1. How long did you sit or lay down while studying **on each of the previous 7 days**? (include the time at university, during lectures, tutorials, meetings, group discussions, self-study, study from home, etc.) Please fill out the most recent day first, and work backwards to the first day of past week. For example, if today is a Monday, start with Sunday and work backwards to Monday of last week. If today is a Thursday, start with Wednesday and work backwards to Thursday of last week.

Monday

		hours			minutes

Tuesday

☐☐ hours ☐☐ minutes

Wednesday

☐☐ hours ☐☐ minutes

Thursday

☐☐ hours ☐☐ minutes

Friday

☐☐ hours ☐☐ minutes

Saturday

☐☐ hours ☐☐ minutes

Sunday

☐☐ hours ☐☐ minutes

Sitting for work

ST 2. How long did you sit at your workplace or working from home in a paid position **on each of the previous 7 days?** (Examples: babysitting, sitting at the reception, minding a stall/shop, data entry/administrative paper work, tutoring, etc.) Please fill out the most recent day first, and work backwards to the first day of the past week.

Monday

☐☐ hours ☐☐ minutes

Tuesday

☐☐ hours ☐☐ minutes

Wednesday

☐☐ hours ☐☐ minutes

Thursday

☐☐ hours ☐☐ minutes

Friday

☐☐ hours ☐☐ minutes

Saturday

☐☐ hours ☐☐ minutes

Sunday

☐☐ hours ☐☐ minutes

Sitting for Transport

ST 3. How long did you spend **sitting** to travel from one place to another **on each of the previous 7 days?** This includes transport in motor vehicles and does not include transport on a bicycle. Please **include sitting and waiting** for transport. Do **not** include any time you were standing up while travelling or waiting. Please fill out the most recent day first, and work backwards to the first day of past week.

Monday

☐☐ hours ☐☐ minutes

Tuesday

☐☐ hours ☐☐ minutes

Wednesday

☐☐ hours ☐☐ minutes

Thursday

☐☐ hours ☐☐ minutes

Friday

☐☐ hours ☐☐ minutes

Saturday

☐☐ hours ☐☐ minutes

Sunday

☐☐ hours ☐☐ minutes

Television Viewing

ST 4. How long did you spend sitting or lying down to watch TV or DVDs or play games on the TV, such as PlayStation/Xbox **on each of the previous 7 days**. This includes if you watch TV in bed. Please fill out the most recent day first, and work backwards to the first day of past week.

Monday

		hours			minutes

Tuesday

		hours			minutes

Wednesday

		hours			minutes

Thursday

		hours			minutes

Friday

		hours			minutes

Saturday

		hours			minutes

Sunday

		hours			minutes

Computer, Internet, Electronic Games

ST 5. How long did you spend sitting or lying down and using the computer **on each of the previous 7 days**. (For example, include time spent playing games on your Iphone/Ipad/tablet, using the internet or activities that **were not for studying or working purposes**, like Facebook, Twitter, Skype, YouTube, online-shopping, etc.) Please fill out the most recent day first, and work backwards to the first day of past week.

Monday

		hours			minutes

Tuesday

		hours			minutes

Wednesday

		hours			minutes

Thursday

		hours			minutes

Friday

		hours			minutes

Saturday

		hours			minutes

Sunday

		hours			minutes

Sitting for eating

ST6. How long did you spend sitting down for eating and drinking, including meals and snack breaks **on each of the previous 7 days**. If a meal was eaten while watching TV, this should be reported as either TV viewing in ST4 or reported here in ST6, but not both. Please fill out the most recent day first, and work backwards to the first day of past week.

Monday

		hours			minutes

Tuesday

		hours			minutes

Wednesday

		hours			minutes

Thursday

		hours			minutes

Friday

		hours			minutes

Saturday

		hours			minutes

Sunday

		hours			minutes

Sitting for socializing

ST7. How long did you spend sitting down to socialize with friends or family, regardless of location **on each of the previous 7 days?** (at university, at home or in a public place). Include time on the telephone. Please report sitting time during socializing separate from all other activities. Do NOT combine socializing time with any of the previous questions above. If you watched TV for 2 hours with a friend, this should be recorded in ST4 and not double counted for socializing. Please fill out the most recent day first, and work backwards to the first day of past week.

Monday

		hours			minutes

Tuesday

		hours			minutes

Wednesday

		hours			minutes

Thursday

		hours			minutes

Friday

		hours			minutes

Saturday

		hours			minutes

Sunday

		hours			minutes

Sitting/lying for other purposes

ST8. We are interested in any other sitting or lying down that you may have done that you have not already told us. For example this could include; hobbies such as doing art and craft, playing board games, reading; listening to music or for religious purposes.
Again thinking of the last 7 days, please estimate the **total time** that you spent sitting or lying down **NOT** including time that you have told us about in the previous answers, **on each of the previous 7 days**.

Monday

		hours			minutes

Tuesday

		hours			minutes

Wednesday

		hours			minutes

Thursday

		hours			minutes

Friday

		hours			minutes

Saturday

		hours			minutes

Sunday

		hours			minutes

That's all the questions we have for you about the time you spent sitting or lying down in the last 7 days. Thinking back on your answers, is there anything you would like to change?

Keep in mind that when the total hours of sitting time per day are added together, the total should not equal more than the number of hours you sleep per night subtracted from 24. For example, if you slept on average for 8 hours per night, the total number of sedentary hours each weekday should not be greater than 16 hours.

Thank you for taking the time to complete the questionnaire!

Appendix C

Ethics Approval – Study 1

Western Research

Date: 23 February 2018

To: Dr. Jennifer Irwin

Project ID: 110847

Study Title: The Agreement Between ActivPAL-Assessed and Self-Reported Sedentary Time in Full-Time Undergraduate Students

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: March 2 2018

Date Approval Issued: 23/Feb/2018

REB Approval Expiry Date: 23/Feb/2019

Dear Dr. Jennifer Irwin

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
ActivPAL4TM Log Sheet	Other Data Collection Instruments	09/Jan/2018	1
Faculty of Health Sciences Facebook Group Recruitment Message PhD study one(1) CLEAN	Recruitment Materials	08/Feb/2018	3
In class verbal script CLEAN	Oral Script	08/Feb/2018	2
Invitation Email to Course Instructors PhD study one(2) CLEAN	Recruitment Materials	08/Feb/2018	2
MM Study One LOI(1) CLEAN	Written Consent/Assent	08/Feb/2018	3
Modified PAST-U (days)	Paper Survey	18/Jan/2018	2

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
Demographic Information (1) CLEAN	Screening Form/Questionnaire	08/Feb/2018	2

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Appendix D

Invitation to Course Instructors – Study 1

Subject Line: The Agreement Between ActivPAL-Assessed and Self-Reported Sedentary Time in Full-Time Undergraduate Students – An FHS Study

Hello Professor,

I am writing to request your assistance for my PhD project involving the sedentary behaviour of undergraduate students. I am wondering if I could make a very brief announcement during your undergraduate class(es) at a time that is convenient for you. The Office of Human Research Ethics requires that professors leave the classroom while this in-class announcement takes place. Below is the formal recruitment message that I will present to your students if this requirement is acceptable to you.
Researchers from the Faculty of Health Sciences are conducting a study to assess the level of agreement between the ActivPAL activity monitor and a modified version of the PAST-U Sedentary Behaviour Questionnaire. In this study, full-time students will be asked to meet with the co-investigator to sign a consent form, be further briefed on the study design, and begin their enrollment in the study. The study will require the participant to wear the ActivPAL activity monitor for one week. The ActivPAL monitor differentiates between sedentary (sitting/lying down), standing, and ambulatory activity using propriety algorithms and is worn on the midline anterior aspect of the thigh. The participant will attach the device to themselves privately and will only receive verbal instructions on how to attach the device . The device will record the total average daily sedentary time over the entire week. The device is attached to the skin by a 3M Tegaderm Film Dressing that is waterproof, gentle on skin, and flexes to provide greater comfort. The device will be wrapped in a waterproof sleeve that will allow participants to bath, shower, or swim while wearing the device. Participants are encouraged to switch legs during the study if they experience skin irritation and will be provided with multiple film dressings in order to do so. At the end of the week, the participant will meet with the co-investigator again to fill out the modified PAST-U sedentary behaviour questionnaire and to return the device. This short questionnaire will again provide an total average daily sedentary time for the past week. Upon completion of the study, if requested, participants will be given a break down of their activity over the past week that can help them identify their true levels of sedentary behaviour and perhaps use it to strategize how to reduce it. Participation is completely voluntary and withdrawal from the study is allowed at any time.

Thank you for considering our request. We would be happy to share the results with you after the study is completed. If you have any further questions and/or require further information about this study, you are welcome to contact Marc Moulin at [redacted] or Dr. Jennifer Irwin at [redacted]

Best regards,
Marc Moulin, MSc., PhD Candidate in Health and Rehabilitation Sciences

Appendix E

Facebook Recruitment Message – Study 1

Faculty of Health Sciences Facebook Group Recruitment Message

Hello Western Health Sci,

My name is Marc Moulin and not too long ago I was right where you are today. I am now working on completing my PhD under the supervision of Dr. Jennifer Irwin and we are hoping that you may be interested in taking part in our current study. If you are interested please review the study description and design below:

Researchers from the Faculty of Health Sciences are conducting a study to assess the level of agreement between the ActivPAL activity monitor and a modified version of the PAST-U Sedentary Behaviour Questionnaire. In this study, full-time students will be asked to meet with the co-investigator to sign a consent form, be further briefed on the study design, and begin their enrollment in the study. The study will require the participant to wear the ActivPAL activity monitor for one week. The ActivPAL monitor differentiates between sedentary (sitting/lying down), standing, and ambulatory activity using propriety algorithms and is worn on the midline anterior aspect of the thigh. The participant will attach the device to themselves privately and will only receive verbal instructions on how to attach the device . The device will record the total average daily sedentary time over the entire week. The device is attached to the skin by a 3M Tegaderm Film Dressing that is waterproof, gentle on skin, and flexes to provide greater comfort. The device will be wrapped in a waterproof sleeve that will allow participants to bath, shower, or swim while wearing the device. Participants are encouraged to switch legs during the study if they experience skin irritation and will be provided with multiple film dressings in order to do so. At the end of the week, the participant will meet with the co-investigator again to fill out the modified PAST-U sedentary behaviour questionnaire and to return the device. This short questionnaire will again provide an total average daily sedentary time for the past week. Upon completion of the study, if requested, participants will be given a break down of their activity over the past week that can help them identify their true levels of sedentary behaviour and perhaps use it to strategize how to reduce it. Participation is completely voluntary and withdrawal from the study is allowed at any time.

Thank you for considering our request! We would be happy to share the results with you after the study is completed. If you would like to learn more or are interested in participating you are welcome to contact me at [redacted].

Appendix F

In Class Announcement Verbal Script – Study 1

In class verbal recruitment script

"Hello Western Health Sci,

My name is Marc Moulin and not too long ago I was right where you are today. I am now working on completing my PhD under the supervision of Dr. Jennifer Irwin and we are hoping that you may be interested in taking part in our current study.

Researchers from the Faculty of Health Sciences are conducting a study to assess the level of agreement between the ActivPAL activity monitor and a modified version of the PAST-U Sedentary Behaviour Questionnaire. In this study, full-time students will be asked to meet with the co-investigator to sign a consent form, be further briefed on the study design, and begin their enrollment in the study. The study will require the participant to wear the activPAL activity monitor for one week. The activPAL monitor differentiates between sedentary (sitting/lying down), standing, and ambulatory activity using propriety algorithms and is worn on the midline anterior aspect of the thigh. The participant will attach the device to themselves privately and privately and will only receive verbal instructions on how to attach the device . The device will record the total average daily sedentary time over the entire week. The device is attached to the skin by a 3M Tegaderm Film Dressing that is waterproof, gentle on skin, and flexes to provide greater comfort. The device will be wrapped in a waterproof sleeve that will allow participants to bath, shower, or swim while wearing the device. Participants are encouraged to switch legs during the study if they experience skin irritation and will be provided with multiple film dressings in order to do so. At the end of the week, the participant will meet with the co-investigator again to fill out the modified PAST-U sedentary behaviour questionnaire and to return the device. This short questionnaire will again provide a total average daily sedentary time for the past week. Upon completion of the study, if requested, participants will be given a break down of their activity over the past week that can help them identify their true levels of sedentary behaviour and perhaps use it to strategize how to reduce it. Participation is completely voluntary and withdrawal from the study is allowed at any time.

Thank you for considering our request! We would be happy to share the results with you after the study is completed. If you would like to learn more or are interested in participating you are welcome to contact me at [redacted]."

Appendix G

Letter of Information and Consent – Study 1

The Agreement Between ActivPAL-Assessed and Self-Reported Sedentary Time in Full-Time Undergraduate Students

Investigators:
Jennifer D. Irwin, PhD, Faculty of Health Sciences, Western University
Marc Moulin, MSc, Faculty of Health Sciences, Western University
Trish Tucker, PhD, Faculty of Health Sciences, Western University
Harry Prapavessis, PhD, Faculty of Health Sciences, Western University

You are invited to participate in this research study because you are a full-time, undergraduate student enrolled in Health Sciences at Western University.

Purpose of the Study:
The purpose of the proposed study is to examine the level of agreement between a modified version of the PAST-U Sedentary Behaviour Questionnaire and the newly introduced activPAL4™ (PAL Technologies, Ltd, Glasgow, UK) over a 7-day recall time frame with a full-time undergraduate population.

Study Procedure:
During the first meeting with the co-investigator (day one of seven days), you will be verbally instructed on how to properly attach the ActivPAL4 device to your upper thigh, attach the device to your thigh, complete a screening questionnaire, and be given an Activity Log Sheet to track your wake up and sleep times, as well as anytime that you remove the device from your leg. This log sheet should be filled out during the 7-day wear period. You will also be given (4) 3M™ Tegaderm™ Film Dressings to use if needed over the 7-day wear period (Component One). The ActivPAL4™ is a very small activity monitor that is attached to the upper thigh and is able to track a person's sedentary behaviour while they sit, stand, and participate in everyday activities. The device is wrapped in a waterproof seal and attached to the thigh with 3M™ Tegaderm™ Film Dressing, containing a hypoallergenic adhesive that gently secures it to the skin. This study consists of you wearing the activPAL4™ for 7 days, 24 hours a day. At the end of those 7 days, you will meet with the co-investigator once more, to return the device and to fill out a short, 10-minute questionnaire about your sitting behaviour over the past 7 days (Component Two). The co-investigator will not be able to help you attach the device to your thigh or help you take off the device. The co-investigator will only be able to provide verbal instructions on how to do so.

Inclusion and exclusion criteria:

In order for you to participate in this study, you must be a full-time Western University undergraduate student enrolled in Health Sciences or a Health Sciences class, who is fluent in English. You will not be able to participate if you are: (a) a Western University undergraduate student who is not a full-time student; (b) a Western University undergraduate student who is not fluent in English; or (c) a faculty member, staff, graduate, or postdoctoral student who is not currently enrolled in an undergraduate program at Western University.

Voluntary Participation:
Participation in this study is voluntary. You may withdraw from the study at anytime without any penalty. Your participation in this study will have no impact on evaluations of you of any kind, academically or otherwise. If you choose to participate, you are able to leave any question unanswered, should you choose to do so, and still complete the remainder of the questionnaire. If you wish to withdrawal your data from the study, please contact the co-investigator at [redacted] There are no limitations in doing so.

If You Decide to Participate:
If you decide to participate in this study, you will be asked to fill out the consent form that has been provided with this Letter of Information. By signing this consent form, you are consenting to all aspects of the study which include: 1) wearing an activPAL4™ activity monitor for 7 days and 2) completing a 10 minute written questionnaire. All information collected is confidential.

Confidentiality:
The information gathered in this study will only be used for publishing or presentations purposes. Each participant will be given an ID Number and all data will be linked to that ID Number. No names will be directly linked to participant data. Data collected from this study will only be accessible by the investigators and will be safeguarded on password protected devices, which will be destroyed after 7 years.

Cost and Compensation:
There is no cost to participate in this study. No compensation will be given for participation in this study.

Risks & Benefits:
There are very minor risks associated with participating in this study. It is possible to experience some very minor skin irritation at the site of the monitor attachment but this is very uncommon. The irritation can be subsided by changing the monitor to the other leg. If skin irritation persists, contact [redacted]. Your participation in this study will provide researchers with valuable information about the usefulness of the above mentioned sedentary behaviour questionnaire in the undergraduate population. Benefits to participating in the study include a break-down of your activity over the week of participation and detailed numbers on your level of sedentary behaviour. You can use this data to improve your health.

Feedback from the Study:
If you wish to receive the results from this study, please send an e-mail to Marc Moulin at [redacted]

If you have any questions and/or require further information about participating in this study, you are welcome to contact Marc Moulin [redacted] or Dr. Jennifer D. Irwin [redacted] If you have any questions about your rights as a research participant, please contact Western's Office of Human Research Ethics at [redacted].

Consent Form

Project Title
The Agreement Between ActivPAL-Assessed and Self-Reported Sedentary Time in Full-Time Undergraduate Students
To be completed by the participant (giving consent):
By signing this form, I confirm that I have read the letter of information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

_____ _____
Signature Date

_____
Printed Name
To be completed by the co-investigator (obtaining consent):

By signing this form, I confirm that I have read the letter of information, have explained the nature of the study to the participant, and the participant is participating voluntarily.

_____ _____
Signature Date

_____
Printed Name

Appendix H

Demographic Information – Study 1

Demographic Information

This section contains questions about your background and personal information. Please select the most appropriate answer relevant for you, personally, for each response.

1. Sex:
☐Male
☐Female
☐Prefer not to disclose
☐ You don't have an option that applies to me. I identify as (please specify)_____.

2. Age:
☐19 years and under
☐20-24 years
☐25-29 years
☐30-34 years
☐35 years and older

3. Ethnicity:
☐Aboriginal
☐Hispanic
☐African Heritage
☐Middle Eastern
☐Caucasian
☐South Asian
☐East Asian
☐Other, please specify: _____

4. Current student's enrolment status at Western University:
☐Part-time
☐Full-time

5. Program of registration:
☐Faculty of Arts and Humanities
☐Faculty of Law
☐Faculty of Education
☐Faculty of Music
☐Faculty of Engineering
☐Faculty of Science
☐Faculty of Health Sciences
☐Faculty of Social Science
☐Faculty of Information and Media Studies
☐Other, please specify: _____

6. Year of academic enrollment:
☐First
☐Second
☐Third
☐Fourth
☐Fifth
☐Other, please specify: _____

7. Employment status:
☐Not employed
☐Part-time
☐Full-time

Appendix I

ActivPAL4™ Log Sheet – Study 1

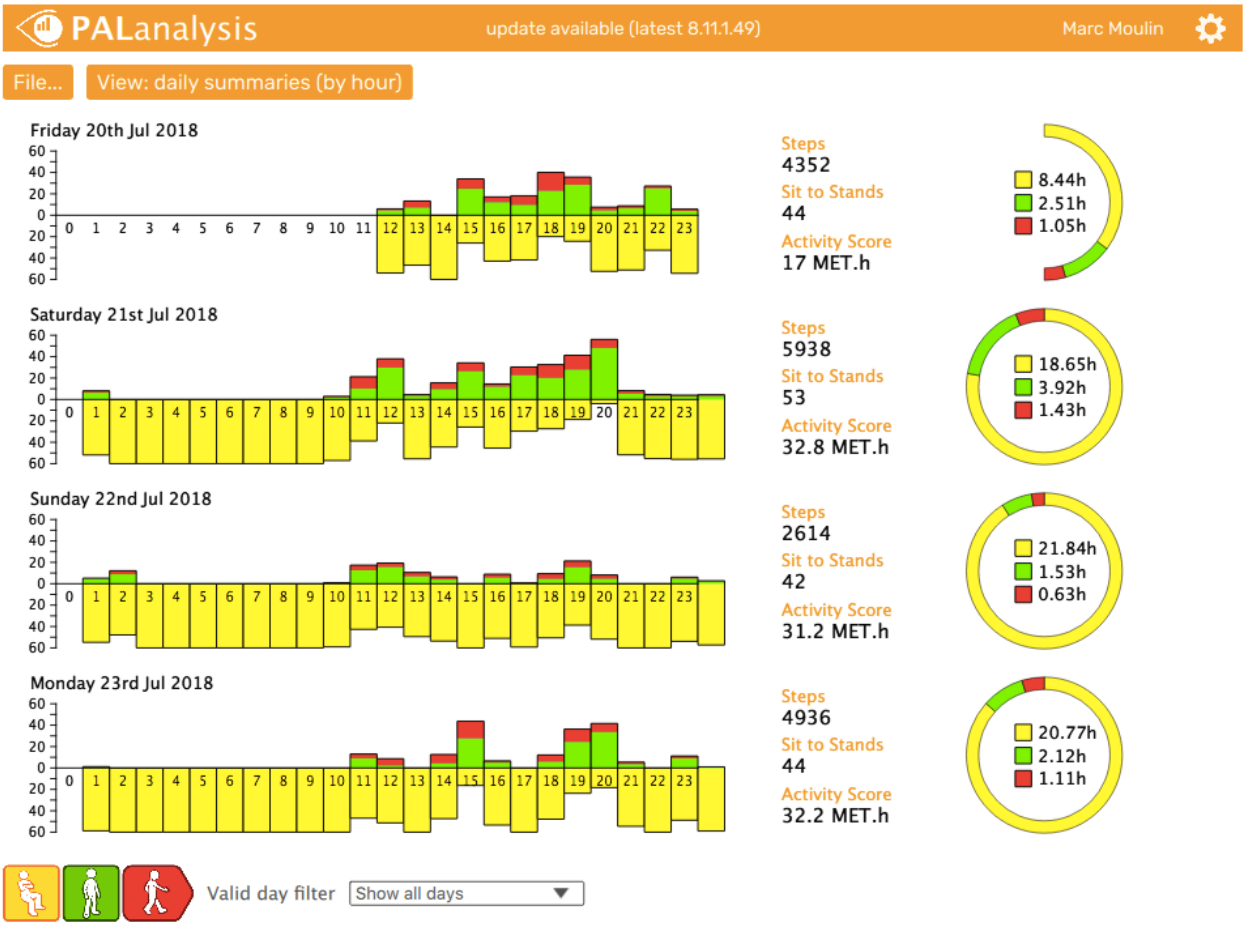
ActivPAL4™ Log Sheet

This log sheet will help us identify any periods of inactivity that do not relate to your sedentary behaviour but were caused by brief periods of the device not being attached to your thigh. Please fill out the date, wake and bed times, whether you removed the monitor from your leg for longer than 10 minutes, and how long the device was removed for. Thank you.

Day and Date	Time Woke Up	Time Out of Bed	Did You Remove Your Monitor for >10 mins Today?	Time off	Time into Bed	Time Went to Sleep	Comments?
Day 1 11/02/17	8:00am	8:15am	Yes	12:45pm to 1:00pm	10:30 pm	11:00pm	Slight irritation on right leg, switched to left leg
Day 1 Date:							
Day 2 Date:							
Day 3 Date:							
Day 4 Date:							
Day 5 Date:							
Day 6 Date:							
Day 7 Date:							

Appendix J

Example ActivPAL4™ Software Analysis



Appendix K

NIGHTLY-WEEK-U Sedentary Time Questionnaire

Participant ID:

Today's date: Today's day:

Please complete this log sheet daily for the next 7 days. Please complete each daily log at the end of the day, as close to you falling asleep, or 12AM midnight as possible (whichever event comes first). Do not complete domains as they happen throughout the day, as this may cause you to miss activities that occur later in the day. Please note that this does not include sleep, either in bed or if you fell asleep while doing another activity, for example watching TV.

You will be asked about when you may have been sitting or lying down in the following domains listed below. For each of these, only count the time this was your main activity. **Refer to the following instructions on how to properly account for sitting/lying time each day.**

Studying: include the time at university, during lectures, tutorials, meetings, group discussions, self-study, study from home, etc.)

Work: paid position only. Examples: babysitting, sitting at the reception, minding a stall/shop, data entry/administrative paper work, tutoring, etc.

Transport: travelling from one place to another. Please **include sitting and waiting** for transport. Do **not** include any time you were standing up while travelling or waiting.

Television Viewing: watching TV or DVDs or playing games on the TV, such as PlayStation/Xbox. This includes if you watch TV in bed. Do not include watching TV that occurred on your computer, such as YouTube.

Computer, Internet, Electronic Games: include time spent playing games on you Iphone/Ipad/tablet, using the internet or activities that **were not for studying or working purposes**, like Facebook, Twitter, Skype, YouTube, online-shopping, etc.

Sitting for Leisurely Reading: Include reading in bed but do not include time spent reading for paid work or for study.

Sitting for Eating: Include eating and drinking, meals and snack breaks. If you went out to eat with friends, consider this sitting for socializing and not sitting for eating.

Sitting for Socializing: Include time with friends and family. Include time on the telephone. Do not overlap with other domains such as eating. If you went out to eat with friends, considering this socializing time and not eating time.

Sitting/Lying for Other Purposes: Any sitting/lying time that has not been accounted for in the previously listed domains. It may include hobbies, listening to music, or for religious purposes.

MONDAY

Sitting for study
How long were you **sitting** while studying on **MONDAY**?
[ ][ ] hours [ ][ ] minutes

Sitting for work
How long were you **sitting** at your workplace or working from home on **MONDAY**?
[ ][ ] hours [ ][ ] minutes

Sitting for Transport
How long were you **sitting** for transport on **MONDAY?**
[ ][ ] hours [ ][ ] minutes

Television Viewing
How long were you **sitting or lying down** to watch TV on **MONDAY**?
[ ][ ] hours [ ][ ] minutes

Computer, Internet, Electronic Games
How long were you **sitting or lying** down while using the computer on **MONDAY**?
[ ][ ] hours [ ][ ] minutes

Sitting for reading
How long were you sitting or **lying down** while reading during your leisure time on **MONDAY**?
[ ][ ] hours [ ][ ] minutes

Sitting for eating
How long were you **sitting down** while eating and drinking on **MONDAY**?
[ ][ ] hours [ ][ ] minutes

Sitting for socializing
How long were you **sitting or lying down** to socialize with family and friends on **MONDAY**?
[ ][ ] hours [ ][ ] minutes

Sitting/lying for other purposes
How long were you **sitting or lying down** in other pursuits **NOT** including the time that you have already logged above on **MONDAY**?
[ ][ ] hours [ ][ ] minutes

Please take a moment to add up your total sitting time for **MONDAY**. Considering how many hours you were awake for on **MONDAY**, does this amount of sitting make sense? If not, please make changes to reflect your true sitting time.

TUESDAY

Sitting for study
How long were you **sitting** while studying on **TUESDAY**?
| | | hours | | | minutes |

Sitting for work
How long were you **sitting** at your workplace or working from home on **TUESDAY**?
| | | hours | | | minutes |

Sitting for Transport
How long were you **sitting** for transport on **TUESDAY?**
| | | hours | | | minutes |

Television Viewing
How long were you **sitting or lying down** to watch TV on **TUESDAY**?
| | | hours | | | minutes |

Computer, Internet, Electronic Games
How long were you **sitting or lying** down while using the computer on **TUESDAY**?
| | | hours | | | minutes |

Sitting for reading
How long were you sitting or **lying down** while reading during your leisure time on **TUESDAY**?
| | | hours | | | minutes |

Sitting for eating
How long were you **sitting down** while eating and drinking on **TUESDAY**?
| | | hours | | | minutes |

Sitting for socializing
How long were you **sitting or lying down** to socialize with family and friends on **TUESDAY**?
| | | hours | | | minutes |

Sitting/lying for other purposes
How long were you **sitting or lying down** in other pursuits **NOT** including the time that you have already logged above on **TUESDAY**?

		hours			minutes

Please take a moment to add up your total sitting time for **TUESDAY**. Considering how many hours you were awake for on **TUESDAY**, does this amount of sitting make sense? If not, please make changes to reflect your true sitting time.

WEDNESDAY

Sitting for study

How long were you **sitting** while studying on **WEDNESDAY**?

		hours			minutes

Sitting for work

How long were you **sitting** at your workplace or working from home on **WEDNESDAY**?

		hours			minutes

Sitting for Transport

How long were you **sitting** for transport on **WEDNESDAY?**

		hours			minutes

Television Viewing

How long were you **sitting or lying down** to watch TV on **WEDNESDAY**?

		hours			minutes

Computer, Internet, Electronic Games

How long were you **sitting or lying** down while using the computer on **WEDNESDAY**?

		hours			minutes

Sitting for reading

How long were you sitting or **lying down** while reading during your leisure time on **WEDNESDAY**?

		hours			minutes

Sitting for eating

How long were you **sitting down** while eating and drinking on **WEDNESDAY**?

		hours			minutes

Sitting for socializing

How long were you **sitting or lying down** to socialize with family and friends on **WEDNESDAY**?

		hours			minutes

Sitting/lying for other purposes

How long were you **sitting or lying down** in other pursuits **NOT** including the time that you have already logged above on **WEDNESDAY**?

		hours			minutes

Please take a moment to add up your total sitting time for **WEDNESDAY**. Considering how many hours you were awake for on **WEDNESDAY**, does this amount of sitting make sense? If not, please make changes to reflect your true sitting time.

THURSDAY

Sitting for study

How long were you **sitting** while studying on **THURSDAY**?

		hours			minutes

Sitting for work

How long were you **sitting** at your workplace or working from home on **THURSDAY**?

		hours			minutes

Sitting for Transport

How long were you **sitting** for transport on **THURSDAY?**

		hours			minutes

Television Viewing

How long were you **sitting or lying down** to watch TV on **THURSDAY**?

		hours			minutes

Computer, Internet, Electronic Games

How long were you **sitting or lying** down while using the computer on **THURSDAY**?

		hours			minutes

Sitting for reading

How long were you sitting or **lying down** while reading during your leisure time on **THURSDAY**?

		hours			minutes

Sitting for eating

How long were you **sitting down** while eating and drinking on **THURSDAY**?

		hours			minutes

Sitting for socializing

How long were you **sitting or lying down** to socialize with family and friends on **THURSDAY**?

		hours			minutes

Sitting/lying for other purposes

How long were you **sitting or lying down** in other pursuits **NOT** including the time that you have already logged above on **THURSDAY**?

		hours			minutes

Please take a moment to add up your total sitting time for **THURSDAY**. Considering how many hours you were awake for on **THURSDAY**, does this amount of sitting make sense? If not, please make changes to reflect your true sitting time.

FRIDAY

Sitting for study

How long were you **sitting** while studying on **FRIDAY**?

		hours			minutes

Sitting for work

How long were you **sitting** at your workplace or working from home on **FRIDAY**?

		hours			minutes

Sitting for Transport

How long were you **sitting** for transport on **FRIDAY?**

		hours			minutes

Television Viewing

How long were you **sitting or lying down** to watch TV on **FRIDAY**?

		hours			minutes

Computer, Internet, Electronic Games

How long were you **sitting or lying** down while using the computer on **FRIDAY**?

		hours			minutes

Sitting for reading

How long were you sitting or **lying down** while reading during your leisure time on **FRIDAY**?

		hours			minutes

Sitting for eating

How long were you **sitting down** while eating and drinking on **FRIDAY**?

		hours			minutes

Sitting for socializing

How long were you **sitting or lying down** to socialize with family and friends on **FRIDAY**?

		hours			minutes

Sitting/lying for other purposes

How long were you **sitting or lying down** in other pursuits **NOT** including the time that you have already logged above on **FRIDAY**?

		hours			minutes

Please take a moment to add up your total sitting time for **FRIDAY**. Considering how many hours you were awake for on **FRIDAY**, does this amount of sitting make sense? If not, please make changes to reflect your true sitting time.

SATURDAY

Sitting for study

How long were you **sitting** while studying on **SATURDAY**?

		hours			minutes

Sitting for work

How long were you **sitting** at your workplace or working from home on **SATURDAY**?

		hours			minutes

Sitting for Transport

How long were you **sitting** for transport on **SATURDAY?**

		hours			minutes

Television Viewing

How long were you **sitting or lying down** to watch TV on **SATURDAY**?

		hours			minutes

Computer, Internet, Electronic Games

How long were you **sitting or lying** down while using the computer on **SATURDAY**?

		hours			minutes

Sitting for reading

How long were you sitting or **lying down** while reading during your leisure time on **SATURDAY**?

		hours			minutes

Sitting for eating

How long were you **sitting down** while eating and drinking on **SATURDAY**?

		hours			minutes

Sitting for socializing

How long were you **sitting or lying down** to socialize with family and friends on **SATURDAY**?

		hours			minutes

Sitting/lying for other purposes

How long were you **sitting or lying down** in other pursuits **NOT** including the time that you have already logged above on **SATURDAY**?

		hours			minutes

Please take a moment to add up your total sitting time for **SATURDAY**. Considering how many hours you were awake for on **SATURDAY**, does this amount of sitting make sense? If not, please make changes to reflect your true sitting time.

SUNDAY

Sitting for study

How long were you **sitting** while studying on **SUNDAY**?

		hours			minutes

Sitting for work

How long were you **sitting** at your workplace or working from home on **SUNDAY**?

		hours			minutes

Sitting for Transport

How long were you **sitting** for transport on **SUNDAY?**

		hours			minutes

Television Viewing

How long were you **sitting or lying down** to watch TV on **SUNDAY**?

		hours			minutes

Computer, Internet, Electronic Games

How long were you **sitting or lying** down while using the computer on **SUNDAY**?

		hours			minutes

Sitting for reading

How long were you sitting or **lying down** while reading during your leisure time on **SUNDAY**?

		hours			minutes

Sitting for eating

How long were you **sitting down** while eating and drinking on **SUNDAY**?

		hours			minutes

Sitting for socializing

How long were you **sitting or lying down** to socialize with family and friends on **SUNDAY**?

		hours			minutes

Sitting/lying for other purposes

How long were you **sitting or lying down** in other pursuits **NOT** including the time that you have already logged above on **SUNDAY**?

		hours			minutes

Please take a moment to add up your total sitting time for **SUNDAY**. Considering how many hours you were awake for on **SUNDAY**, does this amount of sitting make sense? If not, please make changes to reflect your true sitting time.

Appendix L

Ethics Approval – Study 2 and 3

Western Research

Date: 14 August 2018

To: Dr. Jennifer Irwin

Project ID: 112232

Study Title: The Impact of a Mobile Sit-Stand Desk on Undergraduate Students' Sedentary Time

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: 07/Sep/2018

Date Approval Issued: 13/Aug/2018 16:39 14/Aug/2018 15:56

REB Approval Expiry Date: 13/Aug/2019

Dear Dr. Jennifer Irwin

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
CLEAN - ActivPAL4TM Log Sheet Study 2	Other Data Collection Instruments	13/Aug/2018	2
CLEAN - Consent (Aug. 13)	Written Consent/Assent	13/Aug/2018	3
CLEAN - In class verbal recruitment script PhD Study 2 (Aug. 13)	Oral Script	13/Aug/2018	3
CLEAN - Invitation Email to Course Instructors PhD Study 2 (Aug. 13)	Recruitment Materials	13/Aug/2018	3
Demographic Information Study 2	Screening Form/Questionnaire	08/Feb/2018	1
PAST-U daily log sheet short	Paper Survey	13/Aug/2018	1
Semi Structured Interview Guide Study 2	Interview Guide	10/Jul/2018	1
The activPAL4TM	Other Data Collection Instruments		

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 0000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Katelyn Harris, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix M

Letter of Information and Consent – Study 2 and 3

Western UNIVERSITY · CANADA

The Impact of a Mobile Sit-Stand Desk on Undergraduate Sedentary Time

Investigators:
Jennifer D. Irwin, PhD, Faculty of Health Sciences, Western University
Marc Moulin, MSc, Faculty of Health Sciences, Western University
Trish Tucker, PhD, Faculty of Health Sciences, Western University
Harry Prapavessis, PhD, Faculty of Health Sciences, Western University

You are invited to participate in this research study because you are a full-time, undergraduate student enrolled in the School of Kinesiology or School of Health Studies at Western University, and are physically capable of using a sit-stand desk.

Study Procedure:
Your participation in this study will last for two weeks. Over the course of the two weeks, you will meet with the co-investigator and a research assistant three times, with the first 2 meetings lasting approximately 15-20 minutes and the third meeting lasting approximately 30-45 minutes.

- At the first meeting (Day 1 of the study), you will complete a demographic questionnaire, receive an ActivPAL4 Log Sheet, receive a week long sedentary time daily log, and be fitted with an ActivPAL4 activity monitor. The ActivPAL4 is a virtually weightless device that will track your sitting, standing, and ambulatory activity and is waterproofed to allow you to participate in water related activities without removing the device. You will be verbally instructed on how to properly attach the ActivPAL4 monitor to your thigh using hypoallergenic, latex-free 3M Tegaderm Film Dressing. The ActivPAL4 Log Sheet will track your sleep and wake up times, as well as any time that the device is removed from your leg for more than 10 minutes. The Log Sheet should be completed daily for the entire week. You will wear the ActivPAL4 device for 24 hours a day for the next 7 days only removing the device to switch it to your other leg, or due to skin irritation. If skin irritation persists, please contact the co-investigator. The sedentary time log tracks your sedentary time across multiple domains each day, for the entire week. The sedentary time log should be completed on a daily basis, at the end of the day, as close to you going to sleep, or as close to 12AM midnight as possible (whichever event comes first).

- At the second meeting (Day 8 of the study), you will meet with the co-investigator and a research assistant, remove the device from your thigh, and return your week one sedentary time log and ActivPAL4 Log sheet. The co-investigator will further waterproof the device and wrap it in a fresh film dressing. You will attach the device to the leg of your choice and again be instructed to wear the device 24 hours a day for the next 7 days, only removing the device to switch legs. You will receive a new week two sedentary time log and a new week two ActivPAL4 log sheet that should both be completed daily in a similar fashion as you did in week one. At the second meeting, you will also receive a mobile sit-stand desk to use at your own discretion, in any environment you choose for the next week. The mobile sit-stand desk is just over four pounds and can be easily carried from location to location. A sedentary lifestyle with long periods of uninterrupted sitting has been linked to obesity, hypertension, diabetes, cancers, and an increased risk of overall hospitalization. We encourage you to stand with the desk for as long as you are comfortable doing so. The co-investigator will demonstrate how to use the sit-stand desk properly at the end of the second meeting.
- At the third and final meeting (immediately following the completion of Day 14), you will meet with the co-investigator and a research assistant and return the ActivPAL4 device, the week two ActivPAL4 Log Sheet, the week two sedentary time log, and the sit-stand desk. Finally, you will participate in a short interview with the co-investigator detailing your overall experiences using the sit-stand desk. Shortly following this final meeting, a detailed breakdown of your activity over the past two weeks will be emailed to you illustrating your levels of sedentary behaviour and physical activity. For your participation, you will be entered into a draw to win one of two $50 Visa Gift Cards.

Inclusion and exclusion criteria:
In order for you to participate in this study, you must be a full-time Western University undergraduate student enrolled in the School of Kinesiology or the School of Health Studies, who is fluent in English, and be physically capable of standing. You will not be able to participate if you are: (a) a Western University undergraduate student who is not a full-time student; (b) a Western University undergraduate student who is not fluent in English; (c) a faculty member, staff, graduate, or postdoctoral student who is not currently enrolled in an undergraduate program at Western University; or (d) physically incapable of standing.

Voluntary Participation:
Participation in this study is voluntary. You may withdraw from the study at anytime without any penalty. Your participation in this study will have no impact on evaluations of you of any kind, academically or otherwise. If you choose to participate, you are able to leave any question unanswered, should you choose to do so, and still complete the remainder of the sedentary time log. If you wish to withdrawal your data from the study, please contact the co-investigator at [redacted]. There are no limitations in doing so.

If You Decide to Participate:

If you decide to participate in this study, you will be asked to fill out the consent form that has been provided with this Letter of Information. By signing this consent form, you are consenting to all aspects of the study which include: 1) wearing an activPAL4^{TM} activity monitor for 14 days and 2) tracking your sedentary time, and sleep and wake times for 14 days, and 3) participating in a short, audio recorded interview. All information collected is confidential.

Confidentiality:
The anonymous information gathered in this study will only be used for publishing or presentations purposes. Each participant will be given an ID Number and all data will be linked to that ID Number. Any identifiable information (name/contact information) will only be accessible to the investigators. No names or contact information will be directly linked to participant data. Personal data collected from this study will only be accessible by the investigators and will be safeguarded on encrypted, password protected devices, which will be destroyed after 7 years. The anonymous data may be shared in an open access repository for publication purposes. An open access repository allows the anonymous data to be published in a scientific journal and be shared freely to those who wish to access it. Representatives of The University of Western Ontario's Non-Medical Research Ethics Board may require access to your study related records to monitor the conduct of the research. You do not waive any legal right by consenting to this study.

Cost and Compensation:
There is no cost to participate in this study. With participation, you will be eligible to win one of two $50 Visa Gift Cards. The draw will consist of a maximum of 30 participants.

Risks & Benefits:
There are very minor risks associated with participating in this study. It is possible to experience some very minor skin irritation at the site of the monitor attachment but this is very uncommon. The irritation can be subsided by changing the monitor to the other leg. If skin irritation persists, contact Marc Moulin [redacted] to inform him of the problem and then a medical professional. Your participation in this study will provide researchers with valuable information about the effectiveness of sit-stand desks in the undergraduate population to reduce overall sedentary time. Benefits to participating in the study include a break-down of your activity over the week of participation and detailed numbers on your level of sedentary behaviour. Data provided to you can be used to improve your health. It is important to understand the activity patterns of young adults as they enter into adult life stages and solidify behaviour that they might have for the rest of their lives. This study could lead to the development of larger and longer-term interventions to reduce undergraduate sedentary time. If undergraduate students can get used to standing while engaged in academic-related work, it may set them up to stand more once they enter the traditionally sedentary workplace, and therefore improve their health and reduce negative impacts on the healthcare system.

Feedback from the Study:
If you wish to receive the results from this study, please send an e-mail to Marc Moulin at [redacted].

If you have any questions and/or require further information about participating in this study, you are welcome to contact Marc Moulin [redacted] or Dr. Jennifer D. Irwin [redacted] If you have any questions about your rights as a research participant, please contact Western's Office of Human Research Ethics at [redacted]

This letter is yours to keep for future reference.

Consent Form

Project Title:
The Impact of a Mobile Sit-Stand Desk on Undergraduate Sedentary Time

To be completed by the participant (giving consent):

By signing this form, I confirm that I have read the letter of information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

_____ _____
Signature Date

_____
Printed Name

☐ I consent to having my interview audio-recorded and my statements transcribed into direct unidentifiable quotations to be used for publication purposes.

☐ I DO NOT consent to having my interview audio-recorded and my statements transcribed into direct unidentifiable quotations to be used for publication purposes.

To be completed by the co-investigator (obtaining consent):

By signing this form, I confirm that I have read the letter of information, have explained the nature of the study to the participant, and the participant is participating voluntarily.

_____ _____
Signature Date

_____
Printed Name

Appendix N

Invitation to Course Instructors – Study 2 and 3

Subject Line: The Impact of a Mobile Sit-Stand Desk on Undergraduate Sedentary Time – An FHS Study

Hello Professor,

I am writing to request your assistance for my PhD project involving the sedentary behaviour of undergraduate students. I am wondering if I could make a very brief announcement during your undergraduate class(es) (insert class(es) name and number here) at a time that is convenient for you. The Office of Human Research Ethics requires that professors leave the classroom while this in-class announcement takes place. Below is the formal recruitment message that I will present to your students if this requirement is acceptable to you.

Researchers from the Faculty of Health Sciences are conducting a study to assess the impact of mobile sit-stand desks on the sedentary time of undergraduate students. In this study, participation will last for two weeks. Over the course of the two weeks, participants will meet with the co-investigator and a research assistant three times, with the first 2 meetings lasting approximately 15-20 minutes and the third meeting lasting approximately 30-45 minutes. At the first meeting (Day 1 of the study), participants will complete a demographic questionnaire, receive an ActivPAL4 Log Sheet, receive a week long sedentary time daily log, and be fitted with an ActivPAL4 activity monitor. The ActivPAL4 is a virtually weightless device that tracks sitting, standing, and ambulatory activity and is waterproofed to allow participants to engage in water related activities without removing the device. Participants will be verbally instructed on how to properly attach the ActivPAL4 monitor to their thigh using hypoallergenic, latex-free 3M Tegaderm Film Dressing. The ActivPAL4 Log Sheet will track sleep and wake up times, as well as any time that the device is removed from a participant's leg for more than 10 minutes. The Log Sheet should be completed daily for the first week. Participants will wear the ActivPAL4 device for 24 hours a day for the next 7 days only removing the device to switch it to their other leg, or due to skin irritation. If skin irritation persists, participants will be instructed to contact the co-investigator. The sedentary time log should be completed daily, as close to falling asleep, or 12AM midnight, as possible (whichever event comes first). At the second meeting (Day 8 of the study), participants will meet with the co-investigator and a research assistant, remove the device from their thigh, and return their Week 1 ActivPAL4 Log Sheet and Week 1 sedentary time log . The co-investigator will further waterproof the device and wrap it in a fresh film dressing. The participants will attach the device to the leg of their choice and again be instructed to wear the device 24 hours a day for the next 7 days, only removing the device to switch legs. Participants will receive a Week 2 ActivPAL4 Log Sheet and Week 2 sedentary time log and will be instructed to complete both in a similar fashion to Week 1. At the second meeting, participants will also receive a mobile sit-stand desk (3MT Standing Desk Top Extender, T-Zone Vibration) to use at their own discretion, in any environment they

choose for the next week. The mobile sit-stand desk is just over four pounds and can be easily carried from location to location. The co-investigator will demonstrate how the sit-stand desk works at the end of the second meeting. At the third and final meeting (immediately following the completion of Day 14), participants will meet with the co-investigator and a research assistant and return the ActivPAL4 device, the Week 2 Log Sheet, the Week 2 sedentary time log, and the sit-stand desk. Finally, participants will participate in a short interview with the co-investigator detailing their overall experiences using the sit-stand desk. Interview questions will focus on ease of use, enjoyment, motivations, facilitators and barriers to using the desk etc. Shortly following this final meeting, a detailed breakdown of the participant's activity over the past two weeks will be emailed to them illustrating their levels of sedentary behaviour and physical activity. For their participation, they will be entered into a draw to win one of two $50 Visa Gift Cards. Participation is completely voluntary and withdrawal from the study is allowed at any time.

Thank you for considering our request. We would be happy to share the results with you after the study is completed. If you have any further questions and/or require further information about this study, you are welcome to contact Marc Moulin at [redacted] or Dr. Jennifer Irwin at [redacted]

Best regards,

Marc Moulin, MSc., PhD Candidate in Health and Rehabilitation Sciences

Appendix O

Demographic Information – Study 2 and 3

Demographic Information

This section contains questions about your background and personal information. Please select the most appropriate answer relevant for you, personally, for each response.

1. Sex:
☐Male
☐Female
☐Prefer not to disclose
☐ You don't have an option that applies to me. I identify as (please specify)_____.

2. Age:
☐19 years and under
☐20-24 years
☐25-29 years
☐30-34 years
☐35 years and older

3. Ethnicity:
☐Aboriginal
☐Hispanic
☐African Heritage
☐Middle Eastern
☐Caucasian
☐South Asian
☐East Asian
☐Other, please specify: _____

4. Current enrolment status at Western University:
☐Part-time
☐Full-time

5. Program of registration:
☐Faculty of Arts and Humanities
☐Faculty of Law
☐Faculty of Education
☐Faculty of Music
☐Faculty of Engineering
☐Faculty of Science
☐Faculty of Health Sciences
☐Faculty of Social Science
☐Faculty of Information and Media Studies
☐Other, please specify: _____

6. Year of academic enrollment:
☐First
☐Second
☐Third
☐Fourth
☐Fifth
☐Other, please specify: _____

7. Employment status:
☐Not employed
☐Part-time
☐Full-time

Appendix P

In-Class Announcement Verbal Script – Study 2 and 3

In class verbal recruitment script

"Hello Western Health Sci,

My name is Marc Moulin and not too long ago I was right where you are today. I am now working on completing my PhD under the supervision of Dr. Jennifer Irwin and we are hoping that you may be interested in taking part in our current study. The purpose of the study is to determine the effect of providing undergraduate students with a mobile sit-stand desk on their overall sedentary time.

Your participation in this study will last for two weeks. Over the course of the two weeks, you will meet with the co-investigator and a research assistant three times, with the first 2 meetings lasting approximately 15-20 minutes and the third meeting last approximately 30-45 minutes. At the first meeting (Day 1 of the study), you will complete a demographic questionnaire, receive an ActivPAL4 Log Sheet, receive a week long sedentary time log, and be fitted with an ActivPAL4 activity monitor. The ActivPAL4 is a virtually weightless device that will track your sitting, standing, and ambulatory activity and is waterproofed to allow you to participate in water related activities without removing the device. You will be verbally instructed on how to properly attach the ActivPAL4 monitor to your thigh using hypoallergenic, latex-free 3M Tegaderm Film Dressing. The ActivPAL4 Log Sheet will track your sleep and wake up times, as well as any time that the device is removed from your leg for more than 10 minutes. The Log Sheet should be completed daily for the first week. You will wear the ActivPAL device for 24 hours a day for the next 7 days only removing the device to switch it to your other leg, or due to skin irritation. If skin irritation persists, please contact the co-investigator. The sedentary time log should be completed daily, as close to you going to sleep, or 12AM midnight, as possible (whichever event comes first). At the second meeting (Day 8 of the study), you will meet with the co-investigator and a research assistant, remove the device from your thigh, and return your Week 1 ActivPAL4 Log Sheet and Week 1 sedentary time log. The co-investigator will further waterproof the device and wrap it in a fresh film dressing. You will attach the device to the leg of your choice and again be instructed to wear the device 24 hours a day for the next 7 days, only removing the device to switch legs. You will be given a Week 2 ActivPAL4 Log Sheet and a Week 2 sedentary time log and will be instructed to complete both in a similar fashion to Week 1. At the second meeting, you will also receive a mobile sit-stand desk to use at your own discretion, in any environment you choose for the next week. The mobile sit-stand desk is just over four pounds and can be easily carried from location to location. A sedentary lifestyle with long periods of uninterrupted sitting has been linked to obesity, hypertension, diabetes, cancers, and an increased risk of overall hospitalization. We encourage you to stand with the desk for as long as you are comfortable doing so. The co-investigator will demonstrate how to use the sit-stand desk properly at the end of the second meeting. At the third and final meeting (immediately following the completion of

Day 14), you will meet with the co-investigator and a research assistant and return the ActivPAL4 device, the Week 2 ActivPAL4 Log Sheet, the Week 2 sedentary time log, and the sit-stand desk. Finally, you will participate in a short interview with the co-investigator detailing your overall experiences using the sit-stand desk. Shortly following this final meeting, a detailed breakdown of your activity over the past two weeks will be emailed to you illustrating your levels of sedentary behaviour and physical activity. For your participation, you will be entered into a draw to win one of two $50 Visa Gift Cards. Your participation is completely voluntary will have no impact on your academic status, and you are free to withdraw from the study at any time.

Thank you for considering our request! We would be happy to share the results with you after the study is completed. If you would like to learn more or are interested in participating you are welcome to contact me at [redacted]

Appendix Q

ActivPAL4 Log Sheet – Study 2 and 3

ActivPAL4™ Log Sheet

This log sheet will help us identify any periods of inactivity that do not relate to your sedentary behaviour but were caused by brief periods of the device not being attached to your thigh. Please fill out the date, wake and bed times, whether you removed the monitor from your leg for longer than 10 minutes, and how long the device was removed for. Thank you.

Day and Date	Time Woke Up	Time Out of Bed	Did You Remove Your Monitor for >10 mins Today?	Time off	Time into Bed	Time Went to Sleep	Comments?
Day 1 11/02/17	8:00am	8:15am	Yes	12:45pm to 1:00pm	10:30 pm	11:00pm	Slight irritation on right leg, switched to left leg
Day 1							
Day 2							
Day 3							
Day 4							
Day 5							
Day 6							
Day 7							
Day 8							

Appendix R

Ethics Approval – Study 4

Western Research

Date: 13 February 2019

To: Dr. Jennifer Irwin

Project ID: 112737

Study Title: The impact of having a sit-stand desk for one month on undergraduate students' sedentary time

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: March 1 2019

Date Approval Issued: 13/Feb/2019

REB Approval Expiry Date: 13/Feb/2020

Dear Dr. Jennifer Irwin

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Email Script Containing Link to Demographic Questionnaire2 CLEAN	Recruitment Materials	30/Jan/2019	2
Email Script to Welcome Participants to the Study2 CLEAN	Recruitment Materials	30/Jan/2019	2
FaceBook Website Ad Study 3	Recruitment Materials	18/Dec/2018	1
Final Qualitative Questions Study 3	Online Survey	18/Dec/2018	1
Invitation Email to Course Instructors PhD Study 3	Recruitment Materials	18/Dec/2018	1
PAST-U daily log sheet long	Online Survey	12/Dec/2018	1
Study 3 LOI and Consent2 CLEAN	Implied Consent/Assent	30/Jan/2019	3
Verbal Recruitment Script PhD Study 3 CLEAN	Oral Script	16/Jan/2019	2

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
Demographic Information Study 2(1)	Screening Form/Questionnaire	18/Dec/2018	1

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Appendix S

T-Zone Vibration 4MT Standing Desk Top Extender

Appendix T

Semi-Structured Interview Guide – Study 3

Semi Structured Interview Guide

Topic Areas to Cover

- Facilitators to using the sit-stand desk
- Barriers to using the sit-stand desk
- Positives to using the sit-stand desk
- Negatives to using the sit-stand desk
- Overall level of enjoyment throughout the study
- Improvements to the sit-stand desks

Questions

- What aspects of your 'study' environment made using the desk easy, including on campus and off campus?
- What aspects of the 'study' environment made using the desk difficult, including on campus and off campus?
- What did you enjoy about using the desk over the past week?
- What did you not enjoy about using the desk over the past week?
- Where and when did you use the desk most often?
- What impact did the desk have on your sedentary behaviour, if any?
- What made it easier to use the desk?
- What challenges did you have using the desk?
    - Probe: Where was it most awkward to use the desk and why?

- When and if you used the desk during class time, how did the professor and other students react to you using it?
- How often would you use the desk if it was available in all your undergraduate classes?
- What improvements would you make to the desk to make it better?
- What else should we know about your views on the stand-up desk as a tool for reducing students' sedentary time?

Appendix U

Invitation to Course Instructors – Study 4

Subject Line: The impact of having a sit-stand desk for one month on undergraduate students' sedentary time– An FHS Study

Hello Professor,

I am writing to request your assistance for my PhD project involving the sedentary behaviour of undergraduate students. I am wondering if I could make a very brief announcement during your undergraduate class(es) at a time that is convenient for you. Below is the formal recruitment message that I will present to your students if this requirement is acceptable to you.

Researchers from the Faculty of Health Sciences are conducting a study to assess the impact of providing undergraduate students with a sit-stand desk over the course of an entire month. Your participation in this study will last for five weeks. In the first week of the study you will be reporting your baseline levels of sedentary time and behaviours, and for the following four weeks you will be given a mobile sit-stand desk to use in whatever environment you choose until the conclusion of the study. Your participation in this study can be further broken down into three parts:

1) In the first week of the study, researchers will collect your baseline sedentary time and behaviours across multiple domains including: Study, Work, Transportation, Meals, TV Time, Computer and Internet, Socializing, and Sitting/Lying for Other Purposes. This information will be collected by having you complete online daily logs that will be emailed to you in 7 links (one for each day of this first week) following your official enrollment in the study. Each daily log is to be completed at the end of each day, as close to you falling asleep, or 12AM midnight as possible (whichever event comes first) on each corresponding day of the week. Within this first week, you will also be scheduling a meeting with the co-investigator that will occur on Day 8 of the study to pick up and learn how to use a mobile sit-stand desk.

2) At the start of the second week of the study (Day 8), you will meet with the co-investigator at a time most convenient for your schedule. This meeting will last for approximately 10 minutes and will focus on teaching you how to properly use the mobile sit-stand desk. The co-investigator will answer any questions you may have and make sure you are comfortable with the desk before you leave the meeting. The desk is yours to use in whatever environment you choose for the next four weeks.

3) The start of week five (your final week with the desk), the co-investigator will email you 7 links (one for each day of this last week) to collect your daily sedentary time and behaviours in the same fashion as week 1 of the study. You will again complete each daily log at the end of the day, as close to you falling asleep, or 12AM midnight as possible (whichever event comes first). This email will also contain a link to interview

questions that should be completed at the end of this week. The questions asked will focus on your experiences with the sit-stand desk over the past month and cover a range of topics including ease of use, enjoyment, positives, negatives, improvements, etc. If requested, the co-investigator will share with you your total sedentary time and a breakdown of your sedentary behaviours for week 1 and week 5 of this study.

For your participation, you will be entered into a draw to win one of two 50$ Visa Gift Cards. Participation is completely voluntary and withdrawal from the study is allowed at any time.

Thank you for considering our request. We would be happy to share the results with you after the study is completed. If you have any further questions and/or require further information about this study, you are welcome to contact Marc Moulin at [redacted] or Dr. Jennifer Irwin at [redacted]

Best regards,

Marc Moulin, MSc., PhD Candidate in Health and Rehabilitation Sciences

Appendix V

Letter of Information and Consent – Study 4

The impact of having a sit-stand desk for one month on undergraduate students' sedentary time

Investigators:
Jennifer D. Irwin, PhD, Faculty of Health Sciences, Western University (Principal Investigator)
Marc Moulin, MSc, Faculty of Health Sciences, Western University (Co-Investigator)
Trish Tucker, PhD, Faculty of Health Sciences, Western University
Harry Prapavessis, PhD, Faculty of Health Sciences, Western University

You are invited to participate in this research study because you are a full-time, undergraduate student enrolled in the School of Health Studies or School of Kinesiology at Western University, and are physically capable of using a sit-stand desk.

Study Procedure:
Your participation in this study will last for five weeks. In the first week of the study you will be reporting your baseline levels of sedentary time and behaviours and for the following four weeks you will be given a mobile sit-stand desk to use in whatever environment you choose until the conclusion of the study. Your participation in this study can be further broken down into three parts:

1) In the first week of the study, researchers will collect your baseline sedentary time and behaviours across multiple domains including: Study, Work, Transportation, Meals, TV Time, Computer and Internet, Socializing, and Sitting/Lying for Other Purposes. This information will be collected by having you complete online daily logs that will be emailed to you in 7 links (one for each day of this first week) following your official enrollment in the study. Each daily log is to be completed at the end of each day, as close to you falling asleep or 12AM midnight as possible (whichever event comes first). Within this first week, you will also be scheduling a meeting with the co-investigator that will occur on Day 8 of the study to pick up and learn how to use a mobile sit-stand desk

2) At the start of the second week of the study (Day 8), you will meet with the co-investigator at a time most convenient for your schedule. This meeting will last for approximately 10 minutes and will focus on teaching you how to properly use the mobile

sit-stand desk. The co-investigator will answer any questions you may have and make sure you are comfortable with the desk before you leave the meeting. The desk is yours to use in whatever environment you choose for the next four weeks.

3) The start of week five (your final week with the desk), the co-investigator will email you 7 links (one for each day of this last week) to collect your daily sedentary time and behaviours in the same fashion as week 1 of the study. You will again complete each daily log at the end of the day, as close to you falling asleep or 12AM midnight as possible (whichever event comes first). This email will also contain a link to interview questions that should be completed at the end of this week. The questions asked will focus on your experiences with the sit-stand desk over the past month and cover a range of topics including ease of use, enjoyment, positives, negatives, improvements, etc. If requested, the co-investigator will share with you your total sedentary time and a breakdown of your sedentary behaviours for week 1 and week 5 of this study.

Inclusion and exclusion criteria:
In order for you to participate in this study, you must be a full-time Western University undergraduate student enrolled in the School of Health Studies or School of Kinesiology, who is fluent in English, and be physically capable of standing. You will not be able to participate if you are: (a) a Western University undergraduate student who is not a full-time student; (b) a Western University undergraduate student who is not fluent in English; (c) a faculty member, staff, graduate, or postdoctoral student who is not currently enrolled in an undergraduate program at Western University; or (d) physically incapable of standing.

Voluntary Participation:
Participation in this study is voluntary. You may withdraw from the study at anytime without any penalty. Your participation in this study will have no impact on evaluations of you of any kind, academically or otherwise. If you choose to participate, you are able to leave any question unanswered, should you choose to do so, and still complete the remainder of the sedentary time log. If you wish to withdrawal your data from the study, please contact the co-investigator at [redacted] There are no limitations in doing so.

If You Decide to Participate:
If you decide to participate in this study, you will be asked to complete the consent form that has been provided with this Letter of Information. By signing this consent form, you are consenting to all aspects of the study which include: 1) being enrolled in the study for a total of 5 weeks, 2) completing 7 daily logs tracking your sedentary time and behaviours over the first week, 3) using a mobile sit-stand desk in whatever environment you choose over one month, 4) completing 7 daily logs tracking your sedentary time and behaviours during the fifth week, and 5) answering concluding interview questions about your experiences with the sit-stand desk. All information collected is confidential.

Confidentiality:

The information gathered in this study will only be used for publishing or presentations purposes. Each participant will be given an ID Number and all data will be linked to that ID Number. Any identifiable information (name/contact information) will only be accessible to the investigators. The linking of names and contact information (email address) to participant data will only be accessible by the investigators. Personal data collected from this study will only be accessible by the investigators and will be safeguarded on encrypted, password protected devices, which will be destroyed after 7 years. The anonymous data may be shared in an open access repository for publication purposes. An open access repository allows the anonymous data to be published in a scientific journal and be shared freely to those who wish to access it. Representatives of The University of Western Ontario's Non-Medical Research Ethics Board may require access to your study related records to monitor the conduct of the research. You do not waive any legal right by consenting to this study.

Cost and Compensation:
There is no cost to participate in this study. With participation, you will be entered into a draw to win one of two 50$ Visa Gift Cards. The draw will consist of a maximum of 50 people.

Risks & Benefits:
There are no risks to participating in this study. You are welcome to use the sit-stand desk as much as you feel comfortable doing so. If at any point, you are feeling soreness in your feet, knees, back, shoulders, or neck, reduce how much standing you are engaging in. If you would like to withdrawal yourself and your data from this study at any time, contact Marc Moulin [redacted] Benefits to participating in the study include a break-down of your level of sedentary behaviour for week 1 and week 5 of this study. Data provided to you can be used to improve your health. It is important to understand the activity patterns of young adults as they enter into adult life stages and solidify behaviour that they might have for the rest of their lives. This study could lead to the development of larger and longer-term interventions to reduce undergraduate sedentary time. If undergraduate students can get used to standing while engaged in academic-related work, it may set them up to stand more once they enter the traditionally sedentary workplace, and therefore improve their health and reduce negative impacts on the healthcare system.

Feedback from the Study:
If you wish to receive the results from this study, please send an e-mail to Marc Moulin at [redacted]

If you have any questions and/or require further information about participating in this study, you are welcome to contact Marc Moulin [redacted] or Dr. Jennifer D. Irwin [redacted]. If you have any questions about your rights as a research participant, please contact Western's Office of Human Research Ethics at [redacted].

A copy of this letter can be emailed to you upon request. Please contact Marc Moulin [redacted] if you would like a copy emailed to you for your future reference.

Consent Form

Project Title:
The Long-Term Impact of a Mobile Sit-Stand Desk on Undergraduate Sedentary Time

To be completed by the participant (giving consent):

By completing this form (entering my name and the date), I confirm that I have read the letter of information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Name: _____

Date: _____

Email Address: _____

Appendix W

Demographic Information – Study 4

Demographic Information

This section contains questions about your background and personal information. Please select the most appropriate answer relevant for you, personally, for each response.

1. Sex:
☐Male
☐Female
☐Prefer not to disclose
☐ You don't have an option that applies to me. I identify as (please specify)_____.

2. Age:
☐19 years and under
☐20-24 years
☐25-29 years
☐30-34 years
☐35 years and older

3. Ethnicity:
☐Aboriginal
☐Hispanic
☐African Heritage
☐Middle Eastern
☐Caucasian
☐South Asian
☐East Asian
☐Other, please specify: _____

4. Current enrolment status at Western University:
☐Part-time Undergraduate
☐Full-time Undergraduate
☐Part-time Graduate
☐Full-time Graduate

5. Program of registration:
☐Faculty of Arts and Humanities
☐Faculty of Law
☐Faculty of Education
☐Faculty of Music
☐Faculty of Engineering
☐Faculty of Science
☐Faculty of Health Sciences
☐Faculty of Social Science
☐Faculty of Information and Media Studies
☐Other, please specify: _____

6. Year of academic enrollment:
☐First
☐Second
☐Third
☐Fourth
☐Fifth
☐Other, please specify: _____

7. Employment status:
☐Not employed
☐Part-time
☐Full-time

Appendix X

In-Class Announcement Verbal Script – Study 4

Verbal Recruitment Script PhD Study 3

"Hello (insert class number),

My name is Marc Moulin and I am a third year PhD student working with Dr. Jennifer Irwin. We are conducting a study to assess the impact of providing undergraduate students with a sit-stand desk over the course of an entire month. Your participation in this study will last for five weeks. In the first week of the study you will be reporting your baseline levels of sedentary time and behaviours, and for the following four weeks you will be given a mobile sit-stand desk to use in whatever environment you choose until the conclusion of the study. Your participation in this study can be further broken down into three parts:

1) In the first week of the study, researchers will collect your baseline sedentary time and behaviours across multiple domains including: Study, Work, Transportation, Meals, TV Time, Computer and Internet, Socializing, and Sitting/Lying for Other Purposes. This information will be collected by having you complete online daily logs that will be emailed to you in 7 links (one for each day of this first week) following your official enrollment in the study. Each daily log is to be completed at the end of each day, as close to you falling asleep, or 12AM midnight as possible (whichever event comes first) on each corresponding day of the week. Within this first week, you will also be scheduling a meeting with the co-investigator that will occur on Day 8 of the study to pick up and learn how to use a mobile sit-stand desk.

2) At the start of the second week of the study (Day 8), you will meet with the co-investigator at a time most convenient for your schedule. This meeting will last for approximately 10 minutes and will focus on teaching you how to properly use the mobile sit-stand desk. The co-investigator will answer any questions you may have and make sure you are comfortable with the desk before you leave the meeting. The desk is yours to use in whatever environment you choose for the next four weeks.

3) The start of week five (your final week with the desk), the co-investigator will email you 7 links (one for each day of this last week) to collect your daily sedentary time and behaviours in the same fashion as week 1 of the study. You will again complete each daily log at the end of the day, as close to you falling asleep, or 12AM midnight as possible (whichever event comes first). This email will also contain a link to interview questions that should be completed at the end of this week. The questions asked will focus on your experiences with the sit-stand desk over the past month and cover a range of topics including ease of use, enjoyment, positives, negatives, improvements, etc. If requested, the co-investigator will share with you your total sedentary time and a breakdown of your sedentary behaviours for week 1 and week 5 of this study.

For your participation, you will be entered into a draw to win one of two 50$ Visa Gift Cards. Participation is completely voluntary and withdrawal from the study is allowed at any time. If you are interested in participating or want to learn more about the study, please email me at [redacted] Thank you."

Appendix Y

Facebook Recruitment Message – Study 4

FaceBook Website Ad

"Hi Western (Health Sci or Kin),

I am a third-year PhD student working with Dr. Jennifer Irwin and we are hoping you might be interested in taking part in our next sedentary behaviour related study. Do you feel like you sit too much while engaged in study-behaviours? If so, this study is for you! With official enrollment in our study, you will be given a mobile sit-stand desk for an entire month, to be used in whichever environments you choose. The sit-stand desk is light weight and easy to use, allowing you to take the desk from home to campus and back again, depending on where you want to use it. It is completely up to you! To take a look at the sit-stand desk, please visit the following link: http://www.t-zonevibration.com/standing-desks/4mt-standing-desk-top-extender. Your enrollment in the study enters you into a draw to win one of two 50$ Visa Gift Cards!

If interested, please email me [redacted] to receive more information about the study."

Appendix Z

Email Script Welcoming Participants to Study – Study 4

Email Script to Welcome Participants to the Study
(Prior to obtaining consent)

"Hello,

Thank you for your interest in my research study. At the end of this email I have provided you with a link to an online letter of information that will outline the study in full detail and should answer any questions you might have. However, if you have any additional questions, please do not hesitate to ask. Following the letter of information, you will find a consent form. After reviewing the letter of information and gaining a full perspective on all aspects of the study, if you would like to participate please complete the consent form by entering your name, the date, and your email address. Please notify me when you have completed the consent form and we can move forward with your official enrollment in the study!

Please find the online letter of information and consent form here:
https://uwo.eu.qualtrics.com/jfe/form/SV_cxcdEAWd2M13l5P

Thank you again for your interest and I hope to hear from you soon,
Marc Moulin, Co-investigator"

Appendix AA

Email Script Containing Link to Demographic Questionnaire – Study 4

Email Script Containing Link to Demographic Questionnaire
(After Obtaining Consent)

"Hello,

thank you for completing the consent form and officially enrolling yourself in my study. At the end of this email I have provided you with a link to a demographic questionnaire that needs to be filled out before moving forward. The demographic questionnaire begins by asking you to input your participant ID. You will find your three-digit participant ID in a following email. Please enter your three-digit ID and complete the rest of the questionnaire. This three-digit ID will be your participant ID for duration of the study. Please notify me when you have completed the demographic questionnaire.

You can find the online demographic questionnaire here:
https://uwo.eu.qualtrics.com/jfe/form/SV_ewzDj8aVE4ZYoTj

Thank you for your participation,
Marc Moulin, Co-investigator"

Appendix AB

Opened Ended Online Questions – Study 4

Final Qualitative Questions

Topic Areas to Cover

- Facilitators to using the sit-stand desk
- Barriers to using the sit-stand desk
- Positives to using the sit-stand desk
- Negatives to using the sit-stand desk
- Overall level of enjoyment throughout the study
- Improvements to the sit-stand desks

Questions

- What aspects of your physical 'study' environment made using the desk easy, including on campus and off campus?
- What aspects of the physical 'study' environment made using the desk difficult, including on campus and off campus?
- What did you enjoy about using the desk over the past week?
- What did you not enjoy about using the desk over the past week?
- Where and when did you use the desk most often?
- What impact did the desk have on your sedentary behaviour, if any?
- What impact did the desk have on your sedentary behaviour at the beginning of the study, compared to the end of the study, if any?
- What made it easier to use the desk, other than the physical environment, on campus and off campus?
- What made it difficult to use the desk, other than the physical environment, on campus on off campus?
- Where was it most awkward to use the desk and why?
- When and if you used the desk during class time, how did the professor and other students react to you using it? If you didn't use the desk during class time, how do you think the professor and other students would have reacted to you using the desk?
- How often would you use the desk if it was available in all your undergraduate classes?
- What improvements would you make to the desk to make it better?
- What else should we know about your views on the stand-up desk as a tool for reducing students' sedentary time?

CURRICULUM VITAE

1. PERSONAL INFORMATION

Marc Moulin

[redacted]

2. EDUCATION

2016 - Present	**Western University**, London, Ontario, Canada Ph.D. Candidate, Health and Rehabilitation Sciences (Health Promotion)
2014 - 2016	**Western University**, London, Ontario, Canada M.Sc., Health and Rehabilitation Sciences (Health Promotion)
2010 - 2014	**Western University**, London, Ontario, Canada Honours B.H.Sc., Health Sciences

3. TEACHING EXPERIENCE

Fall 2017 - Present

Teaching Assistant, Health Sciences 2250: Health Promotion in Canada
School of Health Studies, Western University

- Facilitated the learning of key concepts in health promotion including the process of developing a health promotion program from planning to implementation to evaluation
- Conducted one on one and group teaching sessions to facilitate student learning and growth
- Supervised lectures and proctored exams

Winter 2015 – Summer 2017 *Teaching Assistant*, Physical Therapy 9590:

Supervised Research Experience
School of Physical Therapy, Western University
- Organized and delivered Graduate Student 'Research Day', a student research conference
- Graded student oral and poster presentations

Fall 2014

Teaching Assistant, Health Sciences 3010F: Introduction to Rural Communities
School of Health Studies, Western University
- Presented lectures to students, provided student writing workshops, and graded student essays

4. EMPLOYMENT HISTORY

Teaching Assistant
2014 - Present
The Faculty of Health Sciences, Western University
London, Ontario, Canada
- Assisted in teaching various health related courses within the Faculty of Health Sciences

April 2017 - Feb. 2018

Research Assistant
School of Occupational Therapy, Western University London, Ontario, Canada
- Facilitated participant recruitment and data collection
- Conducted participant interviews and analyzed qualitative data

Aug. 2016 - Feb. 2017

Graduate Research Assistantship
School of Health Studies, Western University
London, Ontario, Canada
- Conducted market research to aid the Department of Health and Rehab Sciences create new and attractive graduate programs for students
- Co-authored manuscript detailing findings

2011 - 2016

Environmental Service Worker
London Health Sciences Centre
London, Ontario, Canada
- Worked alongside multidisciplinary teams of health professionals to facilitate positive patient outcomes

- Minimized the spread of infectious diseases within the hospital

5. SCHOLARSHIPS AND AWARDS

2014 - Present	Western Graduate Research Scholarship Western University Value: 20,000/year (Canadian dollar) Non-competitive
2012 - 2014	Dean's Honour List Western University

6. PUBLICATIONS

Moulin, M.S., Tucker, P., Prapavessis, H., & Irwin, J.D. (2019). The impact of a mobile standing desk on undergraduates' sedentary time: One week and one month interventions. Manuscript submitted for publication.

Moulin, M.S., Truelove, S., Burke, S.M., & Irwin, J.D. (2019). Sedentary time among undergraduate students: A systematic review. *Journal of American College Health*, 1-8.

Moulin, M.S., Lee, C.J., Tucker, P., Prapavessis, H., & Irwin, J.D. (2019). Weekly recall of sedentary time: validity of two weekly self-reported measures in undergraduate students. Manuscript submitted for publication.

Colley, P., Schouten, K., Chabot, N., Downs, M., Anstey, L., Moulin, M. S., & Martin, R. (2019). Examining Online Health-Sciences Graduate Programs in Canada. *The International Review of Research in Open and Distributed Learning, 20*(3).

Alvarez, L., Classen, S., Medhizadah, S., Knott, M., Asantey, K., He, W., ... & Moulin, M. S. (2018). Feasibility of DriveFocus™ and driving simulation interventions in young drivers. *OTJR: occupation, participation and health*, *38*(4), 245-253.

Moulin, M. S. & Irwin, J. D. (2017). An assessment of sedentary time among undergraduate students at a Canadian university. *International Journal of Exercise Science*, *10*(8): 1116-1129

7. COMMUNITY INVOLVEMENT

2015 - Present	Basketball Coach St. Thomas Aquinas Catholic Secondary School London, ON, Canada

2016 - 2017	Academic Mentor – Western Athletics Western University London, ON, Canada

8. OTHER SCHOLARLY AND PROFESSIONAL ACTIVITES

A. REFEREED ACADEMIC CONFERENCES

Moulin, M.S., Truelove, S., Burke, S.M., & Irwin, J.D. Sedentary time among undergraduate students: A Systematic Review. International Society of Behavioral Nutrition and Physical Activity Annual Meeting. Prague, Czech Republic, June 4-7, 2019. Abstract and Poster Presentation.

Moulin, M.S., Lee, C.J., Tucker, P., Prapavessis, H., & Irwin, J.D. Weekly recall of sedentary time: validity of two weekly self-reported measures in undergraduate students. International Society of Behavioral Nutrition and Physical Activity Annual Meeting. Prague, Czech Republic, June 4-7, 2019. Abstract and Poster Presentation.

B. PROFESSIONAL DEVELOPMENT AND ADDITIONAL TRAINING

Continuous Learning	*Quantitative and Qualitative Research Skills* ▪ Paired sample t-tests, Bland-Altman Analysis, the writing of systematic reviews, and SPSS Software ▪ Inductive Content Analysis, the moderation of focus groups and semi-structured interviews
June 2019	*Quality Improvement* ▪ Health Quality Ontario's e-Learning Modules 1-7
Summer 2018	▪ Excellence Care for All Act *Motivational Interviewing and Coaching Skills – Level 1* *Intensive Workshop*, The Monarch System ▪ A directive, patient-centered counselling style for eliciting behaviour change by helping patients to explore and resolve ambivalence ▪ A collaborative conversation style for strengthening a person's own motivation toward commitment to behaviour change
September 2016	*Athletic Mentor Training Program*

	Western University
September 2014	*Teaching Assistant Training Program* Western University

C. PROFESSIONAL ASSOCIATION MEMBERSHIP

2019 - Present	International Society of Behavioural Nutrition and Physical Activity
2016 - Present	Sedentary Behaviour Research Network
2016 - Present	Canadian Obesity Network

D. UNDERGRADUATE MENTORSHIP

2016 - Present	Mentor to Undergraduate Research Assistants PhD Research Project Western University
2015 - 2016	Mentor to Undergraduate Research Assistants MSc. Research Project Western University

E. CONFERENCE COMMITTEE

Summer 2016	*Abstract Reviewer and Poster Judge* Physical Therapy Research Day Western University
Summer 2015	*Abstract Reviewer and Poster Judge* Physical Therapy Research Day Western University