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An Evaluation of a Mobile Health-Health Action Process Approach Intervention to Reduce Sedentary Behaviour and Stress in Adult Office Workers - Randomized Controlled Trial

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Abstract

Sedentary behaviour (SB) has been linked with a variety of negative health consequences which can be diminished by increasing frequency of breaks. The Health Action Process Approach (HAPA) is an effective behaviour change model for reducing SB in adult office workers. The objective of this study was to evaluate a mobile health HAPA-based sedentary behaviour intervention in office workers. Fifty-three participants (Mean age 40.62, 79.2% women) were randomized into a treatment group or a no-contact control group in a four-week, two-arm parallel randomized controlled trial. All SB outcomes were assessed from Baseline to Week 4, perceived stress was measured at Baseline and Week 4. Large significant effects ($\eta_p^2 = 0.235 – 0.466$) favouring the intervention group were found for break frequency, sitting and moving time. Findings suggest a Smartphone Ecological Momentary Assessment (SEMA3) delivered HAPA intervention can increase SB break frequency and moving time and decrease sitting time in office workers.

Keywords

Sedentary Behaviour, Health Action Process Approach, Action Planning, Coping Planning, Break Frequency, Break Duration, Sitting Time, Perceived Stress, Office Workers, mHealth

Summary for Lay Audience

The main objective of the study was to evaluate a four-week, two-arm randomized controlled trial intervention that was designed to reduce workplace sedentary behaviour by increasing sitting break frequency and break duration and decreasing workplace sitting time while increasing workplace standing time and moving time. Perceived stress was also evaluated to determine if a behaviour change intervention tailored to workplace sedentary behaviour could affect perceived stress levels. The sedentary behaviour and perceived stress outcomes were collected and measured through questionnaires that were delivered through a downloadable mobile phone application. Outcome measures were compared within and between groups to detect differences. Participants were recruited through emails to relevant liaisons and senior executives as well as through emails directly to office working employees throughout Canada. This two-arm, repeated measure randomized controlled trial randomized participants into two groups, an intervention group, and a no-contact control group. The study lasted for four weeks. The intervention group received an initial theory-based behaviour change counselling session through video chat and then continued through a mobile application where weekly theory-based worksheets were delivered to the participants' mobile phones. These two steps worked to encourage the participant to create his/her own personal and specific action plans and coping strategies. Action plans focus on the where, what, when, and how a strategy should be used, and coping plans focus on thinking about possible barriers to an action plan and how to overcome them. The control group received no intervention or further information from the letter of information. The intervention proved to be statistically effective in increasing sedentary break frequency and moving time and reducing overall sitting time in the intervention group as compared to the control group. The results from the study show that an online theory-based mHealth sedentary behaviour intervention can improve the sedentary profiles of office working adults.

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1 Introduction

1.1 Defining Sedentary Behaviour

Sedentary behaviour is defined as any waking activity with an energy expenditure of "less than or equal to 1.5 metabolic equivalents (METs) while in a sitting, lying, or reclining posture" (Tremblay et al., 2017). A MET is an index of energy expenditure, it is the ratio of the rate of energy expended during an activity to the rate of energy expended at rest; one MET is equal to the rate of energy expenditure at rest (American College of Sports Medicine, 2018). Sedentary behaviour, and the regulation of it, has recently been brought to the forefront on a national scale for its impact on people's lives. The Canadian Society for Exercise Physiology (CSEP) has recently provided sedentary behaviour targets for their adult constituents to meet, "limiting sedentary time to 8 hours or less per day including no more than 3 hours of recreational screen time and breaking up long periods of sitting where possible" (Canadian Society for Exercise Physiology, 2021). Other countries and governing bodies have begun to create sedentary behaviour guidelines focusing on reducing the time that adults spend sedentary and breaking up long periods of sitting (Australian Government Department of Health, 2021; Bull et al., 2020). It is important to know that sedentary behaviour is separate from physical inactivity. Physical inactivity is "an insufficient physical activity level to meet present physical activity recommendations" (Tremblay et al., 2017). Sedentary behaviour and physical inactivity are different constructs where a person can be highly sedentary in a day while still being physically active on the same day therefore meeting physical activity guidelines. Sedentary behaviour and moderate to vigorous physical activity are not the inverse of each other (van der Ploeg & Hillsdon, 2017); as such, sedentary behaviour has its own health consequences and outcome specific interventions targeting sedentary behaviour are needed.

1.2 Prevalence of Sedentary Behaviour

The prevalence of sedentary behaviour is quite high in Canada as Canadian adults spend roughly 9-10 hours each day engaged in sedentary behaviours (Prince et al., 2020). The majority of this time spent in sedentary positions involves bouts of prolonged sedentary behaviour, with prolonged bouts lasting for greater than 20 to 30 minutes (Carson et al., 2014). The population of desk-based office workers, workers who typically spend most of their work time in a seated position, are particularly vulnerable to sedentary behaviours. Office-working adults are generally sedentary for 75-80% of their daily working time (Thorpe et al., 2012; Parry & Straker, 2013; Urda et al., 2017) and many of the sedentary bouts fall into the category of prolonged bouts, lasting for greater than 30 minutes (Thorpe et al., 2012; Parry & Straker, 2013).

Due to the global environment present during the current study, many desk-based workers have shifted away from a purely office-based work environment. Office workers now more than ever are working from a home-based work environment or a hybrid environment consisting of occupational time at the office as well as at home. An American study found that in 2019, 24% of people that were employed in all jobs did some or all of their work at home; this percentage increased to 38% during the COVID-19 pandemic (Bureau of Labor Statistics, 2016). Estimates of office-workers indicate a shift from 20% working from home before the COVID-19 pandemic to just over 70% since early 2020 (Pew Research Center, 2020). This shift from in-office work to at-home work was swift and unplanned and has been linked to significant increases in occupational sedentary time, further compounding the prevalence of sedentary behaviour (Stockwell et al., 2021). There is an urgent need to address these higher levels of sitting and paired with the COVID shift, interventions with remote access need to be more readily investigated.

1.3 Health Risks of Sedentary Behaviour

The high prevalence of sedentary behaviour has been linked with a variety of negative health indicators in adults. These health risks include all-cause mortality, cardiovascular disease, different types of cancers, and other health consequences such as depression,

anxiety, and stress. Also, a dose-dependent relationship appears to be related to the association of sedentary behaviour and health risks.

Sedentary behaviour has been related to all-cause mortality where a meta-analysis of 34 studies found a non-linear, positive association between the two variables (Patterson et al., 2018). Lower levels of exposure to sedentary behaviour were found to be related to small increases in the risk of all-cause mortality, however over 8 hours of sedentary behaviour per day was related to a rapid increase of risk (Patterson et al., 2018). Another meta-analysis echoed the findings of Patterson et al. (2018) in that greater sedentary time was found to be positively associated with an increased risk for all-cause mortality when adjusted for physical activity (Biswas et al., 2015). Additionally, a large study examined all-cause mortality rates and sedentary behaviours for 4840 American adults. The study found that adults who spent a long time sedentary each day, 10 hours compared to 6, had 29% greater risk of mortality (HR: 1.29; 95% CI [1.1, 1.5]) and adults who were sedentary for 8 hours per day had a 14% greater risk (HR: 1.14; 95% CI [1.1, 1.2]) (Matthews et al., 2016). Furthermore, Matthews and colleagues (2016) found that by replacing 1 hour of sedentary time in less active adults with any type of physical activity, light or moderate-to-vigorous, lower mortality rates were associated with the replacement, 18% reduction for light physical activity (HR: 0.82; 95% CI [0.73, 0.92]) and 42% reduction for moderate-to-vigorous physical activity (HR:0.58; 95% CI [0.44, 0.77]).

Researchers have conducted numerous studies that have assessed the effect of sedentary behaviour on cardio-metabolic factors. A meta-analysis of 29 studies of adults from the United States and United Kingdom reported that there are unfavourable associations between total sedentary time and insulin sensitivity, fasting insulin, HOMA-IR, and triglycerides (Brocklebank et al., 2015). In a 2011 study on the data collected from the National Health and Nutrition Examination Survey (NHANES) 2003-2006 study, Healy and colleagues (2015) found that there were detrimental linear associations of sedentary time with waist-circumference, HDL-cholesterol, and C-reactive protein as well as the cardio-metabolic biomarkers addressed by Brocklebank and company (2015), triglycerides, insulin levels, and HOMA-IR. Furthermore, Wilmot and colleagues (2012)

reviewed and conducted a meta-analysis on 18 sedentary behaviour studies and when they compared the highest sedentary group with the lowest, they found that the relative risk of type 2 diabetes increased by 112% and the relative risk for cardiovascular disease increased by 147%. Biswas and colleagues (2015) demonstrated similar results in their meta-analysis which featured 45 studies. High levels of sedentary behaviour were associated with the risk for type 2 diabetes (pooled HR: 1.910; 95% CI [1.642, 2.222]) and increased risk for cardiovascular disease incidence and mortality (Biswas et al., 2015).

Sedentary behaviour is also associated with various types of cancer. Recent findings indicate that higher levels of sedentary behaviour are associated with a 28-44% increased risk of colon cancer, an 8-17% increased risk of breast cancer, and a 28-36% increased risk of endometrial cancer, all appearing to be irrespective of physical activity (Jochem et al., 2019). Furthermore, high levels of sedentary behaviour report an increased risk of the incidence of cancer by 13% compared to groups with lower levels of sedentary behaviour (Biswas et al., 2015). Some of the possible mechanisms behind the linkage between sedentary behaviour with various forms of cancer include metabolic dysfunction, alterations in circulating levels of sex hormones and low-grade systemic chronic inflammation (Jochem et al., 2019).

Other health issues have been examined with their association to high levels of sedentary behaviour. Researchers have looked at the association of overall sitting time with depression, anxiety and stress symptoms. A cross-sectional study featuring 1104 adults showed that overall sitting time was significantly associated with more severe depression (b = 0.01, 95% CI [0.00, 0.02]) and anxiety (b = 0.03, 95% CI [0.02, 0.04]) (Rebar et al., 2014). The relation between high levels of sedentary behaviour with perceived stress is less revealed than other mental health indices and the pathways for this interaction are not yet fully understood (Teychenne et al., 2019). Some potential pathways for this association may be that the activities done when engaging in sedentary behaviours may lead to burnout or sleeping problems, leading to increased degrees of stress (Teychenne et al., 2019). Conversely, reducing sedentary behaviour may lead to reduced stress due to the activities done during that reduction, i.e., household chores, physical activity, or

stretching (Teychenne et al., 2019). Concerning the association between sedentary behaviour and stress, Rebar and colleagues (2014) found there to be no relation between overall sitting time and stress while a 2019 study featuring 571 adult workers found high levels of sedentary behaviour in a desk-based office job was a significant risk factor for perceived stress in males (aOR = 4.34, 95% CI [1.46, 12.95]) and females (aOR = 3.26, 95% CI [1.23, 8.65]) (Dedele et al., 2019). A 2019 systematic review from Teychenne and colleagues found there to be no association with sedentary behaviour, both self-reported and objectively measured, and stress. However, the authors discussed the need for further research, particularly longitudinal and interventional, to confirm their findings of the relationship between sedentary behaviour and stress (Teychenne et al., 2019).

There appears to be a dose dependent relationship between sedentary behaviour and health risks from chronic diseases to all-cause mortality. Evidence for this dose dependent relationship is shown through a 2019 systematic review and meta-analysis conducted by Zhao and colleagues which examined the associations between sedentary time and cardiovascular, cancer, and mortality risk. Dose response associations were found for each outcome, indicating that mortality risk increased proportionally to the increment of sedentary behaviour (Zhao et al., 2019).

1.4 Breaking Up Sedentary Behaviour

Currently, the Canadian 24-hour Movement Guidelines recommend that adults 18-64 years limit their sedentary behaviour to 8 hours or less each day and suggest breaking up long periods of sitting when possible (Canadian Society for Exercise Physiology, 2021). These recommendations are backed by research indicating a reduction in sitting time and increased frequency of sedentary behaviour breaks are linked to the prevention of some of the known health risks indicated in the section above (Ross et al., 2020). A plethora of research has gone into uncovering what clinically meaningful change in sedentary behaviour and breaks from sedentary behaviour would be; in general, breaking up prolonged bouts of sedentary time, consecutive sitting time greater than or equal to twenty minutes, may result in beneficial changes in triglycerides, blood glucose, and insulin levels (Biswas et al., 2015). Peachey and colleagues (2018) found that a 30 minute per day reallocation of sedentary behaviour to light physical activity is clinically

meaningful, leading to a 2-4% improvement in cardiometabolic risk biomarkers. The results from Peachey et al. (2018) echoed another study that found the 30 minute reallocation target to be clinically meaningful (Buman et al,. 2013). Buman and colleagues (2013) found that shifting 30 minutes of sedentary time towards any type of physical activity, moderate to vigorous or light, as well as towards sleep, results in clinically meaningful change.

Neuhaus and associates (2014) conducted a systematic review that included 6 intervention studies (2 randomized and 4 nonrandomized) that examined the impact of a sedentary behaviour intervention involving environmental manipulations through activity permissive workstations on body composition. This review relayed that the studies that used a treadmill or pedal desk variant reported significant improvement in waist circumference while the studies using sit-to-stand desks reported no significant change in waist circumference (Neuhaus et al., 2014). The authors concluded that while the findings of their review demonstrated mostly positive findings for waist circumference, the findings for body mass index, were not significant.

Cardiometabolic health may be improved through the breaking up of prolonged sedentary bouts. To this end, Loh and colleagues (2019) conducted a meta-analysis of studies that compared the effects of breaking up prolonged sitting with bouts of physical activity on glucose, insulin, and triacylglycerol (TAG) measures. The researchers included 37 studies in which the intervention group showed statistically significant differences in the three cardiometabolic markers they were measuring compared to sitting control groups (Loh et al., 2019). TAG had a small effect (Standardized Mean Difference (SMD) = -0.26, 95% CI [-0.44, -0.09], $p = 0.002$) between intervention group and control while the effects for glucose (SMD = -0.54, 95% CI [-0.70, -0.37], $p = 0.00001$) and insulin (SMD = -0.56, 95% CI [-0.74, -0.38], $p = 0.00001$) were moderate (Loh et al., 2019). In a study looking at sitting break frequency and intervening with either a standing intervention or a stepping intervention, both resulted in improving cardiometabolic risk markers (Healy et al., 2015). The sitting-to-stepping group resulted in significantly lowering BMI (RR = 0.90, 95% CI [0.86, 0.94], $p < 0.001$), waist circumference ($B = -7.88$, 95% CI [-10.98, -4.79], $p < 0.001$), 2-hour plasma glucose (RR = 0.88, 95% CI [0.83, 0.94], $p < 0.001$),

triglycerides (RR = 0.83, 95% CI [0.75, 0.91], $p < 0.001$), and higher HDL-cholesterol ($B = 0.14$, 95% CI [0.07, 0.22], $p = 0.001$) (Healy et al., 2015). The sitting-to-standing group resulted in significantly lower fasting plasma glucose (RR = 0.98, 95% CI [0.97, 1.00], $p = 0.040$), total/HDL-cholesterol ratio (RR = 0.94, 95% CI [0.92, 0.96], $p < 0.001$), triglycerides (RR = 0.89, 95% CI [0.86, 0.93], $p < 0.001$), and 2-hour plasma glucose (RR = 0.97, 95% CI [0.95, 1.00], $p = 0.039$) and higher HDL-cholesterol ($B = 0.07$, 95% CI [0.03, 0.10], $p < 0.001$) (Healy et al., 2015). Another study looking at replacing sitting time with standing and stepping time demonstrated positive cardiometabolic results as the examples listed above (Edwardson et al., 2017). Edwardson and associates (2017) implemented a standing and stepping intervention in adults aged 30-75 who had a high risk of impaired glucose regulation or type 2 diabetes. The researchers found similar results where reallocating prolonged sitting for standing or stepping was associated with a lower fasting insulin (5% difference, 95% CI [2%, 8%], $p = 0.001$; 11% difference, 95% CI [5%, 16%], $p = 0.001$, respectively) and 2-hour insulin (6% difference, 95% CI [1%, 10%], p = 0.029; 15% difference, 95% CI [8%, 22%], $p = 0.002$, respectively) (Edwardson et al., 2017). Furthermore, HOMA-IS (6% difference, 95% CI [2%, 10%], $p = 0.002$; 15% difference, 95% CI [6%, 26%], $p = 0.001$, respectively) and Mastsuda-ISI (6% difference, 95% CI [1%, 11%], $p = 0.018$; 22% difference, 95% CI [9%, 35%], $p < 0.001$, respectively) increased as well (Edwardson et al., 2017). These results provide credence to standing or light intensity physical activity (LIPA) interventions being effective in reducing some of the cardiometabolic risks that stem from prolonged sedentary behaviour.

Other health outcomes can be alleviated through intervention in prolonged sedentary behaviour, some examples are stress, mood, and fatigue. A recent randomized controlled trial focusing on sedentary behaviour intervention in the workplace assessed the impact of two interventions, an educational intervention and the same educational intervention paired with a height adjustable desk, on stress and wellbeing (Edwardson et al., 2022). The study found an improvement in stress and wellbeing levels in both of their intervention groups over the course of three and twelve months (Edwardson et al., 2022). Giurgiu and colleagues (2020) demonstrated that in a sample of university employees, average age of 33.73, breaking up excessive sitting time can work to enhance mood in

everyday life. Break frequency ($b = 0.07$, $p < 0.01$) and break intensity ($b = 5.18$, $p < 0.01$), the intensity of the non-sedentary behaviour, were positively associated with valence, intrinsic goodness (Giurgiu et al., 2020). Similar results were seen for energetic arousal with break frequency and break intensity positively predicting the outcome ($b = 0.12$, $p < 0.01$; $b = 0.08$, $p < 0.01$, respectively) (Giurgiu et al., 2020). The findings from Giurgiu and associates also indicate that the higher number of transitions from sit-to-stand, the greater the enhancement in mood (2020). Sedentary behaviour interventions have also recently been found to possibly be an effective acute fatigue countermeasure (Wennberg et al., 2016). The results from the study connected by Wennberg and associates (2016) suggest that interrupting prolonged sitting bouts with LIPA may mediate pathways involved in mental fatigue and cognition. However, while the studies from Wennberg and colleagues (2016) and Giurgiu and colleagues (2020) show promising results, an overview of systematic reviews was hesitant to rate the certainty of evidence for the two concepts highly at this time due to consistency and dearth of evidence (Saunders et al., 2020). The same overview of systematic reviews found little evidence that sedentary behaviour interventions are associated with musculoskeletal pain, accidents or injuries, sleep, or work productivity (Saunders et al., 2020). The review of reviews from Saunders and colleagues (2020) highlights the need for continued research related to sedentary behaviour and how interventions focusing on the phenomena relate to different health outcomes.

1.5 Current Occupational Sedentary Behaviour Intervention Landscape

As stated before, sedentary behaviour is a pervasive behaviour in the lives of Canadian adults. This pervasiveness is compounded even more in the lives of office working adults, where most of their occupational time is spent engaged in sedentary behaviours (Thorpe et al., 2012; Parry & Straker, 2013; Urda et al., 2017). Thus, specific sedentary behaviour interventions focusing on this domain of daily life could be expected to yield impactful results. The growing amount of research in the field works to support this expectation, where many studies targeting sedentary behaviour to some degree are focused on occupational sedentary behaviour, typically the office working adult. A

review and meta-analysis from Prince and colleagues (2014) highlighted the effectiveness of different interventions that focused on sedentary behaviour exclusively, sedentary behaviour and physical activity, and physical activity exclusively on total sitting time. The researchers compared interventions that focused on both physical activity and sedentary behaviour as well as interventions that solely highlighted a measure of sedentary behaviour as its primary outcome (Prince et al., 2014). The interventions that evaluated a combination of physical activity and sedentary behaviour outcomes produced less favourable results, less consistent findings, and resulted in only moderate reductions in sedentary time compared to studies that focused solely on sedentary behaviour (SMD = -0.37, 95% CI [-0.69, -0.05]) (Prince et al., 2014). Contrarily, studies that were tailored to sedentary behaviour, six that Prince and colleagues (2014) reviewed, demonstrated large and clinically meaningful reductions in sedentary time (SMD = -1.28, 95% CI [-1.68, -0.87]). The sedentary-based interventions resulted in a mean difference reduction of approximately 91 minutes per day sitting time compared to a mean difference reduction of approximately 35 minutes per day of sitting time in the studies where sedentary behaviour was considered a secondary outcome (Prince et al., 2014). These results lead to the advantage of implementing a sedentary specific intervention to produce significant behaviour change as opposed to an intervention that works to incorporate physical activity outcomes as well as sedentary behaviour outcomes.

Occupational sedentary behaviour interventions have used an abundance of different strategies to promote significant change in occupational sitting time. Interventions can differ based on the intervention function, for example: education, persuasion, incentivization, training, environmental restructuring (Gardner et al., 2015). A review of sedentary behaviour interventions for the adult population elucidated the landscape of worksite sedentary behaviour interventions in which the most frequently used intervention functions were enablement and environmental restructuring (Gardner et al., 2015). Environmental manipulations featuring augmentations such as the implementation of standing workstations, portable elliptical/pedal machines, stationary ergometers, and treadmill desks are powerful sedentary behaviour interventions, demonstrating a reduction in workplace sitting by around -72.8 minutes per 8-hour workday (95% CI [-104.9, -40.6]) according to a meta-analysis of workplace intervention strategies (Chu et

al., 2016). Another powerful type of intervention commonly used in intervention studies are multi-component interventions. These interventions build upon the environmental manipulations by adding a behavioural component to them, such as goal setting, self-monitoring, or enablement. With the addition of the behavioural component comes an increase in the effectiveness of the intervention as Chu and colleagues (2016) report that the multi-component interventions featured in their meta-analysis showed a reduction of occupational sitting time of -88.8 minutes per 8-hour workday (95% CI [-132.7, -44.9]).

The third type of intervention model presented in the meta-analysis are the educational/behavioural strategies which feature some type of individual-based intervention (Chu et al., 2016). This type of strategy boasted a mean reduction in workplace sitting of -15.5 minutes per 8-hour workday (95% CI [-22.9, -8.2]) and a reduction range between -60.9 and -3.5 minutes per 8-hour workday (Chu et al., 2016). From this meta-analysis, the large-scale multi-component interventions appear to be superior in terms of significance in sitting time reduction as they boast much greater reductions in the outcome variable than educational/behavioural strategies (Chu et al., 2016). However, the feasibility of these multi-component interventions come into question when concepts such as scalability, universal implementation, and cost are considered. On the other hand, traditional education/behavioural strategies are more feasible than large scale interventions to implement and scale within organizations of varying sizes (Chu et al., 2016). Recently, individual level technology enhanced interventions have become more prominent in the field. These interventions often use the technology that is at the disposal of the participants to create positive and significant change in their sedentary profiles (Stephenson et al., 2017). Technological strategies such as mobile applications, prompting software, text, and activity monitors have been used to show reductions in sitting time and other sedentary behaviour outcomes (Stephenson et al., 2017). Stephenson and colleague's (2017) meta-analysis of technology focused sedentary behaviour interventions obtained a pooled mean reduction of -41.28 minutes/workday of sitting time (95% CI [-60.99, -21.58]).

Another consideration for individual focused education/behavioural strategies is the implementation of theoretical framework in the designs. Interventions that incorporate a

theoretical framework tend to improve upon results compared to interventions without such framework (Lippke & Ziegelmann, 2008). This notion is evidenced in Rollo & Prapavessis (2020) where an education/behaviour strategy was grounded in a behaviour change theory and significant group by time interaction effects were responded for sitting time and standing time. This provides grounds for further studies in this field to implement theory grounded individual-based interventions.

The current world environment raises questions on the effectiveness of the current sedentary behaviour interventions. As noted previously, the COVID-19 pandemic resulted in a significant shift in office workers' work environment, from a mostly traditional office setting to either fully at-home work or a nouveau hybrid model where work time is split between home and office. There is a sparse amount of intervention research aimed at reducing sedentary behaviour in these new office settings. Thus, future research in office worker occupational sedentary behaviour should look to target these modifiers and assess their impact within the different levels of sedentary behaviour interventions, multi-component, environmental, and educational/behavioural.

1.6 Health Action Process Approach

Interventions intended to change health-related behaviours may be aided in their pursuit when they are grounded in appropriate theories of behaviour change (Davis et al., 2014). The benefit of grounding an intervention in an appropriate theory is they provide targeted mechanisms for the intervention. Targets such as attitude in the theory of planned behaviour, self-efficacy in the social cognitive theory, and autonomy in self-determination theory. Theories also allow the researcher to select specific intervention strategies or techniques such as goal setting, imagery, and action planning. The HAPA model, or Health Action Process Approach, is a behaviour change model that aims to describe, explain, and modify health behaviours (Schwarzer & Luszczynska, 2008). It was specifically designed to overcome the intention-behaviour gap, the challenge to overcome the disconnect between a participant’s intention to perform a specific behaviour and whether that intention responds with an action (Schwarzer & Luszczynska, 2008). Some other theories used previously in the intervention of sedentary behaviour, such as the theory of planned behaviour, do not work to address this gap between

intention and behaviour (Changing Behavior Using the HAPA, 2020). The HAPA model's inclusion of post-intentional mediators, action and coping planning, work to bridge the intention-behaviour gap (Schwarzer, 2016). Additionally, the model's incorporation of dynamic self-regulatory variables is viewed as a strength with regards to behaviour change compared to static motivation and attitude variables as seen in theories such as the theory of planned behaviour (Schwarzer, 2016). Many of HAPA's constructs are built to incorporate temporal change, offering the ability to make fine adjustments in response to recent experiences, i.e., coping planning, self-regulation, maintenance self-efficacy (Schwarzer, 2016). Individuals working within the HAPA model are constantly engaged in refining action and coping plans which speaks to the motivational and volitional aspect of the theory lending itself to the dynamic nature in which people think and behave.

The HAPA model, Figure 1, is broken into two distinct stages, a motivational stage which describes the pre-intentional motivation processes that lead to a behavioural intention and a volitional stage which lead to the actual health behaviour (Schwarzer & Luszczynska, 2008). The motivational stage of the model comprises of three constructs that contribute to the forming of intentions: self-efficacy, positive outcome expectancies, and risk/threat perceptions. Self-efficacy (e.g., I am capable of increasing my sitting break frequency in spite of my work environment) is the belief in one's own capability to perform the goal behaviour. Positive outcome expectancies (e.g., If I reduce my sitting time, I will reduce my cardiovascular risk) are when a person balances the pros and cons of certain behavioural outcome. Finally, risk perceptions (e.g., I am at risk for cardiovascular disease) are seen as a precursor to set the stage for deeper consideration about particular consequences and competencies. Perceived self-efficacy works in tandem with positive outcome expectancies, both of which contribute substantially to forming an intention (Schwarzer & Luszczynska, 2008).

The second stage of the HAPA model works to transform a person's intention into the adoption of a particular health behaviour (Schwarzer & Luszczynska, 2008). Furthermore, this stage works to maintain the action through self-regulatory skills, maintenance self-efficacy and recovery self-efficacy, and strategies, action planning and

coping planning (Schwarzer & Luszczynska, 2008). Maintenance self-efficacy represents the beliefs about one's capability to deal with barriers that arise, persons with higher levels of maintenance self-efficacy tend to invest more effort and persist longer in the face of obstacles (Schwarzer & Luszczynska, 2008). Recovery self-efficacy deals with an individual's ability to get back on track after getting derailed or knocked off of their goal, it addresses the experience of failures and setbacks (Schwarzer & Luszczynska, 2008). Action planning involves creating specific situation parameters (where, when, how, etc.) and a sequence for action (how) (Schwarzer & Luszczynska, 2008). Coping planning is similar to action planning with regards to setting specific situation parameters, however a coping plan's outlook is on potential barriers or obstacles, developing plans or alternative actions in anticipation of a setback (Schwarzer & Luszczynska, 2008). Coupled together, Schwarzer and Luszczynska (2008) indicate that action and coping plans provide more steady ground for good intentions to be translated into action.

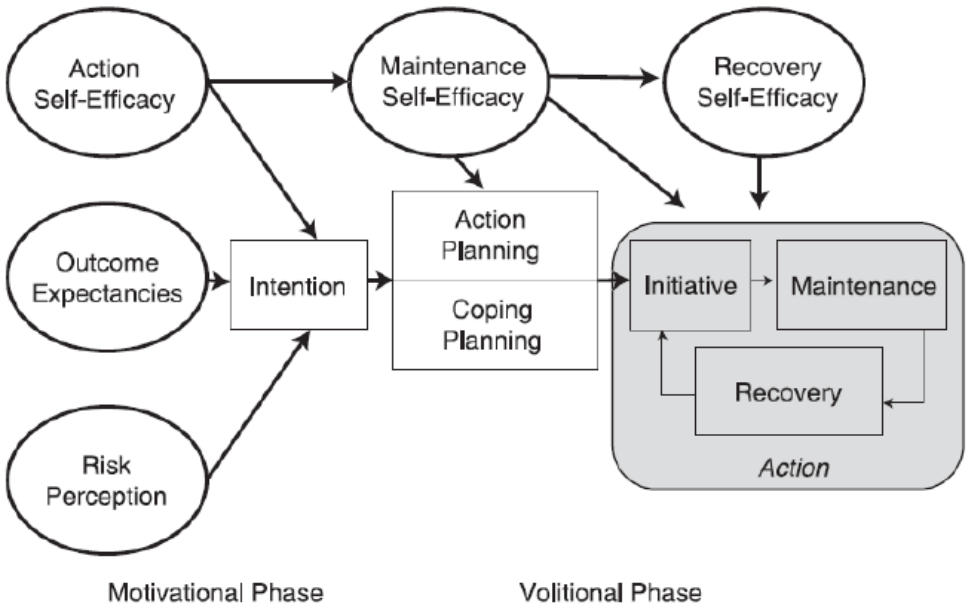

Figure 1: The Health Action Process Approach Model (Schwarzer, 2008).

1.7 HAPA in the Field

The HAPA model has been used in a plethora of different behaviour change intervention studies to a wide degree of success, from enhancing intentions to attend cervical cancer

screening (Luszczynska et al., 2011), to increasing physical activity and preventing functional decline among older adults (Boulton et al., 2019), to improving tooth brushing in secondary school children (Marshman et al., 2021). Notably, the HAPA model has been used with success in interventions concerning sedentary behaviour. A study in 2017 featured the HAPA model entrenched in a face-to-face sedentary behaviour intervention for university students (Sui & Prapavessis, 2017). This study featured a treatment condition which focused on utilizing the concepts contained in the volitional stage of the HAPA model (action and coping planning) compared to an equal contact control group (Sui & Prapavessis, 2017). The researchers obtained a significant interaction effect favouring the intervention group for break frequency and the interaction effect was large ($p = 0.05$, $\eta_p^2 = 0.27$). This study helped to establish the HAPA model as an effective backbone to sedentary behaviour interventions. Another HAPA-based intervention in university students, Dillon and colleagues (2022), displayed the power of a HAPA-based sedentary behaviour intervention. This study, much like Sui & Prapavessis (2017), featured a behavioural counselling session where action and coping plans were built specific to the participant's lifestyle (Dillon et al., 2022). However, the study differed in its adoption of an mHealth (mobile health) measure, the use of daily text-message "mini-boosters" which featured positive reinforcement, sedentary behaviour facts, and daily challenges among others (Dillon et al., 2022). Significant group by time interaction effects were found for sitting time ($p = 0.004$, $\eta_p^2 = 0.10$), walking time ($p = 0.021$, $\eta_p^2 = 0.06$), and stretching time ($p = 0.023$, $\eta_p^2 = 0.20$) (Dillon et al., 2022). University students appear to be an appropriate population to receive and benefit from a HAPA-based sedentary behaviour intervention.

When populations are shifted to office workers, similar promising results appear to be obtained. Another mHealth intervention featuring HAPA constructs and sedentary behaviour was conducted in office working adults. This study employed the same daily text-message based action and coping planning intervention as used in Dillon et al. (2022) in office worker adults (n = 60) (Rollo & Prapavessis, 2020). The HAPA volitional construct-based intervention resulted in significant group by time interaction effects for sitting time ($p = 0.003$, $\eta_p^2 = 0.07$), standing time ($p = 0.019$, $\eta_p^2 = 0.05$), and

stretching time (p = 0.001, η_p^2 = 0.08), that favored the treatment group (Rollo & Prapavessis, 2020). Furthermore, significant correlations in the expected direction were found between the HAPA model's volitional constructs and sitting time, standing time, walking time, and break frequency (Rollo & Prapavessis, 2020). The employment of the volitional constructs in the HAPA model, action planning and coping planning, as strategies or techniques in sedentary behaviour interventions appear to have impactful for changing sedentary behaviour.

The results obtained by Dillon and colleagues (2022) as well as Rollo and Prapavessis (2020) echo the results from other mHealth interventions concerned with sedentary behaviour. A meta-analysis focused on the use of different mHealth interventions found that sedentary behaviour interventions, utilizing some type of mHealth strategy, featured declines in the behaviour as compared to usual care methods (SMD = -0.26, 95% CI [-0.12, 0.41]) (Direito et al., 2017). The studies used in the meta-analysis involved participants from a wide variety of settings, from community settings to primary health care environments (Direito et al., 2017). These taken together, Dillon et al. (2022), Rollo and Prapavessis (2020) and Direito and colleagues (2017), provide credence to the possible effectiveness of mHealth interventions in reducing sedentary behaviour among different populations.

Rollo & Prapavessis (2020) augmented the HAPA intervention for increasing break frequency and reducing sedentary behavior with daily text messages that reminded participants about their action and coping plans. It remains unknown whether incorporated downloadable mobile software (i.e., SEMA3, Koval et al., 2019) to keep participants engaged in weekly HAPA action and coping plans will lead to a more specific, focused, and effective delivery of a HAPA intervention. The previous study featured a single behavioural counselling session where action and coping plans were formed and expected to be maintained for the duration of the study with attention and interaction being augmented by daily text message "mini-boosters" (Rollo & Prapavessis, 2020) This model provides rigid framework for the participants to enjoy the dynamic nature of the HAPA model and perhaps greater application of the involvement in action and coping planning via SEMA 3 throughout the duration of the intervention may lead to

a more impactful intervention. Furthermore, more information on how a fully online study may differ from studies involving face-to-face interaction needs to be unearthed, assessing whether detaching the intervention from in-person meetings may relate to the impact of the intervention. If similar results or greater results were to be obtained, extensive scalability repercussions may result.

Purpose

The primary purpose of the current study was to determine whether a SEMA3 delivered mHealth HAPA-based action and coping planning intervention would increase desk-based office worker sedentary behaviour break frequency and break duration as well as decrease the time workers spent in sedentary behaviours and increase the time spent in non-sedentary behaviours (i.e., standing and moving).

A secondary purpose was to determine if a SEMA3 delivered mHealth HAPA-based action and coping planning intervention tailored to workplace sedentary behaviour would affect perceived stress levels of desk-based office workers from pre- to post-intervention, as compared to participants in a no contact control group.

Hypothesis

H1: It was hypothesized that the mHealth HAPA based intervention group would report increased sedentary behaviour break frequency and duration and reduced occupational sedentary behaviour (sitting time) and increased occupational non-sedentary behaviours (standing and moving time).

H2: It was hypothesized that the mHealth HAPA based intervention would reduce perceived stress as compared to the no contact control group.

2 The Current Study

Ethical approval was granted from Western University's Research Ethics Board (#120488). All participants were given the Letter of Information and provided informed consent through an eConsent Zoom meeting before completing the first questionnaire.

2.1 Methods

2.1.1 Design

This research study used a 4-week parallel two-arm randomized controlled trial with randomization being done using a computer-generated 0 or 1 allocation. The researcher preformed the randomization, enrollment, and assignment of the study which took place from March 2022 to July 2022 and was set throughout Canada with participants being recruited from Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia.

2.1.2 Sample Size Calculation

The initial power calculation was based off a previous sedentary behaviour intervention study by Rollo and Prapavessis (2020), in which a similar design was employed, and similar measures of sedentary behaviour were assessed. The researchers reported a significant group by time interaction for break frequency ($\eta_p^2 = 0.10$). The researchers in the current study looked to adequately power more outcome measures therefore, a target sample size of 58 participants was calculated for an effect size ($\eta_p^2 = 0.08$) with an alpha of 0.05 and a power of 0.80 according to G*Power software calculations.

2.1.3 Participants

Inclusion criteria: (1) at least 18 years of age, (2) be able to read and write in English, (3) be a full-time employee in a desk-based office working job, (4) have access to a smartphone with internet connection. Sixty-four participants consented and were randomized into one of two conditions: the intervention arm (SEMA3 mHealth HAPA based action and coping planning), or the control arm (no-contact control). Sixty-two participants (Mean age = 40.2 +/- 12.0, 75.8% women) completed the baseline

measurements after randomization while two participants were lost to follow-up, where they could no longer be reached, before they had completed any questionnaires. Fifty-three participants (Mean age = 40.6 +/- 11.9, 79.2% women) participants completed the study with full data sets while nine participants were lost to follow-up in Week 2. Figure 2 is a flow diagram illustrating how many participants were recruited for the study and how many remained at targeted timepoints.

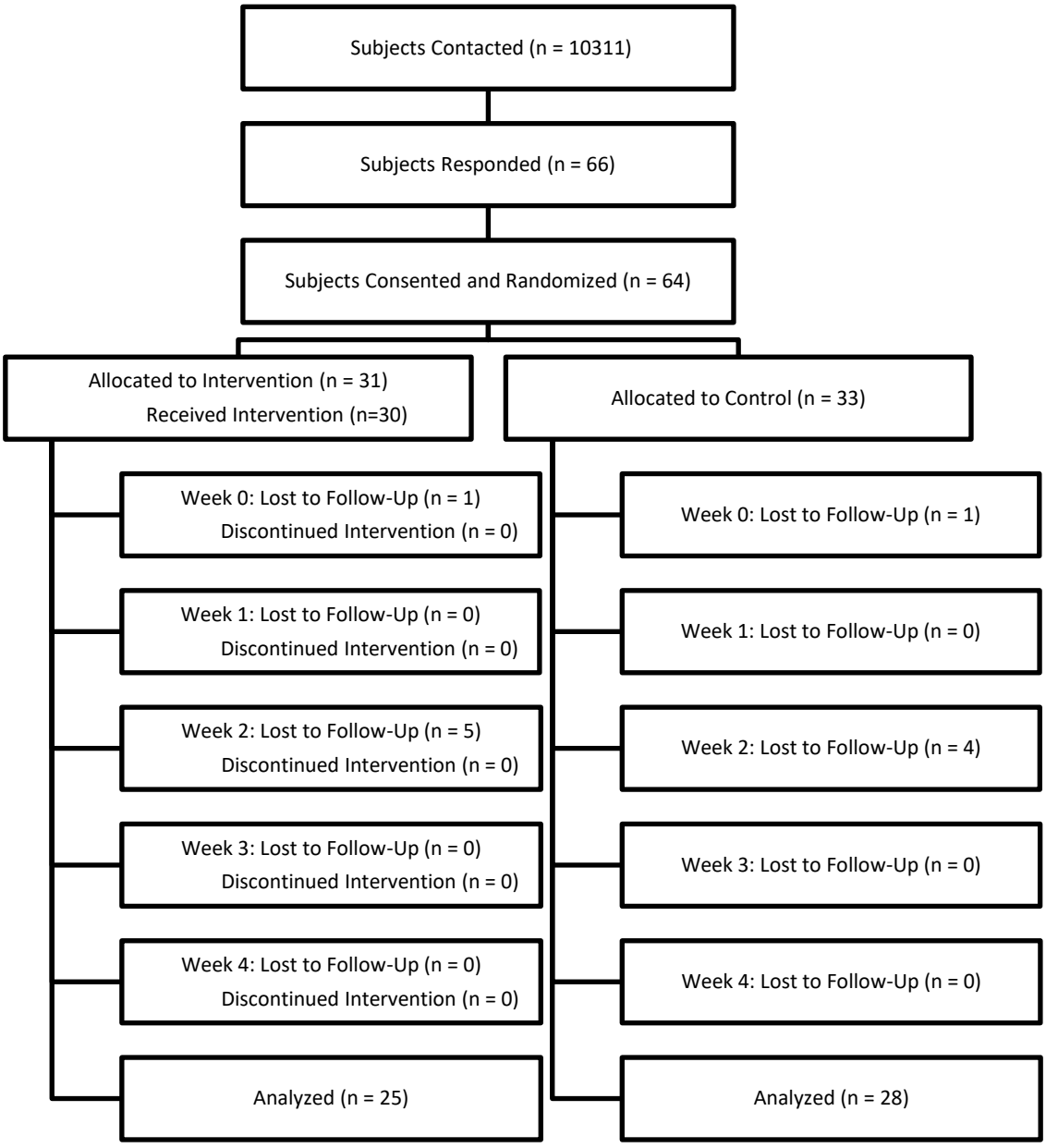

Figure 2: Flow of participants through the study.

2.1.4 Measures

2.1.4.1 Modified SIT-Q 7d Questionnaire

The modified SIT-Q 7d questionnaire from Sui and Prapavessis (2016) was used in the present study to measure occupational sitting break frequency and occupational sitting break duration. The questionnaire expands upon the valid and reliable base SIT-Q 7d questionnaire by including domain-specific break frequency and duration scores (Wijndaele et al., 2014). Sui and Prapavessis' (2016) modified version of the questionnaire has been demonstrated to have adequate test-retest reliability and has shown to be valid in measuring-domain specific sedentary behaviour outcomes. The full questionnaire can be found in Appendix B.

2.1.4.2 Occupational Sitting and Physical Activity Questionnaire

The occupational sitting and physical activity questionnaire (OSPAQ) was used in the present study to measure the percentage of time spent sitting, standing, and moving during work hours (Chau et al., 2012). The OSPAQ used in the current study was modified from the base OSPAQ which includes a measure of "heavy labour or physically demanding tasks." This measure was deemed not prevalent in the sedentary office setting where participants were recruited from. This modification has been echoed in Dillon et al. (2021) and has been based off previous work done with similar populations where very low instances of such a measure were recorded (Chau et al., 2012). The modified OSPAQ has been validated against activPAL4 accelerometers and the questionnaire has been demonstrated to have fair levels of validity for sitting and standing and is comparable to other occupational physical activity measures for assessing time spent walking at work (Dillon et al., 2021; Maes et al., 2020; Chau et al., 2012). The full questionnaire can be found in Appendix B.

2.1.4.3 Perceived Stress Scale

The perceived stress scale (PSS) was used in the current study to measure a participant's perception of stress, the degree to which situations in one's life are appraised as stressful (Cohen et al., 1983). The 10-item questionnaire has been reported to have good internal consistency reliability and adequate convergent validity (Barbosa-Leiker et al., 2012).

Scores on the PSS range from 0 to 40 with higher scores indicating higher perceived stress: low perceived stress (0 – 13), moderate perceived stress (14 – 26), and high perceived stress (27 – 40) (Cohen et al., 1983). The full questionnaire can be found in Appendix B.

2.1.5 Primary Outcome Measures

2.1.5.1 Frequency of Breaks from Occupational Sitting

The frequency of breaks taken from occupational sitting was measured through the following question from the modified SIT-Q 7d Questionnaire (Sui & Prapavessis, 2016), "In the last 7 days, on average, how often did you interrupt your sitting time during work?" Options for the question included: Less than every 30 min, Every 30-45 min, Every 45 min-1 hour, Every 1-1.5 hours, Every 1.5-2 hours, Every 2-3 hours, Every 3-4 hours, Every 4-5 hours, Over every 5 hours, No interruption. These results correspond with a score of 1-10, respectively.

2.1.5.2 Duration of Breaks from Occupational Sitting

The duration of breaks taken from occupational sitting was measured through the following question from the modified SIT-Q 7d Questionnaire (Sui & Prapavessis, 2016): "In the last 7 days, on average, how long were your breaks from sitting during work?" Options for the question included: Less than 30 sec, 30 sec-1 min, 1-2 min, 2-3 min, 3-4 min, 4-5 min, 5-10 min, 10-15 min, 15-30 min, and Over 30 min. These results correspond with a score of 1-10, respectively.

2.1.5.3 Occupational Sitting Time

The duration of daily and weekly occupational sitting time was measured through items 1, 2, and 3a. on the OSPAQ (Chau et al., 2012): "1. How many hours did you work in the last 7 days? 2. During the last 7 days, how many days were you at work? 3a. Record the percentage of time you spent sitting (including driving while at work) at work in the last 7 days." Participants could answer from 0 to 100 percent, with 3a. (sitting), 3b. (standing), and 3c. (moving) totaling to 100 percent. Minutes/work week = Item 1 * Item 3a. Minutes/workday = (Item 1/Item 2) * Item 3a.

2.1.6 Secondary Outcome Measures

2.1.6.1 Occupational Standing Time

The duration of daily and weekly occupational standing time was measured through items 1, 2, and 3b. on the modified OSPAQ (Chau et al., 2012): "1. How many hours did you work in the last 7 days? 2. During the last 7 days, how many days were you at work? 3b. Record the percentage of time you spent standing at work in the last 7 days." Participants could answer from 0 to 100 percent, with 3a. (sitting), 3b. (standing), and 3c. (moving) totaling to 100 percent. Minutes/work week = Item 1 * Item 3b. Minutes/workday = (Item 1/Item 2) * Item 3b.

2.1.6.2 Occupational Moving Time

The duration of daily and weekly occupational moving time was measured through items 1, 2, and 3c. on the modified OSPAQ (Chau et al., 2012): "1. How many hours did you work in the last 7 days? 2. During the last 7 days, how many days were you at work? 3c. Record the percentage of time you spent moving (i.e., walking) at work in the last 7 days." Participants could answer from 0 to 100 percent, with 3a. (sitting), 3b. (standing), and 3c. (moving) totaling to 100 percent. Minutes/work week = Item 1 * Item 3c. Minutes/workday = (Item 1/Item 2) * Item 3c.

2.1.6.3 Perceived Stress

Perceived stress was measured by the Perceived Stress Scale (Cohen et al., 1983). Participants answered the 10-item questionnaire. Options for each question included: Never, Almost Never, Sometimes, Fairly Often, Very Often. These results correspond with a score of 0-4, respectively.

2.1.7 Other Measures

2.1.7.1 Demographics

The following demographic information was obtained: name, email address, sex, gender, age, ethnicity, work environment (home, office, or hybrid), work sector (private, public, charity, or other), hours of work each week, and current formal level of education.

2.1.8 Intervention

Participants randomized into the intervention arm of the study received a single one-on-one behavioural counselling session and weekly HAPA-based action and coping planning worksheets delivered through a downloaded smartphone application, SEMA3. The counselling session used a client-centered counselling approach where the researcher acted as a guide for the client as they explored sedentary behaviour and navigated the core HAPA principles. The researcher was well versed in sedentary behaviour research as well as the different components of the HAPA model and had experience in offering similar HAPA focused counselling sessions. Participants were given the Behavioural Counselling Form (Appendix B) to pair with the counselling session and the document was walked through during the remote, Zoom-held counselling session. The form outlined some of the negative health consequences of prolonged sedentary behaviour and some benefits of breaking up said sedentary behaviour. Also included on the form were the objectives of the intervention: break up extended periods of consecutive sitting, increase sitting break frequency, for every 30-45 minutes of consecutive sitting, break the behaviour for 3 minutes, and increase non-sedentary behaviours (i.e., standing, stretching, walking/light physical activity). The HAPA constructs that the intervention was targeting, action planning and coping planning, were also included on the Behavioural Counselling Form. Beneath the objectives and definitions, the participants could find a table to create their own action plans and coping plans. The table included headings drawn from the FITT principle: Frequency, Intensity, Time, and Type. Frequency is how often a strategy should be sued; Intensity is the duration of breaks from sitting; Time is when the strategy should be enacted; and Type is the activity done during the break from sitting. These headings were for the participants to use to specify their action and coping plans to their personal work environments. During the behavioural counselling sessions, the researcher went over the Behavioural Counselling Form with the participant, taking time at each section of the worksheet to expand on the information provided and afford the participant an opportunity at any time to ask questions. When the researcher arrived at the action and coping planning table, the researcher went over strategies with the participant that the participant felt would be manageable for their work environment and would work to achieve the objectives of the intervention. The researcher started with the creation of an

action plan and focused on highlighting to the participant that they should keep the strategies as specific and authentic to themselves as possible, in order to increase the chance of adherence and effectiveness. After a strategy was formulated, the researcher asked the participant how realistic and manageable the strategy was. Coping strategies were created to pair with the action plans, the participant was asked if they could think of any challenges that might arise from their new action plan and what might be done to overcome said challenges. The researcher placed an emphasis on the participants creating precise and personal plans and encouraging the participant to do the same as they create their own action and coping plans throughout the intervention. The intervention strategies highlighted in the counselling sessions were grounded in the HAPA model, specifically focusing on the creation of action plans and the development of coping strategies. All counselling sessions were kept as consistent as possible, with respect to the tone, demeanor and setting of the session. After the researcher and the participant created one or two specific and meaningful action and coping plans, the researcher expressed that the rest of the intervention would carry out similarly, however through the downloaded mobile application, SEMA3. The SEMA3 app would notify the participant to complete their action and coping plans, the HAPA Intervention Worksheet (Appendix B), for the week once a week, at the beginning of the week through the mobile application. They were prompted to refer to the information conveyed in the one-on-one counselling session when they were completing the worksheet in the following weeks. Participants were notified at the beginning of the week to complete their weekly action and coping plans, however the platform allowed them to create as many action and coping plans as they wished throughout the week. This measure was taken so participants could alter their plans if there was a sudden change in their work environment or if they wished to update or modify their strategies. Participants in this group completed the weekly sedentary behaviour questionnaires at the end of their work week for their baseline and the next four weeks, the PSS during baseline and at week 4, and the HAPA Intervention Worksheets at the beginning of each week, week 1 – 4.

2.1.9 Control

Participants randomized into the control arm of the study received no intervention or further information apart from the Letter of Information and the initial eConsent meeting held over Zoom. Participants in this group completed the weekly sedentary behaviour questionnaire at the end of their work week for their baseline measure and over the next four weeks as well as the PSS during baseline and at week 4.

2.1.10 SEMA3

The SEMA3 mobile application, designed by researchers from the University of Melbourne, is a suite of software intended for intensive longitudinal survey research using iOS and Android smartphones (Koval et al., 2019). The SEMA3 app has been traditionally used for Ecological Momentary Assessment (EMA) applications such as in Schulz and colleagues (2021) where SEMA3 was utilized to capture the development of COVID-19 worries or in a study assessing time-dependent fluctuations of emotions, physical complaints, intention, and self-efficacy in older adults (Maes et al., 2022). However, SEMA3's robust software has been used as a conduit for intervention work that has yielded significant results. For example, Rohde and associates (2022) implemented a self-efficacy intervention through the mobile application to improve key mental health outcomes. The researchers programmed SEMA3 to deliver the ecological momentary intervention, a self-efficacy training intervention, to be released at fixed time points and improved hopelessness and trait anxiety (Rohde et al., 2022).

In the current study, the mobile application was used for data collection and for implementation of the sedentary intervention. SEMA3 was used to deliver all questionnaires (modified SIT-Q 7d break frequency and break duration, OSPAQ, and the PSS) and the HAPA Intervention Worksheets (Appendix B) to a participant's smartphone at fixed intervals. The HAPA Intervention Worksheets were an extension from the behavioural counselling session hosted at the beginning of the intervention period. Participants were accompanied with a unique identifier that paired their entries through the application with their person. This was used for the fidelity check as a measure of

compliance. Participants also completed the demographic questionnaire through SEMA3. Participant information was secured through the SEMA3 servers.

2.1.11 Procedure

Approval for the study was obtained through the Research Ethics Board of Western University. Participants were recruited from large businesses and corporations throughout Canada through targeted emails, either the Individual Contact Email (Appendix A) or the Executive Contact Email (Appendix A). After office-working adults were screened for eligibility and elected to take part in the study, they received a second recruitment email, the Individual Contact Email (Appendix A), containing the Letter of Information and Consent (LOI/C) (Appendix A) and were asked to set up a Zoom meeting through the Western University Corporate Zoom. This Zoom meeting would serve to collect consent from the participant and provided the opportunity to go over the LOI/C. Participants were instructed to take as much time as they required to review the LOI/C before notifying the researcher of an appropriate time to schedule a meeting. Upon completion of the consent discussion, the individual received a unique link to sign the LOI/C through the Qualtrics survey service. After completion of the eConsent, participants were randomized, using an online research randomization program, into either the intervention group (SEMA3 mHealth HAPA intervention) or a no-contact control group. After the randomization, all participants received a personalized email with details to download the SEMA3 mobile application as well as brief information on how to use the application and how it would be used for the weeks to come. SEMA3 was used throughout the study to deliver questionnaires that assessed key variables as well as to deliver the HAPA based action and coping planning intervention. Sedentary behaviour and non-sedentary behaviours were measured at baseline and at the end of Weeks 1 – 4. Perceived stress was measured at baseline and at the end of Week 4. Paired with the email detailing the downloading of SEMA3, participants also received a notification from researchers indicating their first questionnaires were to be sent out at the end of the week that they provided consent. For both groups, they received a notification from SEMA3 to fill out the OSPAQ and Modified SIT-Q 7d questionnaires as well as a brief demographic questionnaire. The intervention group were also asked to provide a day and time to hold a one-on-one

behavioural counselling session to be held online over Zoom. To ensure standardization between participants, the researcher implemented all the HAPA based counselling sessions. The participants in this group received an email with the Behavioural Counselling Form (Appendix B). The researcher used the share screen function on Zoom to display the two pages so that both the researcher and the participant could follow along, however, the participant was also encouraged to print out the documents. The researcher then implemented the behavioural counselling intervention, detailed in the intervention section above. The total time for the behavioural counselling session was around 30 minutes. Through the next four weeks (Week 1 – 4) of the intervention, the participants in the intervention group received the HAPA Intervention Worksheet through the SEMA3 smartphone app where they were to create action plans and coping strategies for their week to come. The total time for this process each week was around 10 minutes. The control group received no additional information or resources throughout the study. They only received weekly notifications through SEMA3 to complete the OSPAQ and Modified SIT-Q 7d questionnaires as well as the PSS (during baseline and Week 4). Upon completion of the intervention period, Week 1 – 4, participants in both groups were notified through email that their weekly questionnaires and worksheets pushed through the SEMA3 app were to be stopped. Regardless of group assignment, all participants completed the same sedentary behaviour questionnaire sent through the SEMA3 mobile app, the OSPA-Q and Modified SIT-Q 7d, for the baseline period (Week 0), Week 1, Week 2, Week 3, and Week 4. Furthermore, each participant received the PSS questionnaire through the SEMA3 mobile app for the baseline period (Week 0) and Week 4. All questionnaires can be found in Appendix B.

2.1.12 Statistical Analysis

2.1.12.1 Primary and secondary outcome analyses

A series of 2 (group) by 5 (time [baseline (Week 0), Week 1, Week 2, Week 3, Week 4]) repeated measures MANOVAs were conducted for each occupational sitting related variable: break frequency, break duration, time spent sitting at work, time spent standing at work, and time spent moving at work, to identify possible time by group interaction effects. Furthermore, for the health-related outcome of perceived stress, a 2 (group) by 2

(time [baseline (Week 0), Week 4)] repeated measure MANOVA was used to identify possible interaction effects. P-value was set at 0.05 and partial eta squared values (η_p^2) are reported along with corresponding P values. A partial eta squared (η_p^2) of 0.01, 0.06, and 0.14 represented small, medium, and large effect sizes, respectively (Stevens, 1996). Data were analyzed using IBM SPSS Statistics (Version 28.0.1.1).

2.2 Results

2.2.1 Missing Data

Of the possible 448 total questionnaires that could have been completed, 48 questionnaires (10.7%) were either unanswered or missing. Of the 217 possible questionnaires for the intervention group, 24 (11.1%) were either unanswered or missing. 1 participant of the intervention group dropped out after allocation, before completing any questionnaires and 5 participants dropped out at the end of Week 2 (Figure 2). Of the possible 231 questionnaires for the control group, 24 (10.4%) were either unanswered or missing. 1 participant dropped out of the control group after allocation, before completing any questionnaires and 4 participants dropped out at the end of Week 2 (Figure 2). Independent samples *t*-tests revealed no significant differences (all *p*-values > 0.05) in the demographic variables for those that completed the study compared to those who did not. There was no differential loss, greater loss to one group or the other, between the intervention group and the control group for those that dropped out during the study. All missing data were considered random. A multiple imputation sensitivity analysis was conducted to test the missing data for significance. Multiple imputation is a technique for analyzing data sets with missing values (Sinharay et al., 2001). The multiple imputation data set provided results for the sedentary outcomes that were non-significantly different from the complete data set, as such the complete data set was used for the remainder of the analysis (n = 53).

2.2.2 Data Exclusion

For any outliers in the data a Winsorization technique was used to replace any data points over the 95th percentile with the value of the 95th percentile and the same process was conducted with any data points under the 5th percentile were replaced with the value of

the 5th percentile. A total of 70 data points out of 2915 primary and secondary outcome data points were imputed this way (16 in the intervention group and 54 in the control group). This method has been shown to be a valid approach to treat outliers (Dixon & Tukey, 1968; Tukey & McLaughlin, 1963; Guttman & Smith, 1969; Hawkins, 1980; Duan, 1998).

2.2.3 Fidelity Check

All questionnaires (sedentary behaviour questionnaires, perceived stress scale, and the HAPA intervention worksheet) could be tracked through the SEMA3 mobile application for: if/when it was sent, if/when the participant had started, and if/when the participant completed the questionnaire. Action and coping plans created in the one-on-one behavioural counselling session were continued in some form through the HAPA Intervention Worksheet in the SEMA3 app for each week during the participant's study period with 100% completion for each participant.

2.2.4 Group Equivalency

Fifty-three office-working adults (79.2% women, Mean age = 40.3 +/- 11.9) were recruited to participate in the study. Twenty-five participants were randomized into the HAPA intervention group (68.0% women, Mean age = 39.6 +/- 11.9) and twenty-eight participants were randomized into the no-contact control group (89.3% women, Mean age = 40.9 +/- 12.1). Descriptive statistics for the demographic variables are shown in Table 1. Independent t-tests showed no significant group differences for the all of the demographic measures at baseline: age, t (51) = -0.381, $p = 0.705$, sex, t (51) = -1.939, $p = 0.058$, gender, t (51) = -1.939, $p = 0.058$, ethnicity t (51) = -1.814, $p = 0.076$, education, t (51) = -1.232, p = 0.224, work environment, t (51) = -1.465, $p = 0.149$, work sector, t (51) = -0.607, $p = 0.546$, and work hours, t (51) = 1.486, $p = 0.144$.

Baseline descriptive statistics for break frequency, break duration, sitting minutes/week, standing minutes/week, moving minutes/week, and perceived stress are shown in Table 2 – 7. Independent t-tests showed no significant group differences at baseline for break frequency, t (51) = 1.455, $p = 0.152$, break duration, t (51) = -1.922, $p = 0.060$, standing minutes/week, t (51) = 0.699, $p = 0.244$, and perceived stress, t (51) = 0.905, $p = 0.370$.

Baseline group differences were found for sitting minutes/week with the intervention group having reported higher sitting time at baseline, t (51) = 2.679, p = 0.010 and moving minutes/week with the control group reporting higher moving time at baseline, t (51) = -2.479, p = 0.017. Due to these differences, a MANCOVA controlling for these baseline scores was also conducted and reported for sitting minutes/week and moving minutes/week.

Table 1: Demographic Variables (Mean, Standard Deviation, Count, Percent)

	Intervention Group (n = 25)				Control Group (n = 28)			
Variable	M	SD	N	%	M	SD	N	%
Sex (Female)			17	68.0			25	89.3
Age (Years)	39.6	11.9			40.9	12.1		
Ethnicity:								
Canadian			0	0.0			1	3.6
Caucasian			23	92.0			22	60.7
European			0	0.0			1	3.6
Filipino			0	0.0			1	3.6
Hispanic			0	0.0			1	3.6
Japanese			1	4.0			0	0.0
Pakistan			1	4.0			0	0.0
Romanian			0	0.0			1	3.6
Southeast Asian			0	0.0			1	3.6
Work Environment:								
Home			9	36.0			6	21.4
Hybrid			11	44.0			12	42.9
Office			5	20.0			10	35.7
Work Sector:								
Private			3	12.0			5	17.9
Public			20	80.0			18	64.3
Charity			0	0.0			0	0.0
Other			2	8.0			5	17.9
Education:								
Graduate Degree			9	36.0			8	28.6
Undergraduate Degree			15	60.0			15	53.6
Other			1	4.0			5	17.9
Hours of work/week	39.8	5.9			37.7	4.1		

2.2.5 Primary Outcomes – Break Frequency, Break Duration, Sitting Time

Descriptive statistics for the variable of interest are shown in Tables 2 through 4 and Figures 3 through 5. These data show the intervention group increasing the frequency of their breaks from roughly every 1.5 – 2 hours to every 45 minutes – 60 minutes and a no change in break frequency for the control group, roughly every 1 – 1.5 hours. These data also show that break duration remained relatively the same for both groups with the intervention group's break duration remaining at around 2 – 4 minutes and the control group around 3 – 5 minutes. These data also display a decrease in occupational sitting time from 2069.80 minutes/week to 1728.00 minutes/week for the intervention group and a small decrease for the control group, 1887.01 minutes/week to 1843.61 minutes/week.

2.2.5.1 Break Frequency

A significant time effect was found for break frequency, $F(4, 48) = 3.090$, $p = 0.024$, Wilks' $\Lambda = 0.795$, $\eta_p^2 = 0.205$. The observed power was 0.771. Additionally, a significant group by time interaction effect was obtained for break frequency, $F(4, 48) = 10.455$, $p < 0.001$, Wilks' $\Lambda = 0.534$, $\eta_p^2 = 0.466$. The observed power was 1.000.

2.2.5.2 Break Duration

No significant time effect was obtained for break duration, $F(4, 48) = 1.527$, $p = 0.209$, Wilks' $\Lambda = 0.887$, $\eta_p^2 = 0.113$. The observed power was 0.437. No significant group by time interaction effect was obtained either, $F(4, 48) = 0.152$, $p = 0.961$, Wilks' $\Lambda = 0.987$, $\eta_p^2 = 0.013$. The observed power was 0.079.

2.2.5.3 Sitting Time

A significant time effect was obtained, $F(4, 48) = 9.328$, $p < 0.001$, Wilks' $\Lambda = 0.563$, $\eta_p^2 = 0.437$. The observed power was 0.999. Additionally, a significant group by time interaction effect was obtained for sitting time, $F(4, 48) = 3.690$, $p = 0.011$, Wilks' $\Lambda = 0.765$, $\eta_p^2 = 0.235$. The observed power was 0.849. Controlling baseline sitting time, the interaction effect was no longer significant, $F(4, 48) = 0.584$, $p = 0.629$, Wilks' $\Lambda =$

0.965, $\eta_p^2 = 0.035$. The observed power was 0.162. However, the time effect remained significant, F (4, 48) = 2.810, $p = 0.049$, Wilks' $\Lambda = 0.851$, $\eta_p^2 = 0.149$. The observed power was 0.640.

2.2.6 Secondary Outcomes – Standing Time, Moving Time, Perceived Stress

Descriptive statistics for the variable of interest are shown in Tables 5 through 7 and Figures 6 through 8. These data reveal that the intervention group increased their standing time by 154.94 minutes/week and their moving time by 141.65 minutes/week. The control group increased their standing time by 33.39 minutes/week but decreased their moving time by 10.42 minutes/week. Additionally, these data show the intervention and the control group maintaining "moderate stress" between the baseline measurement and the end of week 4 (Cohen et al., 1983). However, both groups show improvement in a reduction of stress, the intervention group moving from a score of 18.80 to 16.10 and the control group reducing their score from 17.21 to 16.69.

2.2.6.1 Standing Time

A significant time effect was found for time spent standing at work, F (4, 48) = 5.980, $p < 0.001$, Wilks' $\Lambda = 0.667$, $\eta_p^2 = 0.333$. The observed power was 0.976. No significant interaction effect occurred, F (4, 48) = 1.928, $p = 0.121$, Wilks' $\Lambda = 0.862$, $\eta_p^2 = 0.138$.

2.2.6.2 Moving Time

A significant time effect was obtained, F (4, 48) = 5.619, $p < 0.001$, Wilks' $\Lambda = 0.681$, $\eta_p^2 = 0.319$. The observed power was 0.967. Additionally, a significant group by time interaction effect was obtained for moving time, F (4, 48) = 4.532, $p = 0.003$, Wilks' $\Lambda = 0.726$, $\eta_p^2 = 0.274$. The observed power was 0.919. Controlling baseline moving time, the interaction effect was no longer significant, F (4, 48) = 0.594, $p = 0.622$, Wilks' $\Lambda = 0.964$, $\eta_p^2 = 0.036$. The observed power was 0.164. The time effect remained significant, F (4, 48) = 3.845, $p = 0.015$, Wilks' $\Lambda = 0.806$, $\eta_p^2 = 0.194$. The observed power was 0.789.

2.2.6.3 Perceived Stress

A significant time effect was found for perceived stress at work, F (1, 51) = 7.226, p = 0.009, Wilks' Λ = 0.938, η_p^2 = 0.125. The observed power was 0.753. No significant interaction effect was found, F (1, 51) = 3.356, p = 0.073, η_p^2 = 0.062. The observed power was 0.436.

2.2.6.4 Work Environment Sub-Analysis

Due to COVID-19, it was unknown before recruitment and analysis how many participants in the present study worked from home or a hybrid of home and office. Hence, we decided to conduct a sub-analysis including the work environment as a factor after receiving the data from the demographics questionnaire in which work environment was inquired about. No significant interaction effect between intervention (treatment vs control), work environment (home, office, hybrid), and break frequency (time) was obtained, F (8, 88) = 1.055, p = 0.402, Wilks' Λ = 0.833, η_p^2 = 0.088. The observed power was 0.462. No significant interaction effect between intervention, work environment, and break duration was obtained, F (8, 88) = 1.320, p = 0.244, Wilks' Λ = 0.797, η_p^2 = 0.107. The observed power was 0.571. No significant interaction effect between intervention, work environment, and sitting time was obtained, F (8, 88) = 1.182, p = 0.319, Wilks' Λ = 0.815, η_p^2 = 0.097. The observed power was 0.516. No significant interaction effect between intervention, work environment, and workplace standing time was obtained, F (8, 88) = 0.614, p = 0.764, Wilks' Λ = 0.897, η_p^2 = 0.053. The observed power was 0.267. No significant interaction effect between intervention, work environment and workplace moving time was obtained, F (8, 88) = 1.051, p = 0.404, Wilks' Λ = 0.833, η_p^2 = 0.087. The observed power was 0.460.

Table 2: Means, Standard Deviations, and 95% Confidence Intervals for Frequency of Breaks at Each Time Point.

	Intervention Group (n = 25)			Control Group (n = 28)		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	4.93	1.31	[4.39, 5.47]	4.30	1.80	[3.60, 4.99]
Week 1	3.19	1.02	[2.77, 3.61]	4.72	1.73	[4.06, 5.39]
Week 2	3.40	1.15	[2.92, 3.88]	5.00	1.81	[4.30, 5.70]
Week 3	3.24	0.93	[2.86, 3.62]	4.66	1.65	[4.02, 5.30]
Week 4	3.20	1.12	[2.74, 3.66]	4.84	1.67	[4.20, 5.49]

Scores correspond as follows: **1.00** – less than every 30 min; **2.00** – every 30-45 min; **3.00** – every 45-60 min; **4.00** – every 1-1.5 hours; **5.00** – every 1.5-2 hours; **6.00** – every 2-3 hours; **7.00** – every 3-4 hours; **8.00** – every 4-5 hours; **9.00** – over every 5 hours; **10.00** – no interruption

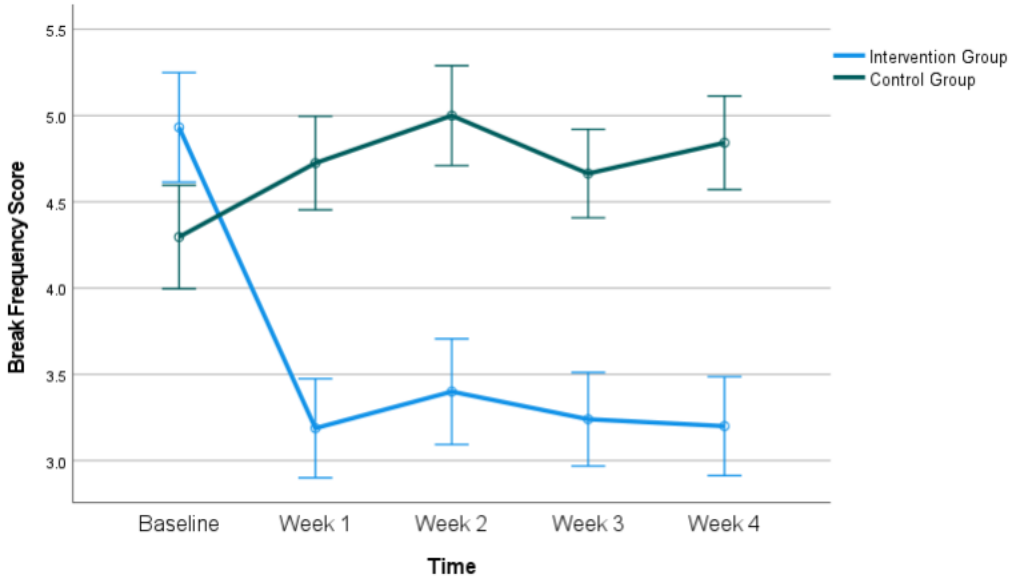

Figure 3: Frequency of breaks from sitting at each time point. Error bars represent standard error.

Scores correspond as follows: **1.00** – less than every 30 min; **2.00** – every 30-45 min; **3.00** – every 45-60 min; **4.00** – every 1-1.5 hours; **5.00** – every 1.5-2 hours; **6.00** – every 2-3 hours; **7.00** – every 3-4 hours; **8.00** – every 4-5 hours; **9.00** – over every 5 hours; **10.00** – no interruption

Table 3: Means, Standard Deviations, and 95% Confidence Intervals for Duration of Breaks at Each Time Point.

	Intervention Group (n = 25)			Control Group (n = 28)		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	4.65	1.98	[3.84, 5.47]	5.62	1.68	[4.97, 6.27]
Week 1	4.36	1.35	[3.80, 4.92]	5.57	1.67	[4.93, 6.22]
Week 2	4.72	1.59	[4.06, 5.38]	5.75	1.82	[5.05, 6.45]
Week 3	4.59	1.37	[4.02, 5.15]	5.74	1.67	[5.09, 6.39]
Week 4	4.72	1.51	[4.09, 5.35]	5.84	1.62	[5.21, 6.47]

Scores for Break Duration correspond as follows: **1.00** – less than 30 sec; **2.00** – 30 sec-1 min; **3.00** – 1-2 min; **4.00** – 2-3 min; **5.00** – 3-4 min; **6.00** – 4-5 min; **7.00** – 5-10 min; **8.00** – 10-15 min; **9.00** 15-30 min; **10.00** – more than 30 min

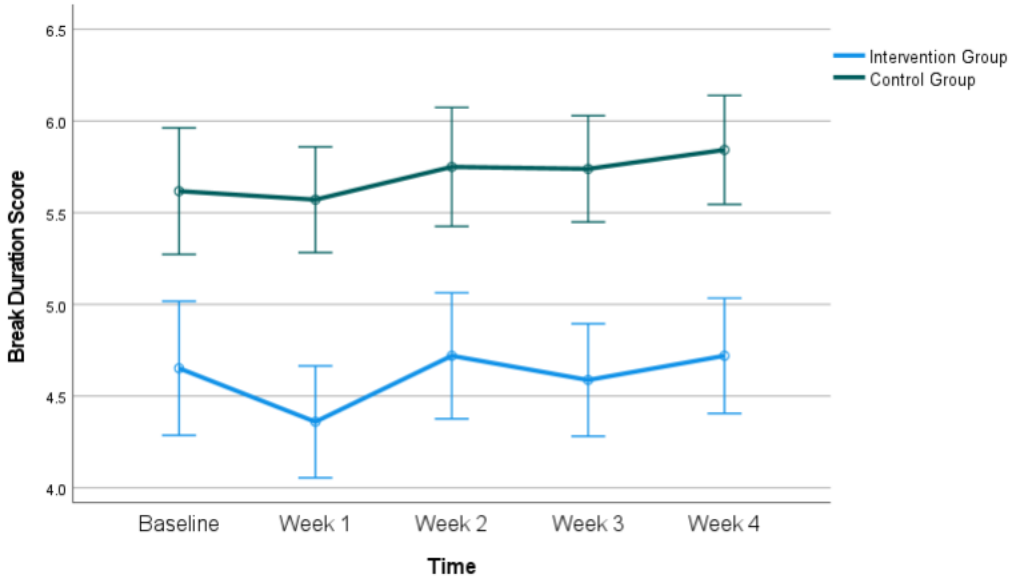

Figure 4: Duration of breaks from sitting at each time point. Error bars represent standard error.

Scores for correspond as follows: **1.00** – less than 30 sec; **2.00** – 30 sec-1 min; **3.00** – 1-2 min; **4.00** – 2-3 min; **5.00** – 3-4 min; **6.00** – 4-5 min; **7.00** – 5-10 min; **8.00** – 10-15 min; **9.00** 15-30 min; **10.00** – more than 30 min

Table 4: Means, Standard Deviations, and 95% Confidence Intervals for Occupational Sitting Time (min/work week) at Each Time Point.

	Intervention Group (n = 25)			Control Group (n = 28)		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	2069.80	275.45	[1956.10, 2183.50]	1887.01	220.65	[1801.45, 1972.57]
Week 1	1853.74	328.58	[1718.11, 1989.37]	1850.28	314.05	[1728.51, 1972.06]
Week 2	1846.92	296.38	[1724.58, 1969.26]	1885.46	246.01	[1790.06, 1980.85]
Week 3	1740.36	395.40	[1577.15, 1903.57]	1747.54	268.17	[1643.55, 1851.52]
Week 4	1728.00	331.28	[1591.26, 1864.74]	1843.61	278.03	[1735.80, 1951.42]

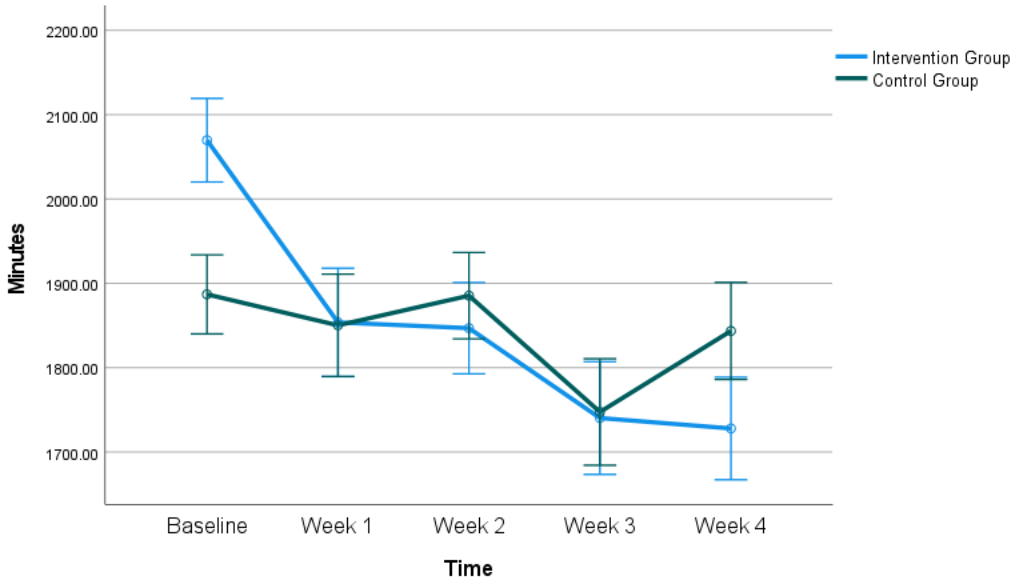

Figure 5: Time spent sitting at work per work week at each time point. Error bars represent standard error.

Table 5: Means, Standard Deviations, and 95% Confidence Intervals for Occupational Standing Time (min/work week) at Each Time Point.

	Intervention Group (n = 25)			Control Group (n = 28)		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	167.02	126.68	[114.72, 219.31]	144.71	105.26	[103.92, 185.56]
Week 1	266.88	192.84	[187.28, 346.48]	185.73	130.12	[135.27, 236.18]
Week 2	245.74	190.46	[167.12, 324.35]	161.68	99.45	[123.12, 200.24]
Week 3	290.40	215.58	[201.41, 379.39]	203.16	183.89	[131.85, 274.46]
Week 4	321.96	230.30	[226.90, 417.02]	178.13	145.19	[121.83, 234.43]

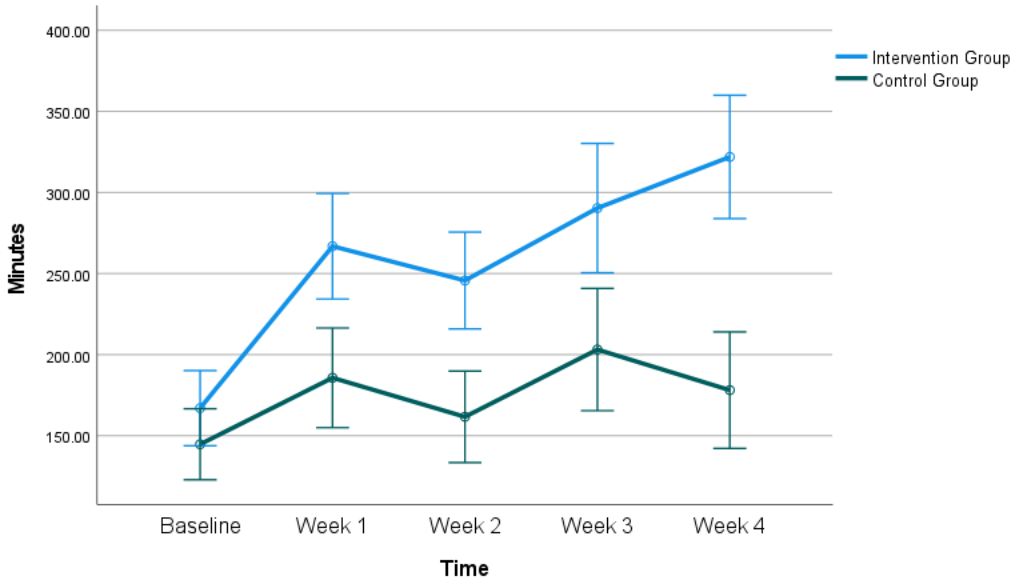

Figure 6: Time spent standing at work per work week at each time point. Error bars represent standard error.

Table 6: Means, Standard Deviations, and 95% Confidence Intervals for Occupational Moving Time (min/work week) at Each Time Point.

	Intervention Group (n = 25)			Control Group (n = 28)		
Time	M	SD	95% CI	M	SD	95% CI
Baseline	124.70	103.73	[81.89, 167.52]	220.64	166.74	[155.99, 285.30]
Week 1	188.52	125.23	[136.83, 240.21]	177.54	136.69	[124.54, 230.54]
Week 2	252.53	150.48	[190.41, 314.64]	217.07	114.21	[172.79, 261.36]
Week 3	220.91	160.93	[154.48, 287.34]	200.08	137.88	[146.61, 253.54]
Week 4	266.36	174.74	[194.23, 338.49]	210.22	126.00	[161.36, 259.08]

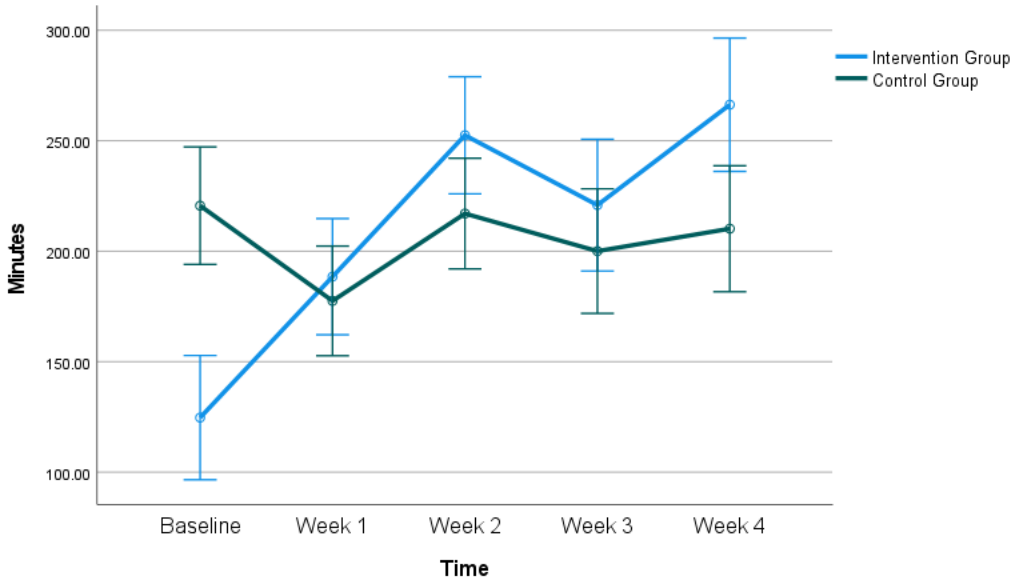

Figure 7: Time spent moving at work per work week at each time point. Error bars represent standard error.

Table 7: Means, Standard Deviations, and 95% Confidence Intervals for Perceived Stress at Baseline and Week 4.

Time	Intervention Group (n = 25)			Control Group (n = 28)		
	M	SD	95% CI	M	SD	95% CI
Baseline	18.80	5.46	[16.55, 21.05]	17.21	7.12	[14.44, 19.97]
Week 4	16.10	6.44	[13.45, 18.76]	16.69	7.40	[13.82, 19.56]

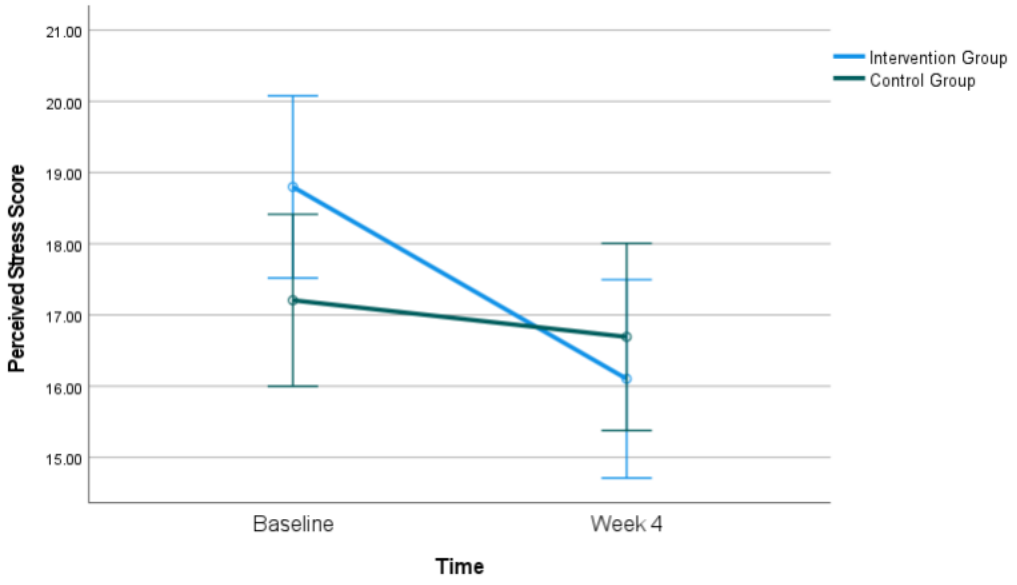

Figure 8: Perceived stress scores at each time point. Error bars represent standard error.

3 Discussion

The primary aim of the current study was to investigate whether a mHealth HAPA based action and coping planning intervention would improve desk-based office workers' sedentary profiles; increasing break frequency and break duration as well as decreasing the time of workers spent in sedentary behaviours and increase the time spent engaged in non-sedentary behaviours (i.e., standing and moving) during occupational hours. A secondary aim of the study was to determine if a mHealth HAPA based action and coping planning sedentary behaviour intervention would affect the perceived stress levels of desk-based office workers from pre- to post-intervention, as compared to participants in a no contact control group. Using a 4-week parallel two-arm randomized controlled trial, the intervention group received a one-on-one behavioural counselling session that featured information on sedentary behaviour as well as a HAPA-based intervention that focused on creating participant specific action and coping plans for increasing sedentary break frequency and reducing sitting time at work. The intervention group also received an mHealth component where they created, refined, and built upon the action and coping plans they created in the counselling session and inputted the strategies weekly into a downloaded mobile application. The control group received no further information from the Letter of Information and the initial eConsent meeting. Both groups completed sedentary behaviour questionnaires at baseline and at the end of each week for the duration of the study as well as a questionnaire focusing on perceived stress at baseline and at the end of week 4. Overall, moderate to large significant effects that favoured the intervention group were found for most sedentary behaviour related variables. These results provide evidence that a HAPA-based sedentary behaviour intervention can promote improvements in the sedentary behaviour profiles of office-workers. Detailed analysis and critique of these general observations warrant expansion and further discussion.

3.1 Sedentary Behaviour Findings

3.1.1 Break Frequency

The group by time interaction effect for the primary outcome of occupational sedentary behaviour break frequency was statistically significant and the accompanying effect size was large. From baseline to follow-up, break frequency score decreased from 4.93 to 3.20 for the intervention group and increased from 4.30 to 4.84 in the control group. This translates to an increased break frequency of roughly every 1.5 – 2 hours to every 45 – 60 minutes for the intervention group and no change for the control group, every 1 – 1.5 hours. These findings are in line with those of Sui and Prapavessis (2017), Rollo and Prapavessis (2020) as well as Dillon and colleagues (2022) where 8-week HAPA-based action and coping planning interventions were employed and resultant increases in break frequency were observed, 90.54 minutes to every 58.39 minutes, 97.38 minutes to every 63.86 minutes and 106.60 minutes to every 83.04 minutes respectively.

3.1.2 Break Duration

Break duration did not result in a significant group by time effect or a time effect highlighting that break duration remained relatively constant throughout the study. These findings were consistent with those of Dillon and associates (2022) where no significant group by time effect or time effect were observed. However, this is contrary to other similar sedentary interventions in which break duration scores decreased over time, resulting in participants' sedentary behaviour breaks lasting for a greater amount of time (Sui & Prapavessis, 2017; Rollo & Prapavessis, 2020). The current study indicated a slight trend for break duration to increase with the implementation of the intervention method. With break duration remaining relatively constant across all time points in the study, it works to demonstrate that no cost trade off occurred in the intervention group. As break frequency increased in the study, break duration remained constant, possibly leading to a rise in overall sedentary break time. If the inverse were true, and break duration fell resulting in shorter breaks from sedentary behaviours, then a cost-trade off could have occurred resulting in possible no change or a negative effect to overall sitting time.

3.1.3 Sitting Time

The group by time interaction effect for occupational sitting time was statistically significant, where from baseline to follow up, the intervention group reduced their sitting time by 341.8 minutes/workweek or 68.36 minutes/workday. When compared to the literature, workplace sedentary interventions typically show a significant workplace reduction of -39.6 minutes/8-hour workday and similar educational/behavioural strategy interventions show a sitting reduction of -15.5 minutes/8-hour workday, the results from the current study are encouraging (Chu et al., 2016). The occupational sitting time results from the current study are comparable to the pooled intervention effects of the multi-component and environmental interventions featured in the review from Chu and colleagues (2016), -68.36 minutes/workday, -88.8 minutes/workday, and -72.8 minutes/workday, respectively. Previous technology-enhanced interventions yielded sitting time reductions of around 41.28 minutes/workday and a similar mHealth HAPA driven intervention yielded sitting time reductions of 87.54 minutes/workday (Stephenson et al., 2017; Rollo & Prapavessis, 2020, respectively). The current study's sitting time reduction (68.36 minutes/workday) falls in between the two points indicating promising results for the employed intervention. However, in the current study, the baseline workplace sitting times were significantly different between the intervention and the control groups where the intervention group reported an initial higher degree of sitting time. When a post hoc analysis controlled baseline sitting times between groups, the time by group interaction was no longer significant, however the time effect held. While the time by group interaction did not remain significant, the data were trending towards a difference and the effect size was moderate ($\eta_p^2 = 0.035$) suggesting that the intervention could have affected the outcome, however the analysis was not adequately powered. The drop in significance may be explained in that by controlling for the baseline data, the removal of the time point, it did not capture the main essence of the intervention. Participants created initial action and coping plans and modified them, or maintained them throughout the intervention period, indicating that the main reduction or difference in sitting time would occur from time point 1 (baseline) to time point 2 (Week 1).

With that being said, the effects seen in the intervention group may have partly been due to their greater sitting time starting point, whereby starting the study with larger amounts of sitting, it may have afforded participants in the intervention group greater room to change those sitting minutes into non-sedentary behaviours. This difference in sedentary level should be looked at more deeply in future research.

3.1.4 Standing Time & Moving Time

The non-sedentary behaviours featured in the current study, workplace standing time and workplace moving time both featured significant time effects which might help to explain the reductions found in workplace sitting time. No significant group by time effect was seen for workplace standing time while the analysis of workplace moving time obtained a significant group by time interaction with a large effect size. Workplace standing time increased by 30.99 minutes/workday – a difference from the control group by 24.31 minutes/workday. Even though this difference was non-significant, the effect size was large ($\eta_p^2 = 0.138$) indicating that while the analysis was underpowered, the intervention may have affected this measure. Workplace moving time increased by 28.33 minutes/workday in the intervention group from baseline to follow-up – a difference of 30.42 minutes/workday when compared to the control group. This significant time by group effect did not hold when further analysis controlled for group differences in baseline moving time, the time effect held its significance. However, much like with sitting time, the data was trending towards a difference and the effect size was moderate ($\eta_p^2 = 0.036$). Taken together changes seen in non-sedentary behaviours (i.e., standing and moving) are clinically meaningful, where a displacement of at least 30 minutes of sedentary time can benefit cardiometabolic risk markers and other health outcomes (Buman et al., 2013; Peachey et al., 2018)

The current study's increases in non-sedentary behaviours are less than studies evaluating large-scale multi-component (62 – 101 min/workday) and environmental interventions (76 – 83 min/workday) (Chau et al., 2014; Neuhaus et al., 2014; Pederson et al., 2014 Kerr et al., 2016). However, these changes in occupational standing and moving time might be clinically significant and suggest that a low-burden mHealth theory-driven

intervention may produce notable increases in non-sedentary behaviours at work. The differences in the magnitude of effects may be a result of difference focuses of the interventions. While multi-component and environmental manipulations focus more on the overt non-sedentary behaviours, the current study focused on breaking prolonged bouts of workplace sedentary time using self-regulatory and self-monitoring strategies. Where the former may promote larger differences in non-sedentary behaviour outcomes, the latter takes into account the specificity of each individual participant and allows them to create strategies that they may find effective with the hope of long-term adoption or habituation.

3.1.5 Perceived Stress

The current study also investigated whether a sedentary behaviour intervention had any effect on perceived stress. No group by time interaction was found. With that being said, the accompanying effect size of the group by time interaction was moderate in size (η_p^2 = 0.062), which may suggest that the intervention could have possibly influenced this outcome measure; however, the study might not have been adequately powered to display such an interaction effect. This type of intervention could affect stress levels in that the activity that the participant selected to introduce during their break from sitting could work to reduce stress levels. The activity/strategy was developed and selected by the participant, with guidance from the researcher, thus the activity would most likely have been meaningful or manageable to the participant, activating a potential pathway highlighted in Teychenne et al. (2019) where the activity replacing the sedentary behaviour could help against psychological stress. The perceived stress results are consistent with current literature concerned with the comparison of perceived stress and sedentary behaviour. Interventions studies looking at perceived stress as a secondary outcome vary in significance (Dedele et al., 2019; Rebar et al., 2014). While the current study obtained a non-significant time by group interaction effect, a positive trend appeared in the data. These findings indicate that further research should be conducted with perceived stress as a focus of the experiment and larger samples should be utilized to increase the power of analysis to detect possible differences. A plethora of personal factors can influence a person's reported perceived stress (i.e., personal characteristics,

lifestyle, social support, etc.) as well as larger scale societal or environmental factors (Phillips, 2013). Larger sample sizes as well as testing for group equivalency on different factors of perceived stress may be able to provide more suitable grounds for assessing the relationship between perceived stress and sedentary behaviour.

3.1.5.1 Work Environment

A sub-analysis was conducted for the interaction of work environment on the sedentary behaviour intervention across all time points. No treatment group by work environment by time interaction was obtained for any of the sedentary behaviour outcomes break frequency, break duration, sitting time, standing time, or moving time. These results may be explained due to the relatively small group sizes not providing the power needed for the detection of differences between groups. With than being said, taken as they are, these results suggest that the type of intervention implemented, a mHealth, HAPA-based action and coping planning intervention, produces similar results regardless of the work environment that its participants are in. This could have important and novel consequences as the dynamic nature of the current work setting makes the implementation of large-scale environmental or multi-component manipulations increasingly more difficult. However, the group by time by work environment analysis could not be highlighted as one of the current study's main research questions as the work landscape due to the COVID-19 pandemic was unclear and group distribution was unknown at the time. Nonetheless, further research should look to expand upon these preliminary findings to elucidate if the changing work environment of office-workers has any significant impact on the implementation of sedentary behaviour interventions and whether that is true across the three different main intervention types, multi-component, environmental, and educational/behavioural.

3.1.6 Effectiveness of Methods

The methods employed in the current study proved to be effective in creating a change in the sedentary profile of the office working participants. This intervention differs from previous HAPA-based sedentary behaviour interventions in that it allowed participants to continually access and reflect upon the volitional principles of the HAPA theory, action

and coping planning. Previous similar studies involved the creation of action and coping plans at the beginning of the intervention period and came with the expectation that participants would remain with that plan throughout the timeline of the study (Sui & Prapavessis, 2017; Rollo & Prapavessis, 2020; Dillon et al., 2022). In the current study, participants could mold their action and coping strategies to their changing work environment and build on strategies as the weeks progressed, accessing more layers of the HAPA model as well as targeting self-monitoring, which has been shown to enhance the impact of a HAPA-based intervention (Chu et al., 2016). The results from the current study are on par with those obtained in Rollo & Prapavessis (2020) with respect to sedentary behaviour outcomes while employing an intervention with less participant burden. Instead of daily "mini-booster interventions" comprising of motivational and factual text messages, participants in the current study were asked to engage in HAPA-principles at the beginning of each week through the mobile application SEMA3. The usage of this mHealth technology to deliver an immersive intervention was the linchpin of the study. This technology allowed participants to have the opportunity to remain involved in the principles that were targeted during the initial counselling session and adapt them to their changing work and world environment. The significant results of the present study demonstrate the same success that SEMA3 has seen as a conduit for behaviour change in other fields of study (i.e., Rohde et al., 2022). Furthermore, the results of the current study display the potential that completely online or remote sedentary behaviour studies have. In the process of removing any in person content of the intervention, similar results were obtained. This alone has extensive implications for sedentary behaviour interventions studies with regards to scalability and universal implementation as it has been shown that face-to-face components may not be needed as a precursor for meaningful change. The current findings demonstrate that a remote and low-cost and low-burden intervention could be used as a potential strategy to reduce occupational sedentary behaviours in office working adults.

3.1.7 Strengths

The current study has a variety of strengths including a randomized controlled trial and repeated measures design, the use of valid and reliable sedentary behaviour and perceived

stress measures. Another strength of the study was the high participant compliance rate (89.29%). Furthermore, the inclusion of a well-established behaviour change theory, the HAPA model, delivered through an mHealth medium (SEMA3) can be seen as a strength as it was used to guide the counselling sessions and intervention. The mHealth component allowed the participants to remain engaged in the theory-based strategies and principles that were the foundation of the intervention. Another strength of the study was the recruitment and population of intervention itself. By offering the study completely online, it reduced the participant burden and aligned the intervention with the guidelines present during the COVID-19 pandemic. Additionally, the timing of the intervention was a strength as it allowed the researchers to collect novel data on the changing work environments of the participants. Finally, the ease of implementation and the low-cost nature as well as the scalability of the intervention are strengths of the study.

3.1.8 Limitations

The main limitation of the study was the use of self-report measures for sedentary behaviour data collections. These data collection methods have been shown to be affected by participant bias and underestimation of sedentary time and overestimation of non-sedentary time. Device measured data would have gained the researchers greater insight into the true nature of participant's sedentary profiles as self-report measures typically underreport both sedentary and non-sedentary behaviour outcomes (Prince et al., 2019) as well as corroborate their adherence to action and coping plans throughout the study. However, the measures used to collect such outcomes, the OSPAQ and Modified SIT-Q 7d, have been shown to be valid and reliable measures (Chau et al., 2012; Sui & Prapavessis, 2016). Another limitation to the current study was the lack of follow-up period. Including a follow-up would allow the analysis of the stability of the intervention effects over time after the intervention had ceased. Time constraints of the Master's program limited the researchers in implementing such a design. Another limitation is the reduced sample size, falling short of the a priori sample size calculation. This reduced the power of subsequent analyses on different sedentary behaviour outcomes. Lastly, the sample characteristics are a limitation. The current sample was made up of predominantly

Caucasian women working in the public sector. This lack of diversity in the sample may reduce the generalizability to a universal office-working audience.

3.1.9 Avenues for Future Research

This study looked at implementing an mHealth theory-based intervention in office workers to reduce prolonged sedentary behaviour. Future research continuing this line of inquiry could assess this type of intervention in exclusively hybrid work environments or exclusively home-work environments. This could work to expand upon the preliminary data that was obtained in the current study and explore the newer work environments that have become more popular due to world events. The outcomes of these experiments could impact the implementation of new sedentary behaviour interventions, guiding them if they need to be adapted to different environments/constraints or whether there is a strategy that could apply to all situations. Another direction for future research would be to include objective measures in the collection of sedentary behaviour outcomes. This adaptation would allow for a more accurate insight into the measures of sedentary behaviour as well as the effects of the intervention on participants. A longer intervention and follow-up period would also allow for more insight into the maintenance component of the HAPA model (i.e., action control). Time constraints limited the length of the current study, so by adding a longer treatment period and a follow-up, future research could analyze if a maintenance effect is obtained and whether there are lasting effects or habit formation. Lastly, including a second control group that receives a condition not related to the intervention could be beneficial for future research. By including this type of equal contact group, it could work to provide insight into the possible incidental effects of the intervention.

3.2 Conclusions

The current study presents evidence that a theory-driven SEMA3 delivered mHealth intervention can decrease sedentary behaviour in office-workers by increasing sedentary behaviour break frequency.

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Appendix A

Individual Contact Email

Subject Line: Invitation to Participate in a Health Psychology Research Study

Study Title: Effects of a mHealth HAPA Based Intervention on Sedentary Behaviour and Stress among Desk-Based Office Working Adults

Hello,

You are being invited to participate in a research study examining occupational activity levels and perceived stress in office-working adults. This is a Master's research project being conducted by researchers in the School of Kinesiology at Western University.

If you choose to take part in this study, you will download a smartphone application that delivers surveys at fixed, scheduled, weekly intervals that measure past week workplace sedentary behaviour. The study would last for eight weeks and consist of a four-week intervention and a follow-up at the end of week eight. The total time commitment for the study is around 5 minutes per week. The goal of the study is to reduce work-related sedentary behaviour by increasing the frequency of sedentary breaks and the duration of those breaks. You would be allocated to either a control group, where no intervention is delivered, or a theory-based behaviour change intervention, where a behavioral counselling session focused on creating behavioural strategies will be paired with weekly worksheets and challenges focusing on topics covered in the counselling session delivered through the downloaded mobile application.

In total, you would complete six workplace behaviour questionnaires over the eight weeks (Baseline, Week 1, Week 2, Week 3, Week 4, and Week 8) each requiring around 5 minutes to complete. Additionally, you will be completing a perceived stress questionnaire twice over the study (Baseline and Week 4). At the beginning of the study, a link for the mobile application would be emailed to your inbox. All data, from the mobile application and questionnaires will only be accessible to the researchers and will be encrypted and stored in a secure server database.

A recruitment poster with brief study information and participant details has been attached to this email. If you would like more information on this study please contact the researcher, Brett Carter, by email at [redacted].

Thank you,

Brett Carter

Executive Contact Email

Subject Line: Invitation to Participate in a Health Psychology Research Study

Study Title: Effects of a mHealth HAPA Based Intervention on Sedentary Behaviour and Stress among Desk-Based Office Working Adults

Hello,

You are being contacted as (fill in role) for (fill in company name). We are conducting a research study examining occupational activity levels and perceived stress in desk-based office working adults and your company is being invited to participate. We would appreciate your help with recruitment by forwarding the attached materials, a recruitment poster with brief study information and participant details, to your employees. If there is a more appropriate person at your company to help us distribute our recruitment materials, please let us know.

This is a research project being conducted by researchers in the School of Kinesiology at Western University for a Master's project.

If you would like more information about the study or have any direct questions, please contact the researcher, Brett Carter, by email at [redacted].

Thank you,

Brett Carter

Initial Contact Email

Subject Line: Invitation to Participate in a Health Psychology Research Study

Study Title: Effects of a mHealth HAPA Based Intervention on Sedentary Behaviour and Stress among Desk-Based Office Working Adults

Hello,

Thank you for your interest in participating in a research study examining occupational activity levels and perceived stress in desk-based office working adults. This is a Master's research project being conducted by researchers in the School of Kinesiology at Western University.

To be eligible to participate, you are required to: i) be 18 years of age or older, ii) be a full-time employee in a desk-based office job (work from home accepted), iii) have access to a smartphone with an internet connection, and iv) be able to read and write in English. The study would last for eight weeks, comprising of a four-week intervention and a follow-up at the end of week eight. The study would consist of participants downloading a smartphone application that delivers surveys at fixed, scheduled, weekly intervals that measure past week workplace sedentary behaviour and perceived stress.

Please review the Letter of Information for this study that is attached to this email for further information.

If you meet these eligibility criteria and would like to arrange an online meeting with the researcher to provide informed consent, or if you have any further questions, please contact Brett Carter by email at [redacted].

Thank you,

Brett Carter

Ethics Approval

Western Research

Date: 8 February 2022

To: Prof. Harry Prapavessis

Project ID: 120488

Study Title: Effects of a Mobile Health-Health Action Process Approach Based Intervention on Sedentary Behaviour and Stress among Desk-Based Office Working Adults

Application Type: HSREB Initial Application

Review Type: Full Board

Meeting Date: 25/Jan/2022 13:00

Date Approval Issued: 08/Feb/2022 16:42

REB Approval Expiry Date: 08/Feb/2023

Dear Prof. Harry Prapavessis

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above mentioned study as described in the WREM application form, as of the HSREB Initial Approval Date noted above. This research study is to be conducted by the investigator noted above. **All other required institutional approvals and mandated training must also be obtained prior to the conduct of the study**.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Email Script - Executive Contact Email 120488	Recruitment Materials	12/Jan/2022	2022/01/11
Email Script - Individual Contact Email 120488	Recruitment Materials	12/Jan/2022	2022/01/11
Email Script - Initial Contact Email 120488	Email Script	12/Jan/2022	2022/01/11
End of study letter 120488	End of Study Letter	12/Jan/2022	2022/01/11
HAPA Behavioural Counseling Information and Worksheet 120488	Other Data Collection Instruments	12/Jan/2022	2022/01/11
Recruitment Poster 120488	Recruitment Materials	12/Jan/2022	2022/01/11
Demographic Questionnaire - 120488	Online Survey	12/Jan/2022	2022/01/11
Perceived Stress Scale - 120488	Online Survey	12/Jan/2022	2022/01/12
HAPA Intervention Worksheet 120488	Online Survey	12/Jan/2022	2022/01/12
Sedentary Behaviour Questionnaire	Online Survey	07/Feb/2022	2022/02/07
Research Protocol 120488 2022-02-07	Protocol	07/Feb/2022	2022/02/07
LOIIC 120488 2022-02-07	Written Consent/Assent	07/Feb/2022	2022/02/07

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
TRAC Response Template - SEMA3	Technology Review document	11/Jan/2022	2022/01/11
Study Budget 120488	Study budget	12/Jan/2022	2022/01/11

No deviations from, or changes to, the protocol or WREM application should be initiated without prior written approval of an appropriate amendment from Western HSREB , 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.

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University HSREB operates in compliance with, and is constituted in accordance with, the requirements of the TriCouncil Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2); the International Conference on Harmonisation Good Clinical Practice Consolidated Guideline (ICH GCP); Part C, Division 5 of the Food and Drug Regulations; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

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

Ms. Nicola Geoghegan-Morphet , Ethics Officer on behalf of Dr. Philip Jones, HSREB Chair

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

Letter of Information/Consent

Study Title:

Effects of a Mobile Health-Health Action Physical Approach Based Intervention on Sedentary Behaviour and Stress among Desk-Based Office Working Adults

Principal Investigator

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

Co-Investigator

Brett Carter, MA Candidate (School of Kinesiology, Western University)

Conflict of Interest

There are no conflicts of interest to declare related to this study.

Introduction

You are being invited to participate in a research study exploring workplace related activity behaviours and stress in office-working adults because you work in an office setting. The purpose of this letter is to provide you with information require for you to make an informed decision regarding participation in this research.

Purpose of this Study

This is a research project being conducted by researchers in the School of Kinesiology at Western University and is a student project to meet degree requirements. The purpose of this study is to reduce sedentary behaviour in office workers by increasing the frequency of breaks from sedentary behaviour and the duration of those breaks. This purpose will be achieved through a theory based mHealth delivered intervention. The intervention involves a counselling session discussing goals and barriers and then weekly personal, goal-oriented worksheets sent through a smartphone app. In order to make comparisons,

we will also have a control run in parallel where we collect data but will offer no intervention.

Duration and Size of this Study

It is expected that you will be in the study for eight-weeks (Baseline (Week 0), Week1, Week 2, Week 3, Week 4, Follow-up (Week 8)). There are no in-person study visits as all communication will be primarily done through email. Up to 64 people will participate in this study.

Inclusion Criteria

To be eligible to participate in the study, individuals must (i) be 18 years of age or older, (ii) be a full-time employee in a desk-based office job (work from home accepted), (iii) own a smartphone with internet connection, (iv) and be able to read and write in English.

Study Procedures

If you decide to participate, then you will be "randomized" into one of the groups described below. Randomization means that you are put into a group by chance (like flipping a coin). There is no way to predict which group you will be assigned to. You will have a 1 in 2 chance of being placed in either group. Neither you nor the study staff can choose what group you will be in. You will be told which group you are in.

There will be no study visits during your participation in this study as all communication will be done online. There will be one meeting hosted through Western University's Corporate Zoom and the possibility of one other Zoom meeting, a behavioural counselling session, depending upon the random group assignment.

If you choose to take part in this study, you will be asked to participate in a Zoom meeting to go over the Letter of Information and Consent (Task 1). After consent has been obtained via an online Qualtrics survey, a survey delivery website, you will be emailed a link to download the SEMA3 mobile application to your smartphone (Task 2). This app will be the used for the delivery of the questionnaires that you will complete over the course of the intervention as well as a delivery method for the intervention itself.

After SEMA3 has been downloaded to your smartphone you will receive an email noting that your first questionnaires, a demographic questionnaire (Task 3), the sedentary behaviour questionnaires (Task 4), and a perceived stress questionnaire (Task 5), will be available on SEMA3 at the end of the week. Throughout the eight-week study, subsequent questionnaires will be sent out weekly, for a total of six questionnaires with each taking around 5 minutes to complete (Baseline (Week 0), Week 1, Week 2, Week 3, Week 4, Follow-up (Week 8)).

Approximately one half of participants will receive a single one-on-one online behavioural counselling session (Task 6) regarding work-related activity patterns, as well as weekly goal-oriented worksheets delivered on the SEMA3 app (Task 7). This group's aim will be to increase the breaking of consecutive work-related sedentary behaviour. Counselling strategies will be grounded in the Health Action Process Approach (HAPA) model, specifically focusing on the creation of an action plan and the development of coping strategies to increase sedentary behaviour breaks. The counselling session (Task 6) will be conducted over Zoom and will last for approximately 30 minutes. Additional to the counselling session (Task 6), participants in this group will also receive weekly goal-oriented worksheets sent through SEMA3 (Task 7). Through these worksheets you will be able to set weekly goals for yourself based on the concepts that were covered in the counselling session. You will also have the opportunity to consider possible barriers to achieving those goals for the week. The worksheets should take around 10 minutes to complete as we want you to create thoughtful and specific goals for the week. The intervention will last for four weeks (Week 1 – 4) and at the end of each week you will be sent the sedentary behaviour questionnaires (Task 4) through SEMA3 and the perceived stress questionnaire (Task 5) at the end of Week 4. After the four weeks, the intervention will cease, and you will only receive one more sedentary behaviour survey (Task 4) through SEMA3 at the end of Week 8.

The other group of participants will not receive any intervention or further instruction past the Letter of Information and Consent and the weekly SEMA3 notifications, from Week 1 to Week 4 and then at the end of Week 8, containing the sedentary behaviour

questionnaires (Task 4) and the perceived stress questionnaire (Task 5) at the end of Week 4.

The information you provide on the questionnaires (Task 3, 4, and 5) is for research purposes only. If you find that some of the questions are personal, you can choose not to answer if you wish. All responses recorded on SEMA3 surveys will be completely confidential, and all data collected will be stored on secure servers with only the Principal Investigator, Co-Investigator, and the software development team having access.

Task Descriptions:

1) Initial Zoom Meeting

Time involvement = <20 minutes

You will meet with the researcher and go over the Letter of Information and Consent. The researcher will answer any questions or concerns you have with the letter and upon completion of the letter, the researcher will release the Qualtrics survey of the Letter of Information and Consent for you to sign.

2) Download Questionnaire Delivery Smartphone Application (SEMA3)

Time involvement = <5 minutes

A personalized link with a personalized identification code will be provided to you to download the smartphone application to your personal device. No personal identification information will need to be entered past the identification code as the SEMA3 software replaces the researcher inputted names and emails with a unique identifier, and only the researcher's master list will have linking information from participant ID's to names and emails.

3) Demographic Questionnaire

Time involvement = <5 minutes

The demographic questionnaire will ask for: age, sex, preferred gender, ethnicity, height, weight, work environment, type of occupation, hours of work per week, and education level.

4) The Modified SIT-Q-7d Questionnaire and OSPA-Q

Time involvement = ~5 minutes

The modified SIT-Q-7d will ask for at work break frequency/duration over the past 7 days. The OSPA-Q will ask about percentages of at-work sitting, standing, and moving (light-physical activity).

5) The Perceived Stress Scale (PSS)

Time involvement = <5 minutes

The PSS will ask about your perception of stress over the past month. It will measure the degree to which situations in your life are appraised as stressful.

5) Behavioural Counselling

Time involvement = ~30 minutes

The behavioral counseling will involve information on the dangers of excessive sedentary behaviour as well as creating an action plan and coping strategies for behavior change. Strategies will be developed with you and will be tailored to be comfortable and realistic, following the FITT principle (i.e., Frequency, Intensity, Time, and Type).

6) HAPA, Goal-Oriented, Worksheet

Time involvement = ~10 minutes

The HAPA worksheet will provide you with the opportunity to create your own goals on a weekly basis. You will be encouraged to use the HAPA principles that were discussed in the behavioural counselling session (Task 5) to create focused and specific goals as well as to consider possible barriers to the goals you have created.

Participant Responsibilities

You will be asked to complete the weekly questionnaires delivered through the SEMA3 smartphone app. This study has very low participant burden as the strategies we will construct revolve around breaking sedentary behaviour and light physical activity.

If you are participating in another study, please inform the researcher to see if you are eligible to participate in this study.

Possible Risks and Harms

The anticipated risks or inconveniences associated with participating in this study may include the disruption of participants' personal and/or work time to complete study surveys and interact with the SEMA3 notifications. Additionally, there is a risk of privacy breach as well as the possibility that SEMA3 may use participant data for their own purposes.

Possible Benefits

By participating in this study, you may learn more about the relationship between workplace sedentary behaviour, health, and perceived stress, as well as have a chance to reflect upon and modify your own behaviour. As a participant you may also learn helpful strategies to modify your activity patterns at work. However, you may also not receive any benefit from participating in this study. The potential benefits to society may be the enhancement of data in the area of workplace-related activity behaviours and perceived stress.

Voluntary Participation

Your participation in this study is voluntary. You may decide not to be in this study, or to be in the study now and then change your mind later. Even if you consent to participate you have the right to not answer individual questions or to withdraw from the study at any time. You do not waive any legal right by consenting to this study. Participants are able to withdraw from the study at any time. If participants choose to withdraw, all data

pertaining to them will be removed from the platform used. No new information will be collected without your permission.

Costs to Participants

You will not have to pay for any of the materials or technology involved with this study and will not incur any expenses as a result of your participation.

Confidentiality and Publication

All data collected will remain confidential and accessible only to the investigators of this study and the team that developed the software, MeG (Melbourne eReaserch Group). As with any online related activity, the risk of a breach of confidentiality is always possible. To the best of our ability your answers and data will remain confidential. Online communication will be done through Western University's secure corporate Zoom. Data from the questionnaires will be de-identified through a secure smartphone application, SEMA3, that restricts access to only the researchers in charge of the study and the developers of the software. No personal data will be stored within the SEMA3 software as names and emails will be imputed into the software in order to generate a 9-digit participant identifier which will be used in place of identifying information. All data from the surveys is encrypted using industry standards (HTTPS). All identifiable information on Qualtrics will be deleted as soon as printed; printed and signed hard copies will be stored in a secure location in the EHPL.

All data from data collecting technology will be exported and securely stored on Western University's secure server. Printed and signed consent forms will be stored in a locked file in the EHPL, with access only available to the listed researchers. Furthermore, as email will be a main source of communication, please be advised that email is not a secure method of communication.

The researcher will keep all personal information about you in a secure and confidential location for 7 years. A list linking your study number with your name and email will be kept by the researcher in a secure place, separate from your study file. If the results of the study are published, your name will not be used. All identifiable information will be

deleted from the dataset collected so that individual participant's anonymity will be protected. The de-identified data will be accessible by the study investigators as well as the broader scientific community. More specifically, the data may be made available to other researchers upon publication, so that data may be inspected and analyzed by other researchers. The data that will be shared will not contain any information that can identify you. Representatives of The University of Western Ontario's Health Sciences Research Ethics Board may require access to your study-related records to monitor the conduct of your research.

A description of this clinical trial will be available on http://www.ClinicalTrials.gov, as required by U.S. Law. The Web site will not include information that can identify you. At most, the Web site will include a summary of the results. You can search this Web site at any time.

Contacts for Further Information

If you require any further information regarding this research project or your participation in the study you may contact Brett Carter [redacted] or Harry Prapavessis [redacted]

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Human Research Ethics [redacted] This office oversees the ethical conduct of research studies. The HSREB is not part of the study team. Everything that you discuss will be kept confidential.

This letter is yours to keep for future reference.

Informed Consent

Study Title:

Effects of a mHealth HAPA Based Intervention on Sedentary Behaviour and Stress among Desk-Based Office Working Adults

This study has been explained to me and any questions I had have been answered. I know that I may leave the study at any time. I agree to take part in this study.

Consenting Signature:

Participant:

_____

Please Print Name

Participant:

_____

Please Sign Name

Date (*DD-MM-YYYY*):

_____

Researcher Signature:

My signature means that I have explained the study to the participant named above. I have answered all questions.

Person obtaining informed consent:

_____

Please Print Name

Person obtaining informed consent:

_____

Please Sign Name

Date (*DD-MM-YYYY*):

_____

Appendix B

Demographic Questionnaire

What is your age?

_____

What is your sex?

E.g. Male, Female, Intersex, Prefer not to answer, etc.

_____

What gender do you most identify with?

E.g. Male, Female, Non-binary Individual, Prefer not to answer, etc.

_____

What ethnicity do you most identify with?

_____

What is your current work environment?

- ○ In office (1)
- ○ At home (2)
- ○ Hybrid (some home, some office) (3)

If "Hybrid" selected, what percentage of your work time is at:

- ○ Home (1) _____
- ○ Work (2) _____

What general sector does your occupation fall under?

- ○ Private (1)
- ○ Public (2)
- ○ Charity (3)
- ○ Other (4)

What are your typical hours of work on an average week?

_____

What is your current formal education level?
E.g. Less than a high school diploma High school degree or equivalent, High school degree or equivalent, Some college, Bachelor's degree, Master's degree, etc.

_____

Sedentary Behaviour Questionnaire

Occupational Sitting and Physical Activity Questionnaire (OSPA-Q)

The next series of questions will work to assess the percentage of time spent sitting, standing, and moving at your work. When answering these questions do not include your time spent travelling to and from work and do not include what you did in your leisure time

How many hours did your work in the last 7 days?

_____

During the last 7 days, how many days were you at work?

_____

How would you describe your typical workday in the last 7 days? (This involves only your workday, and does not include travel to and from work, or what you did in your leisure time).
In the next 3 questions, please record the PERCENTAGE of time spent SITTING, STANDING, and MOVING (i.e., walking) on a typical workday in the last 7 days.
The total of your answers from the next 3 questions should equal 100.

Record the PERCENTAGE of time you spent SITTING (including driving while at work) at work in the last 7 days.

_____

Record the PERCENTAGE of time you spent STANDING at work in the last 7 days.

_____

Record the PERCENTAGE of time you spent MOVING (i.e., walking) at work in the last 7 days.

Modified SIT-Q-7d Questionnaire

The next questions will ask about the frequency and duration/length of breaks from sitting during working hours.

In the last 7 days, on average, how often did you interrupt your sitting time during work?

- ○ Less than every 30 min (1)
- ○ Every 30-45 min (2)
- ○ Every 45 min-1 hour (3)
- ○ Every 1-1.5 hours (4)
- ○ Every 1.5-2 hours (5)
- ○ Every 2-3 hours (6)
- ○ Every 3-4 hours (7)
- ○ Every 4-5 hours (8)
- ○ Over every 5 hours (9)
- ○ No interruption (10)

In the last 7 days, on average how long were your breaks from sitting during work?

- ○ Less than 30 sec (1)

- ○ 30 sec-1 min (2)
- ○ 1-2 min (3)
- ○ 2-3 min (4)
- ○ 3-4 min (5)
- ○ 4-5 min (6)
- ○ 5-10 min (7)
- ○ 10-15 min (8)
- ○ 15-30 min (9)
- ○ Over 30 min (10)

Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts **during the last month**. In each case, you will be asked to indicate by selecting the corresponding option with *how often* you felt or thought a certain way.

0 = Never | 1 = Almost Never | 2 = Sometimes | 3 = Fairly Often | 4 = Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4

2. In the last month, how often have you felt that you were unable to control the important things in your life?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4

3. In the last month, how often have you felt nervous and "stressed"?

- ○ 0
- ○ 1

- ○ 2
- ○ 3
- ○ 4

4. In the last month, how often have you felt confident about your ability to handle your personal problems?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4

5. In the last month, how often have you felt that things were going your way?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4

6. In the last month, how often have you found that you could not cope with all the things that you had to do?

- ○ 0
- ○ 1
- ○ 2

- ○ 3
- ○ 4

7. In the last month, how often have you been able to control irritations in your life?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4

8. In the last month, how often have you felt that you were on top of things?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4

9. In the last month, how often have you been angered because of things that were outside of your control?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4

HAPA Intervention Worksheet

This worksheet it is your chance to create 1 or 2 action plans for this upcoming week and to create coping strategies for barriers that might get in your way from accomplishing your plans!

Remember our objectives:

1. Break up extended periods of consecutive sitting
2. Increase sitting break frequency, for every 30-45 minutes of consecutive sitting, break the behaviour for 3 minutes
3. Increase non-sedentary behaviours (i.e., standing, stretching, walking/light physical activity)

Action Planning:

Specify a specific situation (where/when) and a sequence of action (how) for implementing the intended behaviour.

Coping Strategies:

Anticipating barriers that may arise and developing strategies to overcome said barriers.

Create your Action Plan for the week!

Remember, we want to create an Action Plan that is original and specific to you and your lifestyle as well as realistic!

If you're stuck you can use the FITT principle to help you create an Action Plan:
Frequency: How often a strategy should be used
Intensity: The duration of sedentary behaviour breaks
Time: When the strategy is to be used
Type: The chosen activity to be done

_____

_____

_____

_____

_____

Create another Action Plan for the week!

How else can you try to achieve our objectives in a specific and realistic fashion?

_____

_____

_____

_____

_____

Create a Coping Strategy for an Action Plan that you created!

What is a barrier that you think could stop you from completing your Action Plan? How can you overcome it?

Be specific!

_____

_____

_____

_____

_____

Create another Coping Strategy for the week!

Is there another barrier that might get in your way? How can you get around it?

_____

_____

_____

_____

_____

By this point you should have an Action Plan for the upcoming week and a Coping Strategy for some barriers that you might come across that would work against you completing your plan.

Remember, the more precise, concrete, and personal the plans, the more effective they will be!

Have a good week and good luck working your plan!

Behavioural Counselling Form

Plan to Reduce Sitting Time at Work

What is the problem with too much sitting?

Sitting is positively associated with:

- Dealth from any cause
- Cardiovascular disease
- Type 2 diabetes
- Several types of cancers

(Rezende et al., 2014)

These negative health consequences are associated with sedentary behaviour regardless of physical activity level.

However:

Breaking up consecutive sedentary behaviour has been positively associated with:

- Decreases in waist circumference
- Decreases in systolic blood pressure
- Decreases in blood lipid (fat) levels

(Saunders et al., 2020)

Objectives:

1. Break up extended periods of consecutive sitting
2. Increase sitting break frequency, for every 30-45 minutes of consecutive sitting, break the behaviour for 3 minutes
3. Increase non-sedentary behaviours (i.e., standing, stretching, walking/light physical activity)

Action Planning:

Specify a specific situation (where/when) and a sequence of action (how) for implementing the intended behaviour.

Coping Plan:

Anticipating barriers that may arise and developing strategies to overcome said barriers.

Frequency: How often a strategy should be used

Intensity: The duration of sedentary behaviour breaks

Time: When the strategy is to be used

Type: The chosen activity to be done

Behavioural Counselling – Action & Coping Plans

Action and Coping Plan	Frequency	Intensity	Time	Type
Action Plan 1				
Coping Plan 1				
Action Plan 2				
Coping Plan 2				

Curriculum Vitae

Name:	Brett Carter
Post-secondary Education and Degrees:	University of Waterloo Waterloo, Ontario, Canada 2015-2020 B.Sc. Western University London, Ontario, Canada 2020-2022 M.A.
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