Effectiveness of different interventions to reduce occupational sitting among office administrators at Rhodes University

BY

THATO MALESA

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Abstract

Background: Sitting for prolonged periods is common in the working environment. Office workers are exposed to long periods of sitting time at work. Research has reported associations between prolonged sitting and negative health implications. As such, studies have proposed different interventions aimed at reducing sitting times in the workplace. The aim of the current study was to evaluate the effectiveness of two different interventions, physical intervention (sit-stand worktables) and personal intervention (instruction to stretch) on compliance and reducing occupational sitting behaviour. The study also aimed to investigate the effectiveness of interventions in improving or impairing mood. **Methods:** The study took the form of a field-based study at Rhodes University, Makhanda, South Africa. Fifteen full – time office workers in different divisions participated in the study. Participants were randomly allocated to either the physical or personal intervention group. In both intervention groups, participants were prompted to stand for five minutes every hour during the workday to either work in a standing position or perform stretches. Over the course of the experiment, desk occupancy, sitting/standing time and mood effect were recorded in both intervention groups. Both intervention groups were monitored for a period of three months (58 days). **Results:** The study found that the physical intervention group was an effective approach to reduce prolonged sitting in the workplace in comparison to the personal intervention group. Over the course of the experiment, there was sustain usage of interventions in both groups, however, in the physical intervention group desk usage decreased overtime. The findings of the study also show that some participants were more compliant with the study procedures than others. It was also found that mood improved upon introducing interventions in the workplace. However, with the outcomes of the results, the study acknowledges that several factors emerged which are likely to impact compliance, which future studies may investigate. **Conclusion:** Although sit-stand worktables are expensive, it seems like introducing them was successful in reducing sitting time and changing sitting behaviour in comparison to an intervention that instructs individuals to stand up and stretch.

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CHAPTER 1

Introduction

This chapter will consist of the following sections respectively: Section **1.1. Background** looks at the background of the study whereby it discusses the overview of the problem of prolonged sitting in the workplace. Section **1.2. Focus of the study** address the focus of the study which was derived using available literature to identify the gaps in the literature. Section **1.3. Thesis layout** looks at how the thesis will be structures.

1.1. Background

Sitting for prolonged periods is common in the working environment. Office workers are exposed to long periods of sitting time at work. Occupational sitting is defined as continuous uninterrupted sitting that is equivalent or greater than four hours (Thorp *et al*., 2009 as cited by Mainsbridge *et al*., 2016). Over the years, research on occupational sedentary behaviour has been growing at a rapid rate. Office workers spend two thirds of their time in the workplace sitting (Straker *et al*., 2013). The habit of sitting occurs often over the course of the day in various forms. It can either be consciously or subconsciously driven (Bond *et al*., 2014). For example, there is a culture in the workplace where, when a person enters the office, they are welcomed with a chair, which automatically implies that they will be required to perform work in a seated position (Church *et al*., 2011). Another culture in many workplaces is having seated meetings. Because of these cultures in the working environment, a person does not necessarily contemplate whether they should sit or stand; they form a habit of sitting.

Biologically, human beings were made to be in motion - they have joints and a set of distinct muscle groups that are designed explicitly to accommodate movement (Grismud *et al*., 1990). Therefore, the potential for human beings to move around exists; however, it is suppressed in the working environment, as majority of the working day in an office is spent in seated postures.

In addition to workers spending most of the working day sitting, workplaces have been designed in such a way that movement is restricted. Previously, traditional offices used to facilitate people moving around in the workplace in order to reach the printer and other tools within the office

(McLean *et al*., 2001). However, modern offices are designed in such a way that there is limited space which prohibits people from moving around or working while standing as printers and other tools are located within desk reach (Mainsbridge *et al*., 2016. Poorly designed workplaces give less room for upright stretching and movement. Work desks have become centralised, whereby employees are not required to move from their workstations to get to the printer (Shrestha *et al*., 2018 and Mainsbridge *et al*., 2016). Some workers have chairs that allow swivelling, allowing them to move the chair to the printer and back to their work desks without having to stand up. This shows that workers are dependent on their work desks, and consequently poses the challenge of how best to adjust the workplace design to reduce prolonged occupational sitting behaviour; a necessary consideration given that human beings are bipedal in nature (created to walk, stand and jog), which means standing will be more beneficial to humans than sitting (Grimsrud *et al*., 1990).

Given the evidence that sitting happens frequently in the workplace, and that there is limited space to accommodate movement, the lack of movement and inappropriate design of workplaces has resulted in the development of health problems in the workplace (Mainsbridge *et al*., 2016). Research demonstrates that sitting for prolonged periods at work is linked to detrimental health effects. These health implications include but are not limited to, lower extremity discomfort, lower back pain and entire body fatigue, which increases the risks of developing cardiovascular problems, musculoskeletal disorders, and psychological disturbances such as mood disturbances (Chester *et al*., 2002; Galinsky *et al*., 2007; Chau *et al*., 2010; Chau *et al*., 2012; Healy *et al*., 2013; Grunseit *et al*., 2013).

Advancements in technology have also led to more people adapting to lethargic lifestyles, and research shows that this leads to more people spending most of their working day in stationary postures (Levine, 2010). In the long run, the workplace poses a potential threat to our health and well- being due to sitting for prolonged periods over the course of the day (Law *et al*., 2013; Pesola *et al*., 2014; and Graves *et al*., 2015; Shreuder and Coetzee, 2016). For this reason, many researchers have comprehensively studied the concept of prolonged sitting in the workplace (Chau *et al*. 2014; Graves *et al*. 2015; Hadgraft *et al*. 2017).

Majority of the research that addresses the problem of prolonged sitting in the workplace centres around the effects of sit-stand worktables on physical well-being, musculoskeletal systems, psychological factors and performance. However, very little research quantifies the use of different

sit-stand interventions introduced in the workplace. To minimise the risks associated with prolonged sitting, researchers have presented different intervention strategies that could aid in getting workers to move around in the office. These strategies include introducing short bursts of physical activity (e.g. walking, standing, climbing staircases and stretching), answering telephone calls or emails in a standing position as well as installing sit-stand worktables, in the hope of changing sitting behaviour in the workplace (Levine, 2002).

Some of these intervention strategies are relatively expensive, which means it might be difficult to implement them in some workplaces. On the other hand, low - cost interventions are possible and include incorporating standing meetings, stretches, lunchtime walks, face to face conversations instead of communicating through emails, and sending weekly emails to remind people to break their prolonged sitting behaviour (Levine, 2007a; Mackenzie *et al*., 2015).More costly interventions include sit-stand worktables, treadmill workstations, cycling workstations, and portal and pedal machines (Alkhajah *et al*., 2012; Carr *et al*., 2012; Mackenzie *et al*., 2015). In South Africa, little to no research goes toward investigating occupational sitting behaviour.

1.2. Focus of the study

The study at hand acknowledges that there is extensive research conducted on the health implications associated with prolonged sitting and the benefits induced from alternating between sitting and standing. However, there is limited research that quantifies the sustained usage of different interventions, such as usage of sit-stand worktables or frequency with which the tables are used in the workplace, over time. As such, the study aims to compare different interventions aiming at reduction of prolonged sedentary behaviour over time in terms of compliance and effectiveness in changing sitting behaviour. That is, the study set out to compare two workplace interventions (the physical intervention of sit-stand worktables and a personal intervention of stretching) among office administrators, to assess which intervention is better in terms of compliance over time and of reducing occupational sitting behaviour. In this research study, compliance refers to adherence to and engagement with the interventions provided. The secondary objective of the research study is to investigate mood, to assess whether participants mood perception changes over time before the intervention (baseline intervention) and during the intervention phases (physical and personal intervention).

Research shows (Chau *et al*, 2014) that many workplaces have started to introduce sit-stand worktables, as reports suggest that the sit-stand worktables succeed at interrupting and reducing prolonged sitting. Some of the worktables require workers to take the initiative to alter desk positions, which involves the worker taking responsibility for alternating between sitting and standing, whereas others have an automatic component that switches from a sitting position into a standing position after sitting for a prolonged period. The study acknowledges that sit-stand worktables are expensive and a cheaper (low-cost) alternative need to be considered. Sit-stand worktables are a great investment; however, for many companies they raise the issue of usability (Karakolis *et al*., 2014).

In addition, the study also seeks to evaluate psychological factors such as mood as an indicator of compliance. The study acknowledges that there is limited research conducted on the mood effects of interventions that aim to reduce sitting behaviour at work. A person's mood state depends on specific situations and may be altered by different factors. Studies have reported that the use of sit – stand worktables has an impact on one's frame of mind (Pronk *et al*., 2012). Specifically, Pronk *et al*. (2012) and Chau *et al*. (2014) shows that participants reported to be more focused, alert and full of energy when switching from a sitting to a standing posture. However, this is not the case with other studies. Studies such as that of Husemann *et al*. (2009) found that there were no changes in mood state before and after introducing sit – stand interventions. This study will seek to investigate how different interventions impacts participant's mood effect overtime. This will assist in better understanding how ones mood impacts utilisation of different interventions that aim to reduce prolonged sitting in the workplace.

1.3. Thesis layout

The remainder of the thesis is structures as follows:

Chapter Two: This chapter provides the relevant literature around the subject matter and the intervention strategies that have been used to formulate the research question.

Chapter Three: Provides the experimental concept, intervention design, experimental procedures, ethical considerations, and how the data was reduced to allow for statisical analysis.

Chapter Four: This chapter briefly details the results of the study, including the results of statistical analysis.

Chapter Five: Presents the discussion, which provides the interesting and important findings from the results in light of what other studies have found. Furthermore, the limitations, delimitations, and strength of the study are discussed.

Chapter Six: This chapter contains the conclusion, and provides recommendations for future research. Moreover, the chapter outlines the practical relevance that practioners may consider in implementing the findings of the study in real-world settings.

CHAPTER 2

Literature Review

The literature review provides essential background information on the topic of interest based on ergonomics principles that have been implemented in the workplace in the attempt to optimise human well-being, given the predominance of sedentary jobs. The chapter consists of three sections. Section **2.1. Occupational sitting** describes the statistics that shows the evidence of prolonged sitting in the workplace, furthermore, explains the health implications that stem for sitting/standing for extended periods in the workplace and how people try to compensate prolonged sitting in the workplace outside the workplace. Section **2.2. Interventions to reduce occupational sitting** discusses the strategies that have been employed to break/reduce prolonged sitting in the workplace. Section **2.3. Effectiveness of intervention** explains aspects that need to be considered when designing interventions to ensure that interventions are effective. The last section, **2.4. Interventions in the context of the organization**, highlights the costs of employing different intervention strategies and how organizations can incorporate interventions as part of the organization policies.

2.1. Occupational sitting

Sedentary behaviour is defined as sitting time that is linked with an energy expenditure less than 1.5 METS, which is also associated with the high prevalence of physical inactivity (Tremblay *et al*., 2011; Waters *et al*., 2016; Daneshmandi *et al*., 2017; Mansoubi *et al*., 2016). In the workplace, sedentary behaviour is evident by workers spending majority of their working day sitting at their desks. Many office environments are characterised by low energy expenditure and as a result promote sedentary behaviour (Mansoubi *et al*., 2016).

While there is limited data available on occupational sitting in South Africa, research shows that American workers who primarily have desk based jobs, spend majority of their working day at work sitting - approximately 70% of the working day (McCrady & Levine 2009). It is also estimated that majority of the workers in Australia spend most of their working day in seated postures (Work Safe Australia). In Sweden, 76% of the working population spend their working

hours working on the computer, and 40% of the workers that spend their working day seated, complain about health-related issues resulting from operating the computer for extended periods as well as sitting for long hours at the worktables (Brandstrom and Dueso, 2014). Similar to Australia, workers in the Netherlands also reported spending four or more hours in a sitting posture each working day (Daneshmandi *et al*., 2017). Based on the evidence above, it is clear that work environments promote sedentary behaviour and that office workers are more exposed to long periods of sitting which leads to health risks (Church *et al*., 2011). Research shows that the trend of prolonged sitting in the workplace is influenced by several factors such as changes in infrastructure and advancement in technology (Waters *et al*., 2016; Wang *et al*., 2018).

2.1.1. Health implications of prolonged sitting and standing in the workplace

Sitting for prolonged periods has been shown to be associated with health risks. It has been found that those working in seated postures for extended periods are at a high risk of developing non-communicable diseases such as cardiovascular diseases and diabetes, as well as musculoskeletal symptoms in different regions of the body; for example, symptoms in the neck, shoulders and lower back (Dustan *et al*., 2011; Brakenridge *et al*., 2016). Sitting has disadvantages which include decreased range of reach (i.e. limited arm movement), lower metabolic demands, reduced blood circulation, muscles burning less fat, reduced lumbar curvature, leg-swelling due to leg muscles not being able to maintain a sitting posture, and increased load on the lumbar discs due to tilting of the pelvis. Working in a seated posture is demanding and involves high levels of shoulder abduction, which adds more weight and stress to the shoulder joints and neck (Coury, 1998; Lehaman *et al*., 2001; Wilks *et al*., 2006).

The disadvantages of sitting for extended periods have been briefly discussed and are of great concern. By simply interchanging sitting with standing, the body can benefit by keeping a neutral posture without the risk of developing lower back disorders; and muscles are able to contract, which gives a significant advantage of blood circulation and mobility (Wilks *et al*., 2006; Mansoubi *et al*., 2016). Standing, allows dynamic utilisation of the arms and trunk, which is not the case in a seated position (Lehaman *et al*., 2001). Healy *et al*. (2015) found that there are physiological health benefits related to standing, such as an increase in health range, lower waist circumference, and lower Body Mass Index (BMI). In as much as standing is good for the body,

research shows that there are health repercussions to prolonged standing, such as static contraction of muscles leading to discomfort and muscle fatigue in the lower extremities (Bahk *et al*., 2012; Halim *et al*., 2012; Gallagher *et al*., 2014). It goes without saying that prolonged standing introduces additional risk factors and as such, prolonged sitting should not be substituted with prolonged standing. One study reports that using sit-stand worktables introduces risk factors such as increased discomfort in the shoulders and upper back (Davis *et al*., 2009). With that being said, it is recommended that people alternate between short intervals of sitting and standing to avoid further risks of developing detrimental health risks associated with prolonged sitting and standing in the workplace (Halim *et al*., 2012).

2.1.2. Compensation of sedentary behaviour in and outside the workplace

There has been substantial information on how changes in technology and social settings have changed our lifestyles, and this has been evident in our day to day interactions. Sedentary behaviour does not only take place in the workplace; it is also prevalent outside the workplace in social settings. For example, when people wake up in the morning, they sit down for breakfast, sit down on their way to work, and have seated meetings inside and outside the office (Grimsrud *et al*., 1990; Levine, 2010). The different interventions that have been introduced in the workplace with the aim of reducing sitting time; gives a clear indication that there has been some success in this area, however, there is limited information on how sitting time is compensated the moment people walk away from their workstations (MacEwen *et al.*, 2017).

There are inconclusive findings linking to how workers compensate for prolonged sitting in the workplace and outside the workplace. For example, Mansoubi *et al*. (2016) investigated sedentary behaviour and physical activity outside the office. The findings of the study demonstrate that physical activity in the workplace was compensated for sedentary behaviour outside the workplace, meaning that more sitting took place outside the office. The study found that, during working hours, there was a reduction in sitting time upon the installation of sit-stand worktables and an increase in light physical activity. However, during non-working hours there was an increase in sitting time. Chau *et al.* (2012) notes that it is absolutely normal for workers to want to in engage in some form of sedentary behaviour or physical inactivity after a long day, which probably explains the reason why participants in Mansoubi *et al*. (2016) engaged in sedentary

habits outside their workstations. Jans *et al*. (2007) found that workers who spent the majority of their working day sitting did not compensate for this lack of physical activity at work with physical activity during leisure time. In contrast, those who sat less during the working day were more likely to spend more time sitting during leisure setups

Chau *et al*. (2012) found that workers who were expected to engage in prolonged sitting during the working day engaged in adequate physical activity in their leisure setups when compared to those that spent the day in prolonged standing positions. Tigbe *et al*. (2011), on the other hand, argues that being physically active at work does not necessarily mean that one will engage in or adapt to a sedentary lifestyle during non-working hours or on non-working days. The above studies indicate that studies have attempted to investigate how workers in real-world settings compensate for their physical inactivity or sedentary behaviour in the office when outside the office. From the literature it is evident that there is limited research and contradictory findings on how sedentary behaviour in the office is compensated for the moment people walk away from their workstation during working hours.

2.2. Interventions to reduce occupational sitting in the workplace

To address the problem of prolonged sitting in the workplace, studies have proposed several interventions aimed at reducing sitting time. Some of these interventions require physical restructuring of the workplace, whereas others do not require any form of physical transformation (Husemann *et al*., 2009). These interventions include, but are not limited to, sit-stand worktables, treadmill workstations (Levine and Miller 2007), computer-based prompting, micro-breaks, activity tracking (Edwardson *et al.,* 2018), and short bursts of physical activity (Danquah *et al*., 2017). Some interventions are multicomponent interventions, which combine sit-stand worktables with additional resources to encourage use of interventions.

2.2.1. Sit-stand/ height adjustable worktables

Sit-stand/height-adjustable worktables are defined as worktables that allow workers to change postures i.e. to alternate between sitting or standing during the working day (Ebara *et al*., 2008; Grunseit *et al*., 2013; Karakolis *et al*., 2016). These worktables encourage postural variability

through allowing workers to adapt to neutral postures while standing (Davis *et al*., 2009). Furthermore, they offer workers the opportunity to break their sitting patterns at various points throughout the day, the worktables have automated prompting settings that prompt workers to stand up (Hedge and Ray, 2004; Dustan *et al*., 2012; Grusteit *et al*., 2013; Chau *et al*., 2014; Karakolis *et al*., 2014; Neuhaus *et al*., 2014; Finch *et al*., 2017; Sharma *et al*., 2019).

These worktables come in two different forms. The first of these is a whole table that can be manually adjusted or that uses electric motors that can adjust the desk at different intervals (Hedge and Ray, 2004; Hederson *et al*., 2018). The second kind of desk is placed on top of an existing standard desk and can be manually adjusted to facilitate the change from a sitting position into a standing position (Hederson *et al*., 2018). Practically, sit-stand worktables have been considered to be feasible for reducing prolonged sitting and increasing standing time in the workplace (Neuhaus *et al*., 2014). Over the years, workplaces have recognised the adverse effects of prolonged sitting in the workplace and as a result, many workplaces have become involved in introducing sit-stand worktables (Chau *et al*., 2014; MacEwen *et al*., 2017; Mansoubi *et al*., 2016). The proposition of these worktables being introduced in the workplace as well as the option of making changes to traditional non – adjustable worktables is appealing and shows that something is being done regarding prolonged occupational sitting.

2.2.2. Effectiveness of sit-stand worktables

There is sufficient literature that has shown that sit-stand worktables are effective in reducing sitting in the workplace. For example, studies such as Chau *et al*. (2014); Pronk *et al*. (2012) and Alkhajah *et al*. (2013) have installed sit-stand worktables in the workplace. The results of the studies showed a reduction in sitting time in the intervention group upon installation of the worktables, in comparison to the control group that did not receive sit-stand worktables. Mansoubi *et al*. (2016) and MacEwen *et al*. (2017) also found that sit-stand worktables were effective in reducing sitting time and increasing standing time over long interventions of approximately three months. In another study conducted by Schofield *et al*. (2009), sit-stand worktables were implemented for a week. The results of the study showed an increase in standing times over the course of the week. Arguably, in terms of feasibility and effectiveness of having sit-stand worktables it is hard to argue whether the study will be successful in reducing sitting time in the

long run. On the other hand, Gilson *et al*. (2012) did not find similar results in terms of reduction in sitting time; instead, the study found that sit-stand worktables were not effective in reducing sitting time. Other studies that have introduced sit-stand worktables in the workplace have found that there are more benefits than just reducing sitting time that could be derived from the provision of sit-stand worktables.

The benefits of utilising sit-stand worktables include among others, reduction in physical complaints, decrease in lower back pain, and less discomfort as well as an increase in energy expenditure and better leg circulation (Hedge and Ray, 2004; Hedge *et al*., 2005; Straker *et al*., 2013; Karakolis *et al*., 2014; Mansoubi *et al*., 2016). Wilks *et al*. (2006) surprisingly discovered that the utilisation of sit-stand worktables was dependent on age. The study revealed that the older generation (over 51 years) did not frequently utilise sit-stand worktables, when compared to the younger generation (those younger than 50 years). This could be explained by the fact that, as one gets older, one makes conscious decisions to stop learning new things or adjusting to new routines, whereas the younger generation finds it easier to learn new information and form new habits (Wilks *et al*., 2006).

Although research shows reductions in sitting time and benefits derived from providing sit-stand worktables in the workplace, that there are very few studies that compare the effectiveness of sit-stand worktables in reducing sitting time with changing behaviour before introducing sit-stand interventions and following the introduction of the interventions (baseline phase and post - intervention phase). Pronk *et al*. (2012) conducted a study that looked at the utilisation of sit-stand worktables during a 4-week intervention and 2-week post-intervention. The findings of the study showed a decrease in sitting time during the intervention period, with an increase in sitting time observed post-intervention. A possible reason for the outcome of the post-intervention results; could be that sitting behaviour changes over time, and that the intervention phase of the study was unsuccessful in ensuring that sitting behaviour is not only changed during the intervention phase, but also transferred and maintained in the post-intervention phase. The results also show that when sit-stand worktables were removed from the workplace, participants went back to their normal sitting behaviours. Ideally, participants would consciously create a habit of breaking their sitting behaviour following the intervention; however, that was not the case in this study. This raises the

question of how to ensure that the interventions that are introduced are sustained over time and that participants create habits of breaking sitting behaviour in the workplace. In another study conducted by Alkhajah *et al*. (2012), it was found that introducing sit-stand worktables resulted in a reduction in sitting time of more than 2-hours per day, and that the decrease in sitting time was not only motivated by the utilisation of sit-stand worktables, but by other factors as well.

2.2.3. Effectiveness of sit-stand worktables on performance

Existing literature suggests that the introduction of sit-stand worktables in the workplace may alter performance (Shrestha *et al*., 2018). Interestingly, studies have produced inconsistent findings relating to the effect of sit-stand worktables on performance. Some studies reveal that the provision of sit-stand worktables in the workplaces does not necessarily enhance performance, whereas other studies argue that the provision of sit-stand worktables improves performance (Hedge and Ray, 2004; Pronk *et al*., 2012; Robertson *et al*., 2013; Karakolis *et al*., 2014; Finch *et al*., 2017). In a study conducted by Kar and Hedge (2016) on the effects of sitting and standing work postures on short-term typing performance and discomfort, the study reported that performance outcomes varied based on posture variation. The study found fewer typing errors when participants executed tasks in a standing posture in comparison to a sitting posture. Husemann *et al*. (2009), on the other hand found small reductions in data entry efficiency during standing postures. It must be noted that not all studies have found sit-stand worktables effective in improving worker performance; as such the question of effectiveness is inconclusive. The conflicting results on sit-stand worktables not being able to enhance performance could be explained by the fact that office work requires a lot of effort and attention to detail and therefore, alternating between sit-stand paradigms could possibly cause a reduction in mental performance (Husemann *et al*., 2009).

2.2.4. Taking micro-breaks in the workplace

Micro-breaks are defined as short breaks lasting for 3-5 minutes every hour. These breaks are exclusive of anything work related. In some organisations micro-breaks have been legalised and are part of the organisation's policy. For example, California Industrial Welfare Commission (2001) encourages workers to take 10-minutes micro-breaks every hour. Micro-breaks have also been considered as an alternative strategy for reducing prolonged sitting time at work. Research

on micro-breaks shows that taking micro-breaks during working hours happens for various reasons, and in many cases they are perceived to be interruptive; however, the breaks are necessary, and could be related to going to the toilet, a stretch, a cigarette, a drink, food or emotional reasons (Strongman and Burt, 2000). For example, Ryan *et al*. (2011) conducted a study assessing different sitting times between 20 minutes; 30 minutes; 55 minutes and 5 minutes break every hour. The study discovered that none of the participants met the recommendations of sitting less than 20 to 30 minutes at a time every day of the week. However, it was found that some participants met the recommendation of sitting no longer than 55 minutes at a time. Some studies recommend taking micro-breaks that range from three 30-seconds and one 3-minute break, and 10-second micro-breaks every 6 minutes, to 15-minute break every 2 hours (Henning *et al.,* 1997; Galinsky *et al*., 2007). In another study, four different sit-stand schedules were introduced in the workplace, 90 minutes sitting and 30 minutes standing, 80 minutes sitting and 40 minutes standing, 60 minutes sitting and 60 minutes standing and 105 minutes sitting and 15 minutes standing (Bao and Lin, 2018). It is apparent from these studies that there are attempts to break prolonged sitting in the workplace, and introducing micro-breaks is one form of doing so. Research also reports that taking micro-breaks at work has been beneficial in reducing discomfort, fatigue, and mood disturbances, as well as effective in improving health (Dababneh *et al*., 2001; Galinksy *et al*., 2007). Taking breaks has also shown to assist with the reduction of musculoskeletal disorders in office workers, enhancing performance and lessening exhaustion (Balci and Aghazadeh, 2003).

2.2.5. Activity Tracking

Apart from installing sit-stand worktables to reduce sitting time, research has found that activity trackers aid with breaking/reducing sitting time in the workplace. Activity trackers are wearable technological devices that can be worn on the wrist, and measure activity levels such as sitting and standing activities, sleep patterns, step counts, and calories (Brakenridge *et al*., 2016; Guitar *et al*., 2018; Edwardson *et al.,* 2018; Henriksen *et al*., 2018). Activity trackers have been used in the workplace to record sitting time and standing time over the course of a day. These tracking devices provide users with notifications that prompt users to step away from their workstations. Over the years, they have become very popular, and with technological advancements, these tracking devices have improved features, such as that they can be synced with mobile phones, have

additional sensors, and use algorithms that are constantly attracting consumers and bringing about an improved fantastic atmosphere (Henriksen *et al*., 2018).

The emergence of activity trackers has been of great benefit as they provide opportunities for people to gain insight on their activity levels, and to become competitive with their friends and families regarding their activity levels. Beyond that, they have the additional benefit of causing people to become more health conscious than before (Brakenridge *et al*., 2016). With the trackers becoming more popular, they have also gained momentum in the workplace as an alternative option to assess sitting and standing activities (Brakenridge *et al*., 2016; Guitar *et al*., 2018). Brakenridge *et al*. (2016) evaluated the effectiveness of organisational level strategies with or without an activity tracker to reduce prolonged sitting time in the workplace. It was found that activity trackers were effective in reducing sitting time and essentially changed one's sitting behaviour. The feedback mechanism of the trackers provided participants with real-time feedback that resulted in self-directed change in sitting behaviour. In addition to the great features and excitement that come with operating an activity tracker, research around the devices is also increasing.

2.3. Effectiveness of interventions

To ensure that the interventions that are introduced in the workplace are effective in reducing sitting time, it has been established that factors such as behavioural change and compliance would have to be considered.

2.3.1. Behaviour Change Model and compliance

The behaviour change wheel allows for the exploration of other factors that could be considered to ensure that there is change in behaviour. The behaviour change wheel is made up of 31 layers (figure 1, page 16). The centre of the model consists of three layers (capability, motivation, and opportunity), which are referred to as the COM-B model (figure 2, page 17). The centre of the model is bound by nine layers (enablement, training, coercion, incentivisation, persuasion, education, restriction, environmental restructuring and modelling). Surrounding the nine layers are seven other layers (guidelines, fiscal measures, regulations, service provision, legislation, communication/marketing, and environmental social planning). These layers are all integrated and could be used to explore and develop interventions that aim to change behaviour effectively (Michie *et al*., 2011). According to Michie *et al*. (2011) behaviour change interventions are interventions that aim to modify certain behavioural patterns. Michie *et al*. (2011) outlines that behaviour is formed by multiple factors such as expectations, attitudes, subjective norms and perceived behavioural controls. The model recognises that there are other potential variables that are likely to influence behavioural change, as behaviour change is not primarily dependent on one factor. The literature and results from multicomponent interventions also supports the idea that the integration of additional elements to an intervention results in the reduction of sitting time and sitting behaviour in the workplace (Robertson *et al*., 2013; Healy *et al*., 2013; and Smith 2014).

The behaviour change wheel has been used in many other studies such as in a study by Lai (2018) conducting workplace interventions in China. Based on the available research on occupational sitting behaviour, research shows that there is an urgent need to implement different sit-stand interventions that aim to reduce sitting time and change sitting behaviour in the workplace over time. The literature shows that there is a gap of knowledge and uncertainty on the effectiveness of the interventions in changing sitting behaviour.

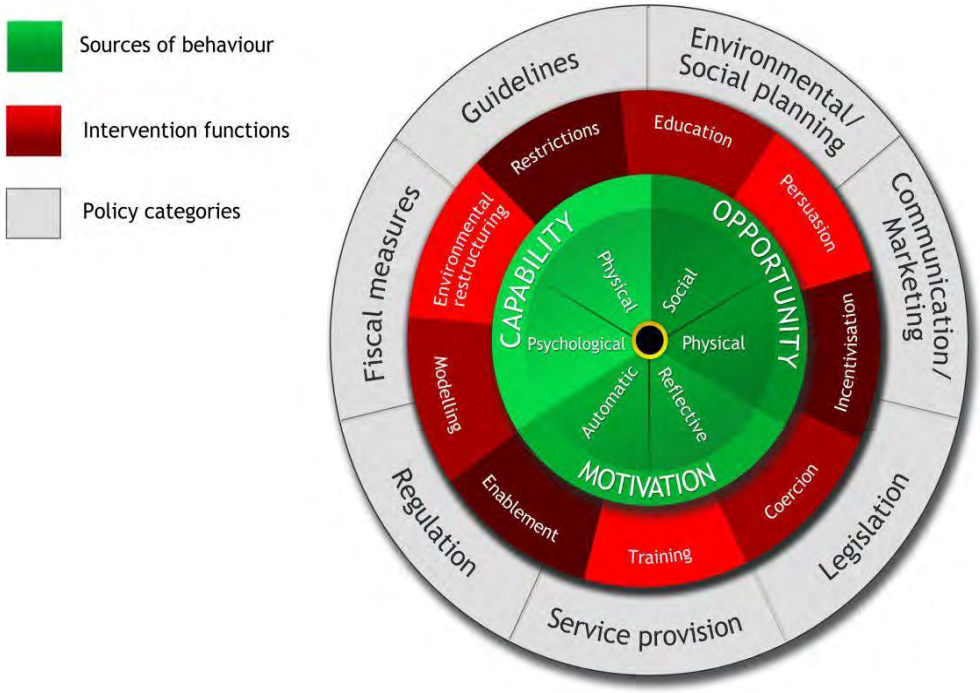

Figure 1: The Behaviour Change Wheel. Adapted from: Michie et al. (2011).

2.3.2. The Capability – Motivation – Opportunity – Behaviour Theory

The COM-B model explains that interventions should consist of capability, motivation, and opportunity to ensure that interventions serve the purpose of changing behaviour. Furthermore, it highlights that these three variables cannot be assessed separately; they are interconnected and interact to ensure that there is behavioural change. In the event that one of the variables is missing, it is unlikely that the intervention will be effective in changing behaviour.

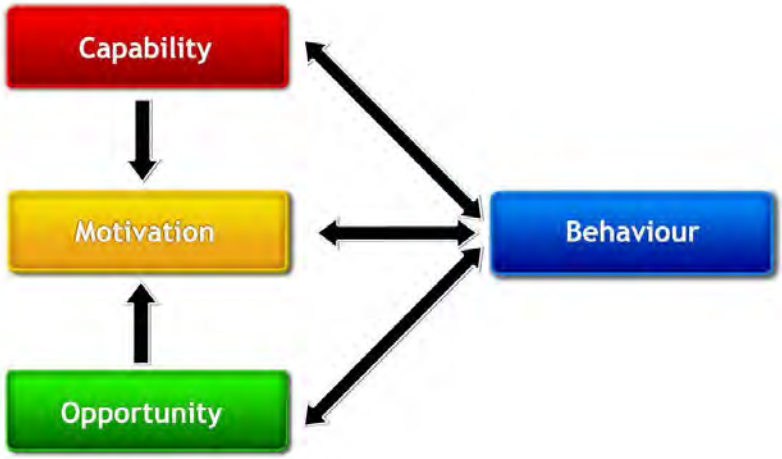

Figure 2: Illustrates the COM – B system – a framework for understanding behaviour (Michie et al., 2011).

Capability: Is refers to a person's physical and psychological ability to engage with the intervention concerned.

Motivation: Is defined as the internal processes in the brain that allows a person to engage in different things. Behaviour is a by-product of motivation, this means that if an individual is motivated towards a certain goal, they are more likely to change their behaviour. If the individual is not motivated, they are unlikely to change their behaviour.

Opportunity: Is defined as factors that are not within the individual's surroundings such as physical or social opportunities. These factors provide individuals with opportunities that could help the individual prosper or prevent the individual from succeeding in changing their behaviour.

2.3.3. Compliance with interventions

In this research study, compliance refers to the adherence to or engagement with the study interventions provided. Non-compliance refers to the inability to engage precisely with the study interventions provided. Introducing interventions in the workplace does not guarantee that

participants will automatically start using the different sit-stand interventions. Research shows that ensuring that participants sustain the usage of sit-stand worktables has been perceived as a challenge (Barbieri *et al*., 2017). Grunseit *et al*. (2013) found that usage of sit-stand worktables was influenced by several other factors such as the health effects linked to alternating between sitting and standing. Furthermore, the usage of sit-stand worktables has shown to be higher in the early days following the introduction of the worktables. This could be the result of the idea of alternating between sitting and standing being more exciting at the beginning of the interventions, and declining some weeks later (Barbieri *et al*., 2017). In another study by Frost (2016) similar results were found to those of Barbieri *et al*. (2017); that the idea of having sit-stand worktables is exciting in the beginning and utilisation is higher. For example, Frost (2016) found that desk usage of sit-stand worktables in a college classroom was higher at the beginning of the intervention, the desk usage decreased before the spring break and started fluctuating after the spring break (.i.e. interchanging increasing and decreasing). This shows that utilisation of sit-stand worktables and compliance with the interventions is not absolutely guaranteed, and that there are other factors that could possibly add to one complying or not complying with the interventions provided.

In a study conducted by Straker *et al.* (2013), it was found that when workers were provided with sit-stand worktables, some workers operated the sit-stand worktables for an hour, while some did not bother to utilise the worktables by any means. In the same study, workers were provided with ergonomics training on the best way to utilise sit-stand worktables, and it was found that there was frequent utilisation of sit-stand worktables, which consequently resulted in a reduction in sitting time (Straker *et al*., 2013). This alone shows that combining educational information with the provision of sit-stand worktables has an impact on the utilisation of sit-stand workstations as well as participants complying with the study protocol. In another study, Verwejj *et al*. (2012) investigated the effectiveness of physical activity guidelines on sedentary behaviour. The study conducted a questionnaire six months after the intervention. The results indicated that the intervention group; that is, the group that received behaviour change counselling; showed a decrease in sedentary behaviour. The group showed a 15 minutes decrease in their sitting time in comparison to the control group.

In an interesting study conducted by Wilks *et al*. (2006), assessing compliance upon the introduction of sit-stand worktables among workers who were desk-bound across four different

companies, it was found that 60 % of men and 12 women who were provided with sit-stand worktables revealed utilising sit-stand worktables once per month or less. Furthermore, Wilks *et al*. (2006) found that participants who experienced pain in different regions of the body or had any musculoskeletal symptoms were more prone to utilising the sit-stand worktables at least once a day. It was also found that participants with no pain or musculoskeletal symptoms utilised sit-stand worktables more than once a month. Barbieri *et al*. (2017) conducted a study intervention for two months evaluating user compliance of sit-stand worktables. It was found that there was an increase in standing position for 1 hour per day both in the first and eighth week of the intervention.

In another study by Sharma *et al*. (2019), determining the effectiveness of health behaviour interventions to increase sit-stand desk usage in a year, it was found that there was an increase in desk position changes in workers that spent more than 5 hours at their desk stations. The study also found that a quarter of the workers did not bother to change desk positions (i.e. switching from sitting to standing positions). Nonetheless, the additional component of the sit-stand worktables that had an in-built prompt designed to prompt participants to stand for 20 minutes, after sitting for 30 minutes was effective in reducing sitting time. The study also revealed that in the first three months of the intervention, participants stood more as compared to in the remaining months. This calls for more research studies to observe utilisation of sit-stand worktables beyond three months, and to find effective interventions that are sustainable in the long run. It is evident from the literature that compliance is impacted by different factors, such as providing ergonomics knowledge, age, experience of pain or musculoskeletal symptoms as well as acceptable postures when standing (Wilks *et al*., 2006; Smith *et al*., 2013). Arguably it is clear that interventions have an implication on compliance, and the reasons for compliance varies between individuals (Thogersen-Ntoumani *et al*., 2010).

2.3.4. Personal factors that affect usage of sit-stand worktables in the workplace

Despite the factors that have been mentioned that are most likely to influence compliance (age, educational counselling, mood effect, musculoskeletal symptoms), it has been found that there are other individual factors that could possibly cause barriers in utilisation of sit-stand worktables. Research demonstrates that there is little research that investigates the usage of sit-stand worktables in a naturalistic environment (actual workplaces). In studies conducted by Chau *et al*.

(2014); Hadgraft *et al*. (2017) and Hederson *et al.* (2018), it was found there are several factors that may impact or hinder individuals from not utilising sit-stand worktables. Factors such as table space were reported as barriers to using sit-stand worktables. The desk layout was perceived not to have enough space to accommodate all the tools one required on their desk, which resulted in less utilisation of the sit-stand worktable. It is worth noting that the issue of desk space raises the questions of acceptability and functionality of the sit-stand worktables. If participants find desk space not to be big enough for their belongings, then it is more likely that they will not use the sit-stand worktables. Chau *et al*., 2014; Hadgraft *et al*., 2017 and Henderson *et al*., 2018, found that desk usage was dependent on the type of task that had to be executed. For instance, Chau *et al*. (2014) and Henderson *et al*. (2018) found that the sitting part of the worktable was preferred when performing complex tasks; for example, refining documents; while the standing part was preferred when performing simple tasks; for example, sending emails.

Both studies (Chau *et al*., 2014 and Henderson *et al*., 2018) also found that time of day was also another factor that influenced usage. Participants reported preference to utilising sit-stand worktables during the morning rather than in the afternoons. The unwillingness to use sit-stand worktables after lunch can be explained by the circadian rhythm which regulates body processes such as sleep, appetite and other routines (Kline *et al*., 2007; Thun *et al*., 2015). It is suggested that after lunch our bodies experience a post-lunch dip which is a result of physiological changes that happen in the body after having lunch. Our body temperature, energy levels, and concentration levels decrease after lunch, which explains why people prefer performing tasks in the early morning as compared to the late afternoon. Some participants reported that the use of sit-stand worktables was socially desirable, especially using the worktables as a collective and having managerial support (Henderson *et al*., 2018). Chau *et al*. (2014), on the other hand, found that using sit-stand worktables in an open plan office was perceived as both distractive and supportive. Having to constantly stand up would be distracting for other colleagues, but also helpful to colleagues in that it would create a standing culture for those that want to take a break from prolonged sitting in the workplace.

2.3.5. Recommended sitting and standing ratios in the workplace

The common view in the workplace is that people in desk-based occupations should alternate between sitting and standing positions based on the literature that explains the health implications of prolonged occupational sitting at work (Buckley *et al*., 2015). Although people are advised to stand up more at work, research shows that there are no standardised guidelines as to when people should alternate between sitting and standing positions, in the workplace. Owing to the lack of these standardised guidelines, studies have used different sitting and standing ratios in the workplace, in the attempt to break and address the problem of prolonged occupational sitting (Bao and Lin, 2018). The suggested sitting and standing ratios are unclear, as some studies argue that sedentary activities should not last for more than 30 minutes, whereas others argue differently (Owen *et al*., 2011).

Buckley *et al*. (2015) recommends that desk-based workers should break their sitting patterns by accumulating 2 hours of standing or engaging in light activity, such as walking during the working day. In a laboratory study conducted by Karakolis *et al*. (2016), participants were advised to alternate between 15 minutes sitting and 5 minutes standing; however, it must be noted that the suggested sit-stand ratio of 15 minutes sitting and 5 minutes standing would not be practical for a real-world setting. This emanates from the fact that real-world settings are complex, and dynamic, and workloads differ daily. As a result, the ratio may not be ideal and could interrupt work.

In an intriguing study conducted by Gallagher *et al*. (2014), participants alternated between 45 minutes standing and 15 minutes sitting. The findings of the study revealed that the sit-stand ratio did not provide any recovery in lower back pain and suggests that people should adapt to habits of changing between sitting and standing positions as frequently as possible. Gallagher *et al*. (2014) outlines that switching from a sitting to a standing position is important; however, it is also important that the ratios that are proposed are undertaken with caution, and health professionals are involved in the decision-making process of the appropriate and correct ratios. Karakolis *et al*. (2016) emphasises that, when establishing sit-stand ratios, factors such as individual differences, the complexity of the work environment, and productivity concerns should be considered. It is also recommended that desk-based workers should stand up every hour of their working day in the attempt to lessen health risks. In response to the lack of standardised sit-stand ratios, it is apparent

that researchers have made efforts to address the question of when workers could possibly alternate between sitting and standing.

2.3.6. Multi-component interventions

Previous studies have reported that the provision of sit-stand worktables alone, or any other intervention, may not sufficiently increase sustained usage of sit-stand worktables (Gao *et al*., 2016). Research suggests that a multicomponent intervention may be more effective in reducing sitting time and changing prolonged sitting behaviour in the workplace. A multicomponent intervention entails provision of sit-stand worktables coupled with additional resources that could adequately encourage participants to step away from their workstations, thus breaking their prolonged sitting habits. The effect of introducing a multicomponent intervention is that the intervention does not only attenuate sitting- related problems at work, but also has the potential to influence participants to change their sitting behaviour outside the workplace (Wang *et al*., 2018). In a study conducted by Healy *et al*. (2013), a multicomponent intervention was introduced to assess the efficacy of including individual, environmental, and organisational elements to assist with reducing prolonged sitting in the workplace. The individual element included providing prompts and motivation; the environmental element included installing sit-stand worktables; and the organisational element included providing a briefing session that involved outlining the health consequences associated with prolonged sitting. The findings of the study demonstrated that providing a multicomponent intervention could successfully assist with reducing occupational sedentary behaviour.

Having said that, factors such as providing participants with additional information on the importance of alternating between sitting and standing in the workplace need to be considered as strengthening mechanisms that aid in reducing sitting time as studies have reported that additional information or training on how to go about interventions contributes greatly towards participants reducing their sitting time and frequently switching between sitting and standing positions (Robertson *et al*., 2013). As reductions in prolonged sitting time are observed in different studies, it can be reasoned that the findings of these studies could be interpreted in a way that participants were aware of their sitting behaviour due to being knowledgeable and well-informed about the

health risks associated with prolonged sitting and as a result made more effort to stand up frequently.

2.3.6.1. Computer-based prompting

Research has reported computer-based prompting as another method for reducing prolonged sitting time in the workplace. A computer prompt constitutes of a web application that is designed specifically to interrupt computer users for various reasons. These prompts have shown to be very effective in reducing prolonged sitting time. For example, in a study conducted by Mainsbridge *et al*. (2016), a computer prompt software was installed to interrupt workers from long bouts of sitting as a form of combatting sedentary behaviour in the workplace. The web application was designed in such a way that workers received computer notifications that disengaged them from their computers to engage in short bursts of non-structured exercises during the working day, whenever the notification message appeared on their computer screens. An interesting study done by Pedersen *et al*. (2014) installed an e-Health software on workers desktop computers. The objective of the study was to increase workday energy expenditure by interrupting periods of prolonged sitting with short bursts of physical activities. As such, the software offered an active prompt that gave workers the opportunity to engage in activities such as one-legged squats, desk push-ups, or climbing office stairs. The prompting intervention automatically deactivated workers' computer screens after every 45 minutes. The outcomes of the study revealed that participants whose computers had the e-Health software installed, showed an increase in energy expenditure as well as a reduction in sitting time. The results indicated that introducing computer prompts coupled with adding short bursts of non-structured exercises in the workplace could potentially reduce prolonged sitting time. In another study conducted by Evan *et al*. (2012) investigating the effects of prompt software and providing education training on the consequences of prolonged sitting in the workplace, it was found that introducing prompting software resulted in a reduction in sitting time compared to the group that only received education training. It is evident from the above studies that computer-based prompting is an alternative intervention option to reduce or break prolonged sitting in the workplace.

2.3.6.2. Micro-breaks combined with short non-structured stretches

Present-day occupations often lack physical activity, as the advanced modern office workspace comprises of computers, printers, emails, and teleconferencing. These devices are within reach, which results in less movement in the work environment. Workers are constantly fixed to their computer screens, and subsequently, physical loading of the body is lessened (Commissaris *et al*., 2006). Physical inactivity is thus evident in the workplace and increases the risks of developing non-communicable and communicable diseases (Commissaris *et al*., 2006). The growing evidence on the association between prolonged occupational sitting time and the negative health implications suggests that interrupting or breaking prolonged sitting with short bursts of physical activity could lessen the risks of developing negative health implications attributed to prolonged occupational sitting.

For example, in one study physical activity booster breaks were added in the workplace (Taylor *et al*., 2013). Booster breaks are defined as 'organised, routine work breaks intended to improve physical and psychological health, enhance job satisfaction, and sustain or increase work productivity' (Taylor *et al*., 2013). The booster breaks entailed aerobic movements, and flexibility movements. It was found that introducing booster breaks in the workplace resulted in a change in behaviour beyond the workplace, i.e. increase in health awareness and enhanced social interactions.

In a study conducted by Balci and Aghazadeh (2003) on the effect of supplementary breaks and stretches for data entry operators, it was discovered that taking micro-breaks every 15 minutes to perform stretches reduced musculoskeletal discomfort around the neck region. The findings of the study are inconclusive, as it is not clear whether supplementary breaks coupled with stretching exercises influenced the reduction in musculoskeletal discomfort. In another study conducted by Smith (2014), it was found that micro-breaks were quite effective when participants were interrupted with a computer-based prompt and required to perform neck exercises in an attempt to reduce neck pain. In a study conducted by Strongman and Burt (2000), it was found that participants took a break from their work for reasons such as drink, food, cigarette, tiredness, boredom, and poor concentration, as well as the need to socialise. It was also found that some participants did not take a break due to chasing deadlines. Some participants reported that taking

a break was time-consuming and that they would rather endure the sitting until the task was completed. Studies show that in many cases workers wait until they start experiencing musculoskeletal problems before accustoming themselves to taking frequent breaks from their computer workstations, which is deemed to be problematic as health risks could have been prevented prior to the development of musculoskeletal discomfort (Henning *et al.*, 1997).

In another study, short bursts of physical activity interventions were introduced, such as standing or moving every 30 minutes for 1-2 minutes or taking 15 minute breaks from sitting each working day (Mailey *et al*., 2016). It was found that there was a reduction in sedentary time during the workday as a result of participants engaging in physical activity interventions that attempted to break prolonged sitting behaviour. The findings also showed a decrease in total cholesterol and other health outcomes (Mailey *et al*., 2016). Therefore, it is apparent that incorporating short bursts of physical activity in the workplace has beneficial health effects besides reducing sitting time.

Galinksy *et al*. (2007) introduced supplementary breaks and stretching exercises in the workplace to assess the effects thereof on computer users. It was found that there are benefits to both supplementary breaks and performing stretching exercises. The benefits included reduced intervertebral disc pressure, less discomfort, increased blood circulation, reduced lactic acid in muscles, increased physiological arousal, and increased alertness.

It is thus evident that taking a break from work could have positive or negative effects, and that the perceptions around taking micro-breaks differ between individuals. Drawing on the benefits of micro-breaks, it is evident that workplaces have begun to optimise human well-being coupled by introducing non-structured stretches in the workplace to reduce prolonged sitting in for health reasons, and to reduce uneasiness linked with prolonged sitting at a computer workstation (Henning *et al*., 1997). However, there is still a lack of guiding principles as to when people should take breaks from prolonged sitting in the workplace. Nonetheless, with the increase in research around prolonged sitting in the workplace, it can be seen that there are attempts to introduce breaks that allow people to switch postures.

2.4. Interventions in the context of the organization

2.4.1. Cost-benefit ratio

Addressing the problem of prolonged sitting in the workplace primarily originates from ergonomics literature (Healy *et al*., 2012). Research shows that ergonomics interventions are relatively expensive, and that there is limited research that assesses the cost and benefits of investing in these interventions (Lahiri *et al*., 2005). Although ergonomic furniture is expensive, some companies have started to invest in purchasing height-adjustable worktables and other ergonomic furniture. However, there are some companies that remain reluctant and are not interested in investing in ergonomic technology as a means to accomplishing and solving business goals in the workplace (Puleio and Zhao – Humanscale). This could be explained by a lack of understanding of the importance of the principle of ergonomics. This means that how ergonomics fits into the workplace is still not understood, and not linked to how the understanding can greatly assist with reducing health risks and costs. Research shows that investing in ergonomic interventions that are deemed to be expensive can have a positive return on investment in the long run. As soon as height-adjustable worktables are available to workers, workers are able to utilise these tables for years without having to worry further about health-related problems. Moreover, the investment saves the company money from injury claims, as well as optimising the health and well-being of workers. The General Accounting Office (GAO) 1997 demonstrates that implementing ergonomics interventions leads to a significant reduction in injury claims. Therefore, investing in ergonomics adaptations seems to be feasible, and should reach a wider audience. On the other hand, performing stretches is relatively affordable, as it does not require any outlay, compared to restructuring the workplace through introducing various ergonomic furniture.

2.4.2. Company policy

Research shows that there are definitive benefits to implementing different interventions in the workplace. However, whether organisations have integrated these interventions as part of workplace policies is still unknown. The idea of promoting any form of physical activity or introducing interventions that aim to reduce prolonged occupational sitting is important, and by far better than targeting individuals, as organisations offer team effort and social support, considering that workers spend most of their working day at work (Barr-Anderson *et al*., 2014). With that being said, not focusing specifically on the individual does not necessarily mean that the

individual is disregarded; an organisational routine that promotes team effort will steer the individual to change their own sitting behaviour. Knox *et al*. (2017) notes that the impact of policy-based support in workplaces and prioritisation of integrating physical activity in the workplace is to a certain extent not known. This shows that there is limited research that highlights how interventions or physical activity could be incorporated as part of workplace policies. Therefore, incorporating any form of physical activity in the workplace would be beneficial as workers well-being would be optimised through reducing prolonged occupational sitting behaviour. Moreover, it would also cause organisations to look into expanding their policies and integrating these interventions in the workplace (Barr-Anderson *et al*., 2014). This could greatly help with identifying which interventions are effective and have been well-accepted in the workplace. Moreover, it will indicate the success rate of these interventions and help with implementation and increase awareness in the workplaces (Knox *et al*., 2017).

CHAPTER 3
Methodology

The preceding chapter reviewed literature from previous scholarly work on prolonged occupational sitting; health implications of prolonged sitting; and benefits of reducing sitting time; different intervention strategies implemented in the workplace; as well as the gaps and themes that have been found around the research topic; and discussed the theoretical frameworks that guided the research. The chapter starts with the description of the **Research concept** (3.1) and the **Experimental design** (3.2). Section 3.3. **Research hypotheses**. Section 3.4 **Interventions** it describes the theoretical framework that was used to develop the interventions. In Section 3.5. **Dependent variables** the variables that were recorded during the testing period are outlined. This is followed by the **Experimental procedure** in section 3.6, the **Participant characteristics** in section 3.7 and **Ethical considerations** in section 3.8**. S**ection 3.9. **Data processing** describes how the recorded data were processed.

3.1. Research concept

There is extensive research on the problem of prolonged sitting in the workplace. However, little to none of the research goes towards understanding how compliance is most likely to have an impact on the effectiveness of introducing sit-stand interventions and change sitting behaviour in the workplace. The sit-stand paradigm is unknown; however, office-based workers are recommended to alternate between sitting and standing during their working day. The aim of the current study was to evaluate the effectiveness of two different interventions, physical intervention (sit-stand worktables) and personal intervention (instruction to stretch) on compliance and reducing occupational sitting behaviour. The study also aimed to investigate the effectiveness of interventions in improving or impairing mood. In order to do that, different sit-stand interventions would have to be implemented in the workplace and be compared. The interventions would be compared to the baseline phase and intervention phase to assess the effectiveness of the interventions in changing occupational sitting behaviour in the specified workplaces.

The intervention phases are as follows:

1. **Baseline phase**: The aim of the baseline phase was to assess current sitting patterns in the workplace for a month.
2. **Intervention phase**: The aim of the intervention phase was to introduce a physical (sit-stand worktables) and personal intervention (stretches) in the workplace in the attempt to break prolonged occupational sitting behaviour over 58days.

3.2. Experimental design

To complete the research study, a field-based intervention study was conducted at Rhodes University. A field study was chosen over a laboratory study given that there is limited research that investigates the sustained utilisation of different sit-stand interventions in real-world settings. The study used a non-repeated measures design; in other words, it took measurements on the same participants over time, under the same conditions. The study consisted of two intervention groups; a physical intervention group (sit-stand worktables) and a personal interventional group (instruction to stretch). Participants in the different divisions were randomly allocated to either the physical or personal intervention groups. The study began with a one-month baseline phase, which assessed participants' normal sitting patterns in the workplace. Participants in both intervention groups were required to complete a baseline phase for a month. Upon completion of the baseline phase, all participants received educational training on the benefits of alternating between sitting and standing as well as the health implications of prolonged sitting in the workplace. Following the educational training, participants began with the intervention phase for a period of 58days.

3.3. Research Hypotheses

The intervention was expected to impact occupational sitting habits and have an impact on the mood effect of the participants. The following null hypothesis were proposed:

1. There will be no change in desk occupancy during the baseline intervention.
2. There will be no change in mood effect during the baseline intervention.
3. There will be no change in standing time (compliance indicator) over the course of 58 days in the physical intervention group.

4. There will be no change in standing time (compliance indicator) over the course of 58 days in the personal intervention group.
5. There will be no change in mood effect over the course of three weeks in both interventional groups (physical and personal intervention).

3.4. Interventions

3.4.1. Theoretical framework for the intervention development

The two types of interventions (physical and personal intervention) were developed and designed using existing literature on the different intervention strategies that have been employed to reduce occupational sedentary behaviour, as well as the behaviour change model (see literature review, page 21).

The behaviour model was used as a frame of guidance to design the interventions of the study, particularly using the centre of the behaviour change wheel (COM-B model) to develop the workplace interventions to ensure that the intervention strategies proposed in the workplace serve their purpose, and are effective in changing sitting behaviour in the workplace. The framework helped with unpacking and understanding the behaviour that needs to be changed, understanding the process that would be required to target the specified behaviour, and how to go about designing effective interventions. The provision of evidence-based interventions assists with discovering appropriate techniques to implement in real-world settings (Michie *et al.*, 2011). In addition, the behaviour change wheel framework was used as a mechanism to influence participants to adhere and engage with the study interventions, and to provide participants with the necessary tools that will allow them to engage with the study interventions.

In terms of capability, the study assessed psychological factors such as mood to assess how interventions are successful in changing one's state of mind. Motivation was put into perspective by providing participants with educational information on the negative effects of sitting for extended periods. The focus of the motivational factor was to offer participants the opportunity to enhance their knowledge on the health risks associated with prolonged sitting in the workplace, with the hope of motivating participants to change their sitting behaviour. When looking at opportunity, the study provided participants with both physical and social opportunities, in the

physical intervention group participants received sit-stand worktables, and in the personal intervention group, participants received instructions to stretch.

3.4.2. Multi-component intervention

Emerging research shows that incorporating a multicomponent intervention in the workplace is better and more effective in targeting the ideal behaviour, rather than introducing one type of intervention. A multicomponent intervention entails various aspects, such as combining the provision of sit-stand worktables with training sessions, face to face coaching, computer prompts, and motivational websites (Carr *et al*., 2013; Neuhaus *et al*., 2014; Swartz *et al*., 2014). The present study took a similar approach and incorporated a multicomponent intervention. The components of the intervention included ergonomics training/education, computer prompts (55 minutes to 5 minutes sit-stand regime), face to face interactions with the researcher, sit-stand worktables, and stretches. Considering that the study had two intervention groups, the components of the interventions varied based on the intervention type. For example, participants in the physical intervention group received ergonomics training/education, sit-stand worktables, computer prompts (55 minutes to 5 minutes sit-stand regime), as well as face to face interaction with the researcher. The group did not receive instructions to stretch, whereas participant in the personal intervention group received ergonomics training/education, instruction to stretch, computer prompts (55 minutes to 5 minutes stretching) and face to face interaction with the researcher. The group did not receive sit-stand worktables.

3.4.3. Physical intervention

This intervention entailed participants receiving sit-stand worktables (Quickstand Eco tables). These tables allowed participants to perform tasks either in a seated or standing position throughout the working day (figure 3) (Dustan *et al*., 2012; Grusteit *et al*., 2013; Chau *et al*., 2014; Karakolis *et al*., 2014; Finch *et al*., 2017).

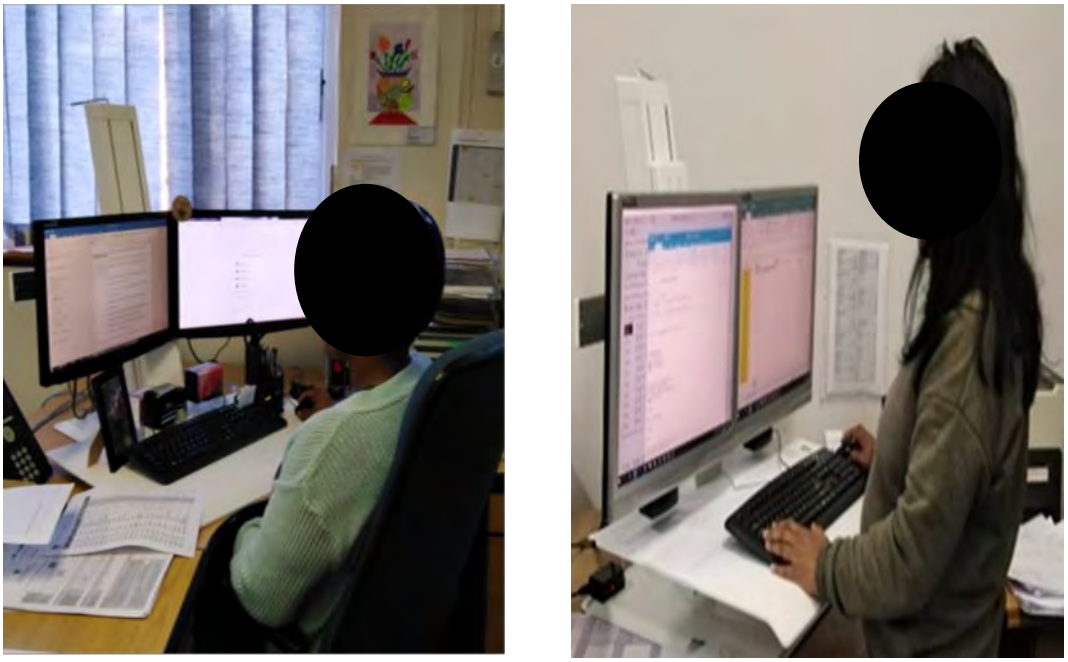

Figure 3: Participant working in a sitting position (left) and participant in a standing position (right).

3.4.4. Personal intervention

This intervention entailed participants eliminating themselves from prolonged sitting by performing the stretches outlined in appendix 4, page 98. Sitting involves spinal flexion; therefore, introducing stretching exercises in the workplace helps with the mechanism to counter-movement (Holzgreve *et al*., 2018). Studies have introduced stretching exercises in the working environment in light of workers encountering desk-based musculoskeletal disorders. The aim of introducing stretching exercises in the workplace is essentially to promote a range of motion in the muscles and to increase flexibility in various areas of the body (Shariat *et al*., 2018). The research of Holzgreve *et al*. (2018) and Shariat *et al*. (2018) found that stretching exercises help with reducing stiffness and pain in muscles of the back, shoulders, and neck. The ability for stretches to ease bodily pains led to the current study introducing stretching exercises in the workplace; however, this was in the hope of reducing prolonged sitting and promoting standing rather than reducing pain. In a study by Pedersen *et al*. (2014), short bursts of stretches were introduced. These stretches included one-legged squats, desk push-ups, and climbing office stairs as a way of interrupting prolonged sitting time in the workplace. This research study took a similar approach and introduced simple stretches; however, different stretches were chosen, such as neck

flexion/extension stretches, supraspinatus stretches, quadriceps stretches, forward lunge stretches, and leg swings.

3.5. Dependent variables and experimental set-up

The dependent variables for the study were evaluated using a mixed method approach i.e. a quantitative and qualitative method. A quantitative method uses numerical data to answer empirical questions, whereas a qualitative design method is a method that makes use of words in its analysis and the collection of data (Bryman, 2012). The dependent variable for the study are:

3.5.1. Desk Occupancy

To measure the total time spent at work desks during the entire working day, participants in both intervention groups received SenzoUnit sensors. The sensors were attached under participants'' worktables and were connected to a Vodacom 21. 6 mbps Wi-Fi router (ZTE H209Z). The sensors automatically recorded real-time desk occupancy i.e. the amount of time participants spend at their desks and away from their worktables.

3.5.2. Sitting time

To assess sitting/standing time i.e. usage of the sit-stand worktables (compliance indicator) in the physical intervention, participants received data logger sensors that were attached to the sit-stand worktables. The sensors recorded the date, time in hours, minutes, or seconds, and the state of the tables (i.e. indicating whether participants were in a standing position or sitting position). The command for the standing position was 'U', indicating that the table was elevated, and the command for the sitting position was 'D', indicating that the table was lowered down. The readings from the sensors provided an indication of how frequently participants used the sit-stand worktables during the study. The data logger sensor had two indicator lights (red and green), a connection socket for a USB cable and a wired connection for the magnetic reed switch. The sensor was plugged into the USB cable, running through the PC. The indicator lights were used to check for functionality of the sensor. The red light flashed every 2 seconds, giving an indication that the sensor was working. The green light showed the state of the desk; when the green light turned on, that was an indication that the desk is in a sitting position and when the green light turned off, that

was an indication that the desk was in a standing position (see figure 4, page 34). The sensors recorded the sit-stand transitions with the time stamps as a text file. The files were downloaded on a weekly basis, using a USB connection on a weekly basis. Participants in the intervention group were also provided with an off-desk activity diary to reflect on their off-desk physical activity patterns, such as attending meetings, walking, and standing, and fetching or delivering documents outside the office. The diary gave an indication on other activities that participants engaged with to break their prolonged sitting behaviour.

To assess sitting/standing time (compliance indicator) in the personal intervention (i.e. stretches), participants received an activity diary to reflect on their sitting behaviour during the five minutes break. Participants' were asked to indicate whether they performed stretches or decided to walk or stand up during their break.

Figure 4: Sensor attached to sit-stand worktables recording sit-stand transitions in the physical condition.

3.5.3. Mood

The concept of mood is complex, as one's frame of mind or mood state changes over time. Research shows that the result of providing participants with sit-stand worktables in the workplace has resulted in participants reporting feeling comfortable, less stressed, and more energized using the profile mood state questionnaire (Pronk *et al*., 2012). To assess participants' subjective responses (i.e. mood) in this particular study, the positive affect and negative affect schedule (PANAS) mood questionnaire tool was used to assess mood once a week during the entire working

day. A high negative affect is portrayed by subjective distress along with un-pleasurable engagement with the environment, with an absence of these feelings indicating a low negative affect (Crawford and Henry, 2004). A high positive effect is portrayed by excitement, alertness, and pleasurable engagement with the environment, and feelings of sadness and laziness show a low positive effect (Crawford and Henry, 2004). This subjective measure was used as an indicator of how workers felt having to engage with the study intervention during the working day.

3.6. Experimental procedure

3.6.1. Recruitment Process

Participants were recruited through the researcher taking a tour around Rhodes University premises, identifying administrative divisions that are office-bound and where workers spend most of the working day sitting. Office workers from three divisions (finance, academic, and library) were identified and approached. Thereafter, communication was sent to the relevant supervisors in the different administrative divisions via email requesting an office visit to gather more information about the office division and to provide employees with a brief background on the research study and the proposed methodology. Participants that showed interest in the study received a formal email invitation with the study information.

3.6.2. Pre-screening

Before the study commenced, the investigator requested participants to complete the NORDIC musculoskeletal questionnaire (appendix 3, page 97), to assess musculoskeletal symptoms in different regions of the body that could potentially prevent participants from participating in the research study. The problem of experiencing musculoskeletal disorders in different regions of the body is a big health concern worldwide (Hildebrandt, 2001). The NORDIC musculoskeletal questionnaire was developed as a standardised tool for assessing general complaints of the lower back, neck, and shoulders for use in epidemiological studies. The validity and reliability of the NORDIC musculoskeletal questionnaire to assess musculoskeletal symptoms has been extensively shown in different research studies. For example, Daneshmandi e*t al.* (2017) used the questionnaire, and the results revealed that prolonged sitting among office workers generally

influences one's health. The results also showed that workers experienced great pain or aching symptoms in the neck, shoulder, and lower back region. For this particular study, the NORDIC questionnaire was used to discover participants with medical conditions that could prevent them from partaking in the research study to avoid further injuries.

3.6.3. Baseline

The study conducted a baseline phase to assess existing sitting patterns in the workplace. The sitting patterns were assessed using the SenzoUnit sensors to calculate the amount of time participants spend at their worktables during their 8 hour working day.

3.6.4. Ergonomics training

Participants received ergonomics training upon completing the baseline phase of the research study. The aim of the training was to inform participants of the health implications associated with prolonged sitting, as well as to inform participants of the benefits of alternating between sitting and standing based on the literature, and common interventions that have been developed in workplaces to break prolonged sitting. Research has shown that participants that receive ergonomics training on the consequences of prolonged sitting and health risks are more likely to be conscious of their sitting behaviour, and to change their sitting behaviour (Wilks *et al*., 2006 and Robertson *et al*., 2013).

3.6.5. Sit-stand regime and computer-based reminders

The study employed a physical intervention and personal intervention to break prolonged sitting in the workplace. In the physical intervention each participant received either a single or dual sit-stand worktable (Quickstand Eco Table), depending on whether the participant had one or two computers screens. The sit-stand worktables were attached to a small data logger sensor that detected utilisation of the tables. Participants in the personal intervention were provided with stretches (appendix 4, page 98).

Participants in both intervention groups were instructed to interchange between 55 minutes sitting and 5 minutes of standing during their 8 - hour workday. Those in the physical intervention were

instructed to utilise the standing component of the sit-stand worktable during their 5 minutes. This required participants to alternate between sitting and standing positions throughout the working day, in the attempt to break prolonged sitting time (Mainsbridge *et al*., 2016; Mansoubi *et al*., 2016). Participants in the personal intervention were instructed to do the stretches during the five minutes standing as outlined in appendix 4, page 98. In both intervention groups participants received computer based prompts (reminders), however, the reminders consisted of different instructions depending on the intervention type. Figure 5, and figure 6, page 37 and 38 shows the different message notifications that appeared in the middle of participant's computer screens, which allowed participants to engage with the study procedure.

Both intervention groups also received activity diaries. Participants in the physical intervention were instructed to record their off-desk activities such as attending meetings and delivering documents. Participants in the personal intervention group were instructed to record whether they performed the stretches outlined or engaged any other activities that did not involve sitting, such as attending meetings, standing or walking to different offices. Once a week participants in both intervention groups were required to complete complete the positive affect and negative affect schedule (PANAS) mood questionnaire in order to assess how the intervention impacted their mood over the study duration. This intervention lasted for a period of three months (58 working days).

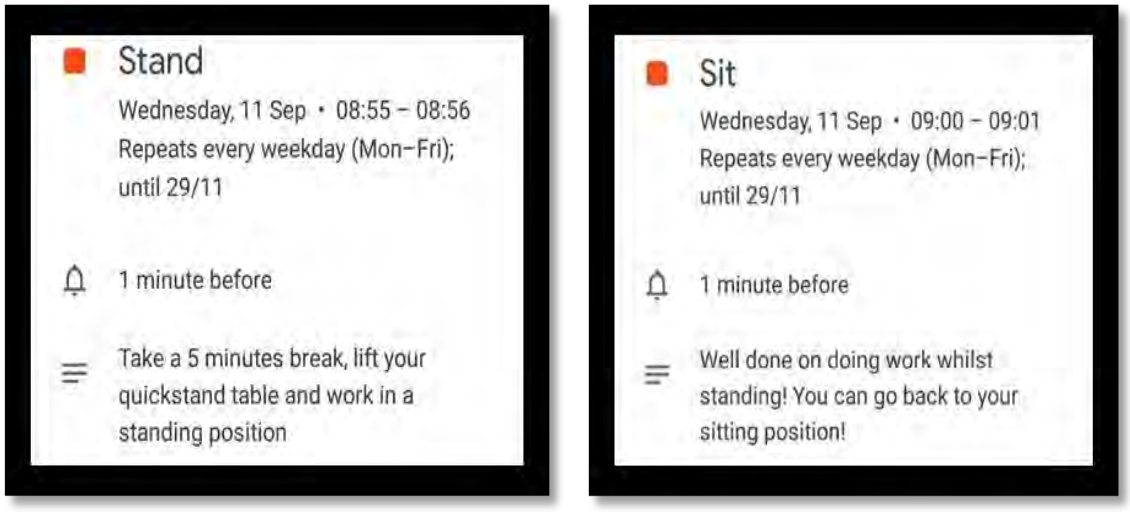

Figure 5: Computer prompt notification reminding participants to use their height adjustable worktables

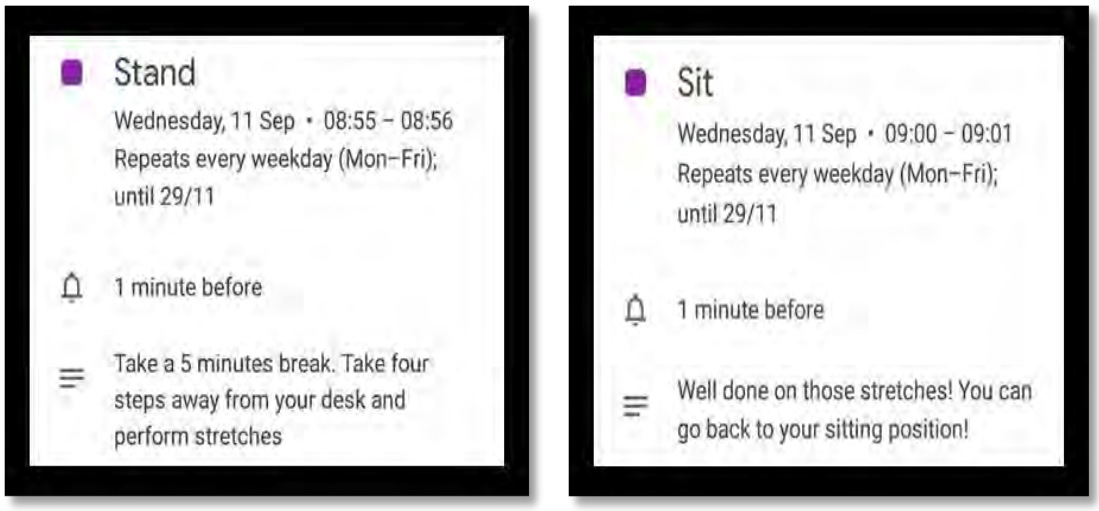

Figure 6: Computer prompt notification reminding participants to stand up from their workstation and perform short stretches.

It is noteworthy that there are no set recommendations as to when workers are required to alternate between sitting and standing postures in the workplaces. However, Worksafe Australia suggests that all computer-based employees should remove themselves from a sedentary position for a short period every 60 minutes (Pedersen *et al*., 2014). The set time for participants to alternating between sitting and standing - 55 minutes sitting and 5 minutes standing (height-adjustable table or stretches) - was chosen on the basis that the investigator did not want to interfere with participants work, considering that the research was conducted in a real-world setting.

3.7. Participant characteristics

The sample characteristics were required to be (a) full-time Rhodes University employees, (b) desk-bound, and (c) free from musculoskeletal disorders. All participants worked a typical working day shift from 08:00 am to 16:00pm. Participants included in the study were both male and female adults, aged between 18 and 50 years. The age range was based on the Basic Conditions of the Employment Act in South Africa and availability of participants based on their different age groups. In total, 17 participants were recruited to participate in the research study due to the availability of resources. However, due to medical reasons one participant was excluded from the research study.

3.8. Ethical considerations

Conducting research that involves human participants by way of questionnaires requires certain code of ethics or, in simpler terms, morals or manners that need to be abided by. The research study received ethical clearance (HKE-2018-29) from the Department of Human Kinetics & Ergonomics and permission to conduct the study from the relevant gatekeepers of the University, being the Director of Human Resources, as per the ethical standards.

3.8.1. Information to participants

At the beginning of the study, the researcher explained the basis of the research study and the subject matter of the study to participants. Participants were well informed of the study and how their contribution would help.

3.8.2. Consent and Anonymity

During the research, informed consent was received from all participants as a matter of assuring participants that their privacy will be protected, and no harm would come to them. Consent was both verbal and written. Participants were well informed that to protect their identity they would receive codes to ensure that all information provided retains their anonymity. Participation was voluntary, and participants could decide to withdraw from the study at any time by advising the researcher.

3.9. Data processing

3.9.1. Data Reduction and Statistical Analysis

The data was first imported to Microsoft Excel; thereafter, means and standard deviations were calculated. To determine the differences within the results, all the data were statistically analysed using the Statistica Software version 13.4 (Statistica©, Statsoft, Inc.; Tulsa, OK74104, USA). Where suitable, a general linear model analysis and post-hoc tukey test were performed to determine any significant differences. Due to participants taking leave of absence during the testing period, some participants did not complete the full testing duration as anticipated. Therefore, to allow for statistical analysis, the data was reduced as follows:

3.9.2. Standing time (Compliance)

In the physical intervention (sit-stand), the text file data was imported to Microsoft Excel; thereafter the sit-stand transitions were converted into hour-long durations. To validate the data, the data was cross-checked with off-desk diaries. The data was averaged over the duration of the experiment (hours), averaged for each hour of the day, and averaged for each day of the week over the course of the experiment.

To allow for statistical analysis, the data were statistically analysed using the general linear model, in particular a two-way analysis was performed with the following factors: day (58 days), hours (7 working hours), weekdays (Monday to Friday), and intervention type (physical/ personal intervention). To determine statistical differences within the intervention types over the day, a post-hoc tukey test was performed. Because of the different number of leave days taken, participants completed a minimum of 58 days of the experiment. Only the first 58 days were included in the analysis instead of 60 days. To authenticate the results, those participants that did not complete the full experiment were excluded from the analysis. Thereafter, another analysis was done including the three participants; however, testing the analysis over 58 days. The outcomes for both analyses gave the same results, and as such, only the first 58 days were included in the analysis. Hours where participants were absent or in a meeting, etc. (the missing values) were excluded from the time of day analysis.

In the personal intervention (stretches), the data was imported to Microsoft Excel. The desk occupancy data was presented as zeroes ‘0’ and ones ‘1’, which presented desk occupancy every 2 minutes. The data was converted into durations and cross-checked with the activity diary information. The same statistical procedure was followed as the physical intervention.

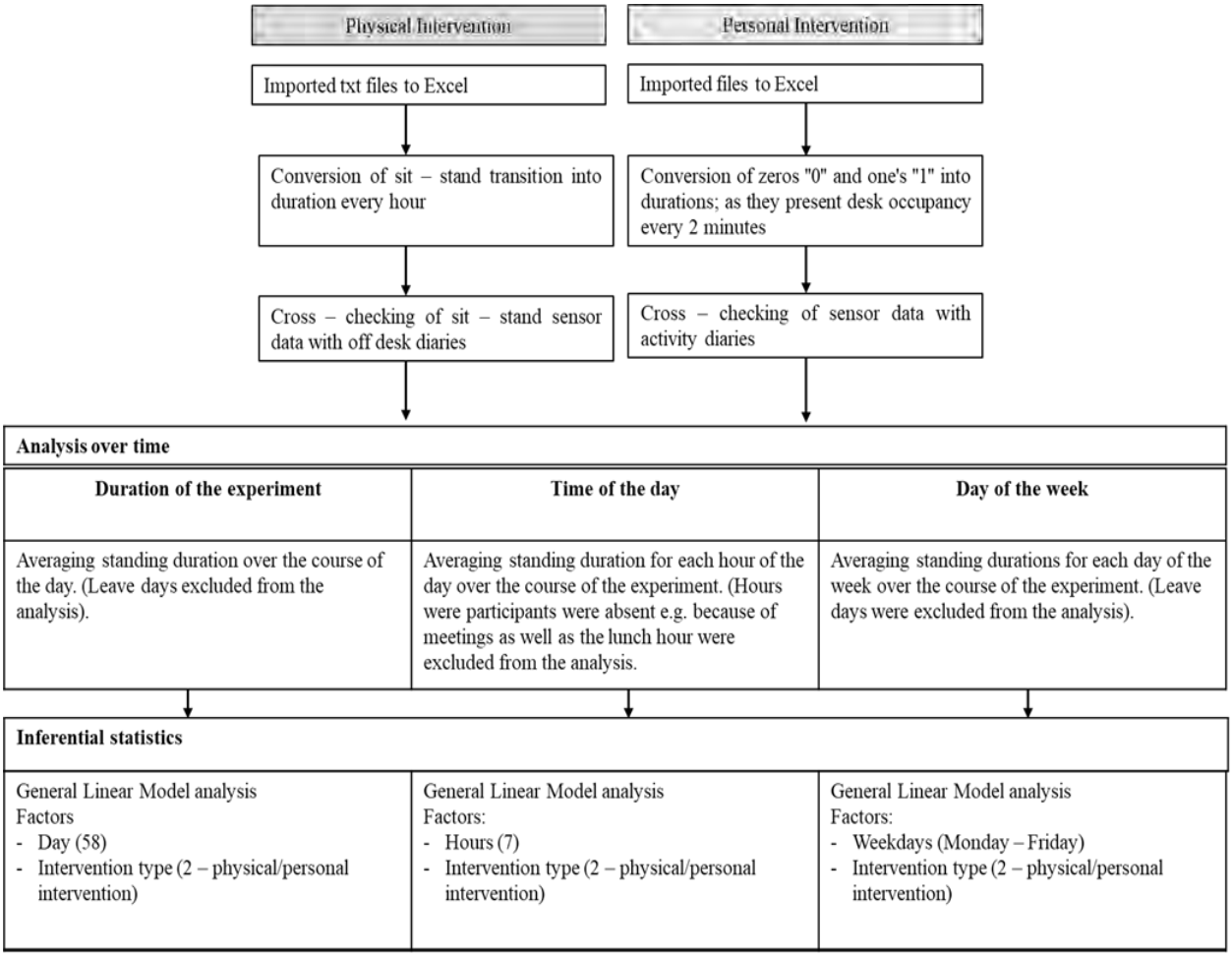

Figure 7: Data reduction process over the course of the experiment to investigate compliance.

3.9.3. Desk occupancy

In both the baseline and intervention data was reduced through converting the desk occupancy data into durations. Thereafter, the relative percentage time spent at the desk was calculated for the entire working day. The desk occupancy data was cross-checked with the activity diaries for authentication. The data was averaged over hours and days for baseline and intervention. Hours and days where participants were absent were excluded from the analysis. Because the baseline was conducted for a month (20 days), to compare the baseline with the intervention, the last 20 days of the intervention were assessed in contrast with the first 20 days of the baseline to minimise the effect that might be the result from the change in sitting behaviour during the experiment. A general linear model analysis with two factors, i.e. baseline/intervention and intervention type (physical/personal intervention), was performed to compare desk occupancy during the baseline and intervention over the 20 days.

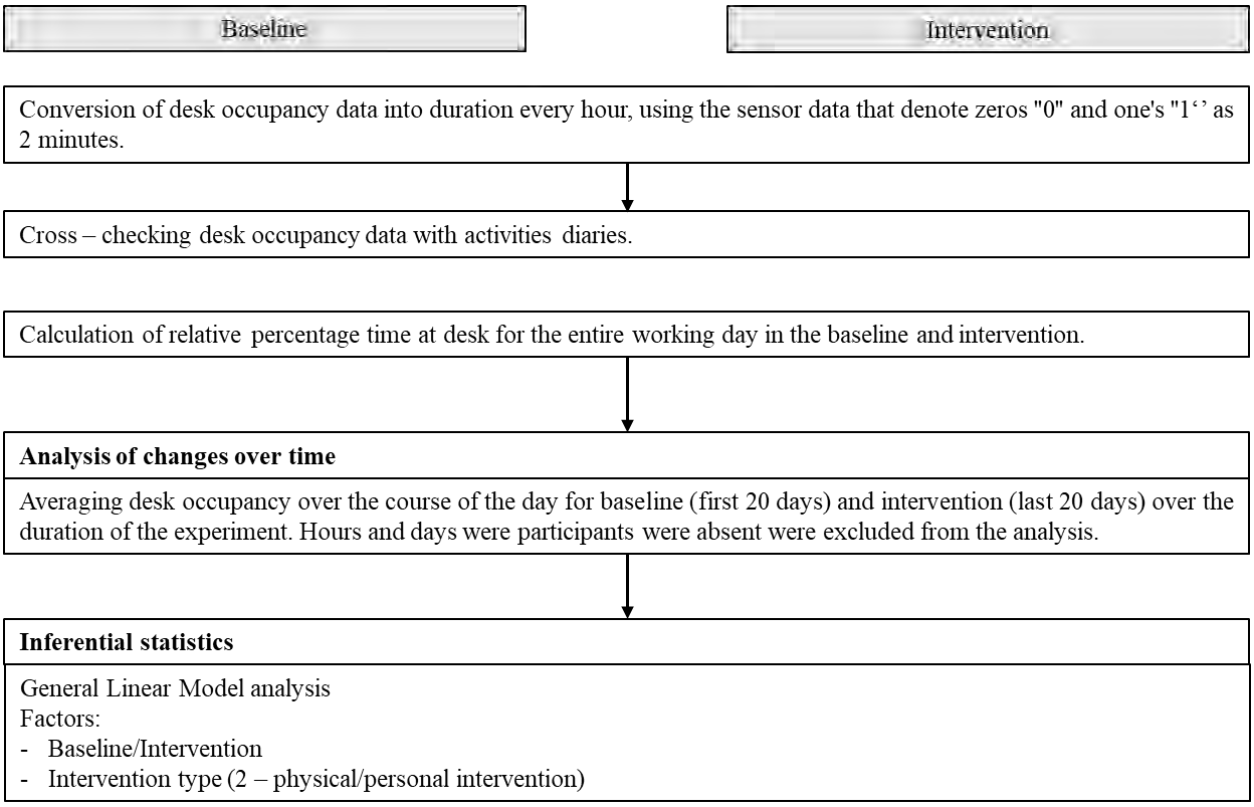

Figure 8: Description of data reduction in the baseline intervention and intervention phase to assess desk occupancy.

3.9.4. Positive and negative mood affect

The data from the mood questionnaire were used to calculate the positive and negative mood affect according to the questionnaire ratings. Thereafter, a general linear model analysis was performed with three factors intervention type (physical/personal), baseline/intervention, and number of weeks (1-3), to compare mood affect in the baseline and intervention over three weeks.

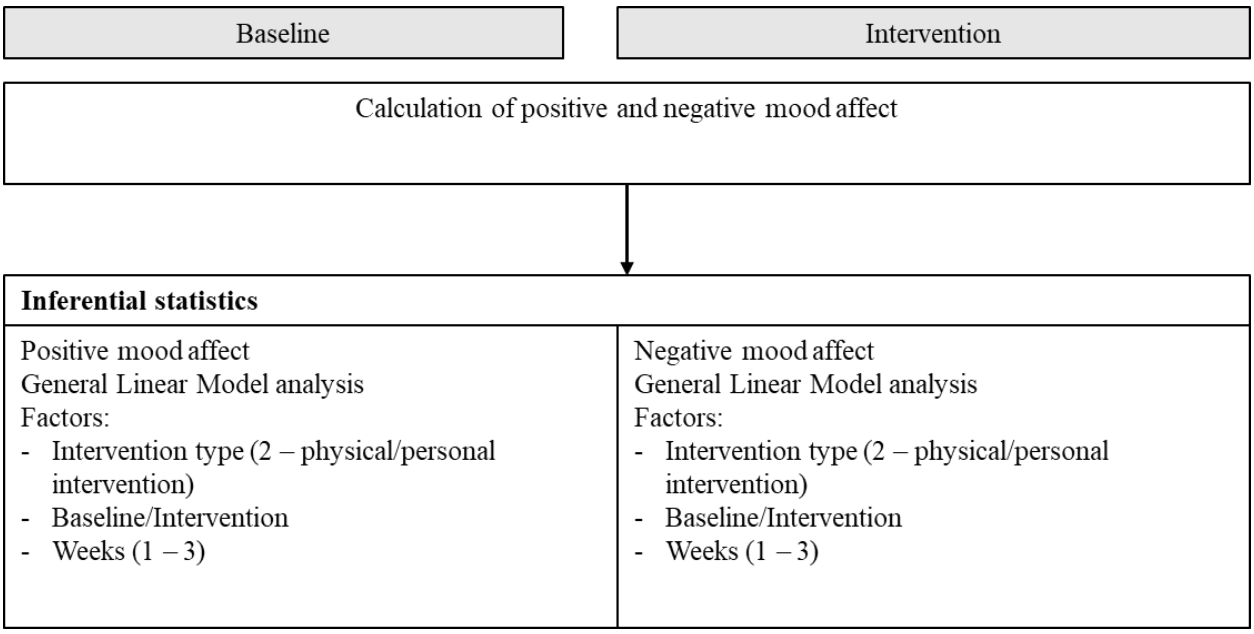

Figure 9: Description of mood data reduction in the baseline intervention and intervention.

CHAPTER 4

Results

This chapter presents the results of the study. The aim of the study was to investigate the effect of different interventions on compliance with the aim to reduce occupational sitting behaviour among office-based workers. The study consisted of two intervention groups (physical and personal intervention). To investigate compliance in the two intervention groups, the dependent variables that were investigated were standing time (compliance indicator), desk occupancy and mood effect. These variables were investigated to determine whether standing time (compliance) was dependent on the type of intervention, or whether there were any behavioural changes overtime. Desk occupancy was assessed in the baseline and intervention phase. The purpose of investigating desk occupancy in the baseline phase was to observe the amount of time participants spent at their workstations prior to the introduction of interventions in the workplace. Upon introducing the interventions, the desk occupancy results provided evidence of the effectiveness of the intervention in reducing sitting time, as well as giving an indication of whether performance is likely to be impaired in the different types of intervention. Furthermore, the mood perception results gave evidence as to whether the interventions aided in changing their mood perceptions. The data was cross-checked in both intervention groups to ensure that the results from the objective data were authenticated with the subjective data where applicable. The data was analysed statistically over time using the general linear model analysis, taking into account the different factors to determine any statistical differences. This chapter entails the following sections: Section 4.1. **Compliance** results; Section 4.2. **Average standing time over the course of the working day** results; Section 4.3. **Average standing time over the course of the weekday** outcomes; Section 4.4. **Effectiveness of intervention in reducing sitting time at work desk**; Section 4.5. **Effect of interventions on mood** results; Section 4.6. **Response to hypotheses.**

4.1. Compliance

To investigate whether the standing time (compliance) varied between the interventions, three questions were developed to assess compliance over the duration of the study. The questions were as follows:

1) Does standing time (compliance indicator) change over the 58-day duration of the experiment? Is this change dependent on the type of intervention?
2) Does the standing time change over the course of the week (Monday to Friday)? Is this change dependent on the type of intervention?
3) Does the standing time change over the course of the working day (morning to afternoon)? Is this change dependent on the type of intervention?

4.1.1. Change in (sitting/standing time) compliance over the course of the intervention

The average standing time in the physical intervention is higher than in the personal intervention over the course of the experimental intervention (figure 10, table 1), thus being statistically significant ($p = 0.0002$). This shows that compliance was higher in the physical intervention group and lower in the personal intervention group.

*Table 1: Two-factorial analysis of variance of average standing time over the course of the experiment for the factors days and intervention (physical and personal) (n = 15, * denotes statistical significance p<0.001).*

Effect	**Df**	**F**	**P**
Intervention Type	1, 13	24, 03940	**0.000289***
Days	57	2, 44223	**0.001***
Days*Intervention Type	57, 741	1, 84982	**0.000224***

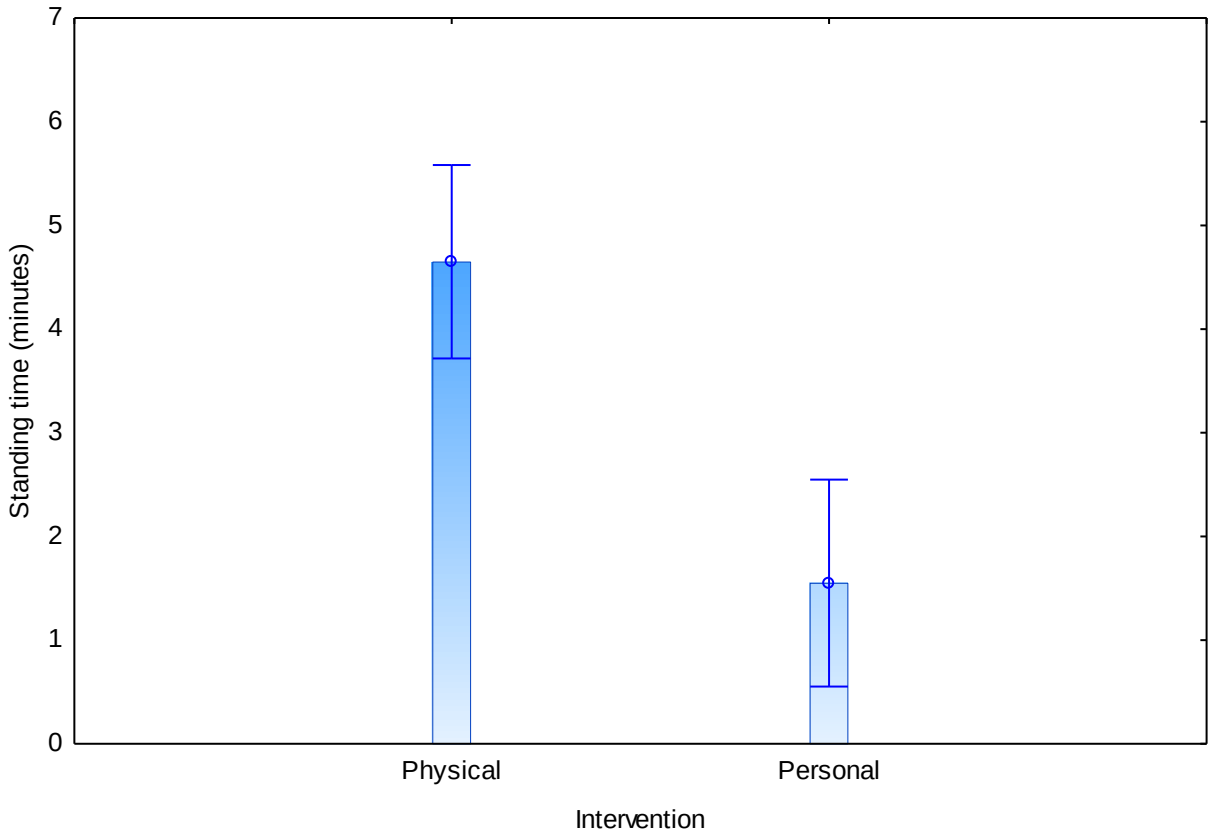

Figure 10: Average standing time (per hour) for the physical intervention (sit-stand worktables) and personal intervention (stretches) over the testing period of 58 days (n = 15, error bars signify 95% confidence interval).

Over the 58 days of the testing period, it is evident that the average standing time changed in both interventions (physical and personal) throughout the experiment. When comparing the two interventions, it is evident that at the beginning of the intervention participants in the physical intervention stood more regularly than participants in the personal intervention. Figure 11 additionally shows that approximately after day 26, the average standing time decreased in the physical intervention. A post-hoc analysis revealed statistical differences at day 27 (appendix 8, page 102) in the physical intervention. Furthermore, table 1 shows that there was an interactional effect between the number of days and average standing time in both the physical and personal intervention.

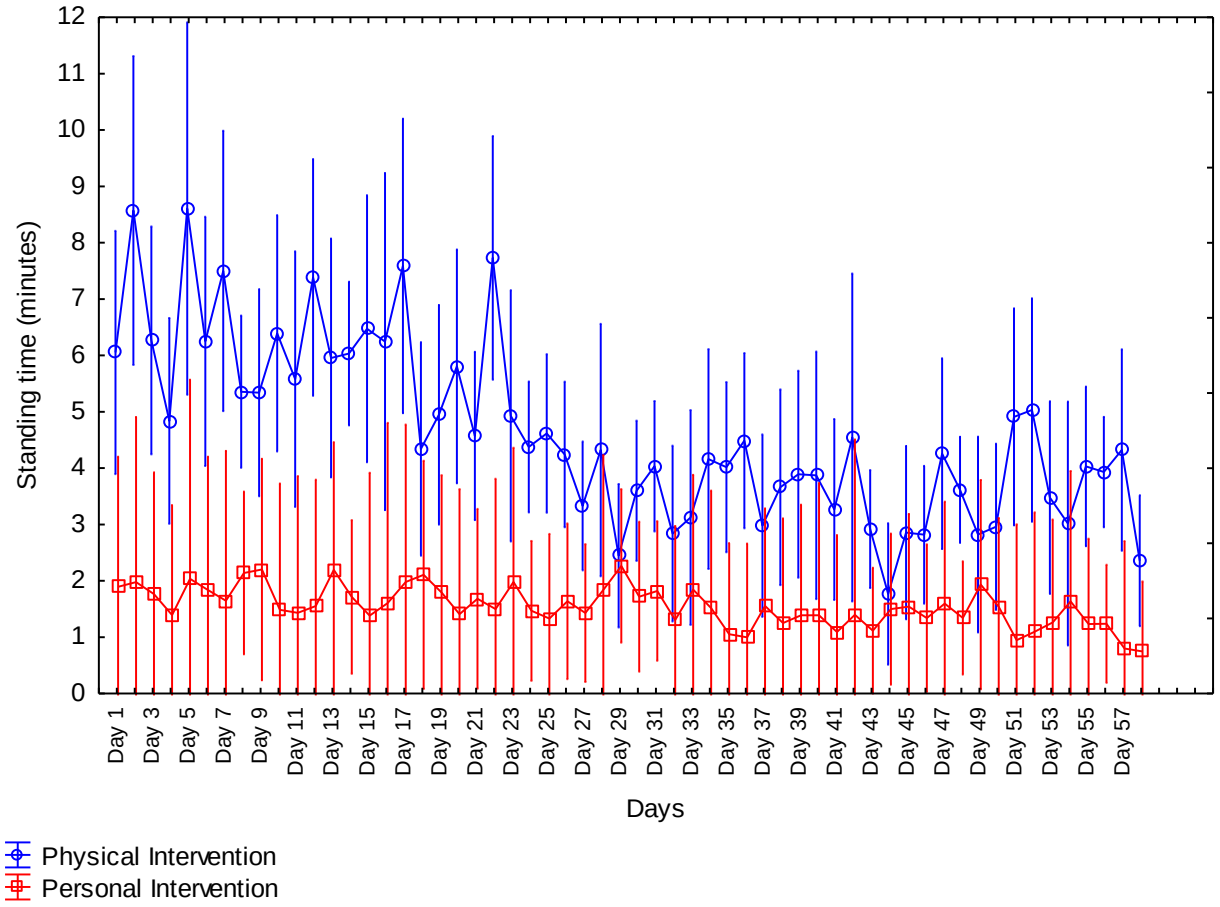

Figure 11: Change in average standing time (per hour) for both interventions over 58 days (n =15, the error bar denotes 95% confidence interval).

4.2. Average standing time over the course of the working day

*Table 2: Analysis of variance of average standing time per hour over an entire working day for 58 days (*significance p<0.001).*

Effect	**Df**	**F**	**P**
Intervention Type	1,13	23, 83321	**0.0003***
Hours	6	5, 52749	**0.001***
Hours*Intervention Type	6,78	3, 99179	**0.001***

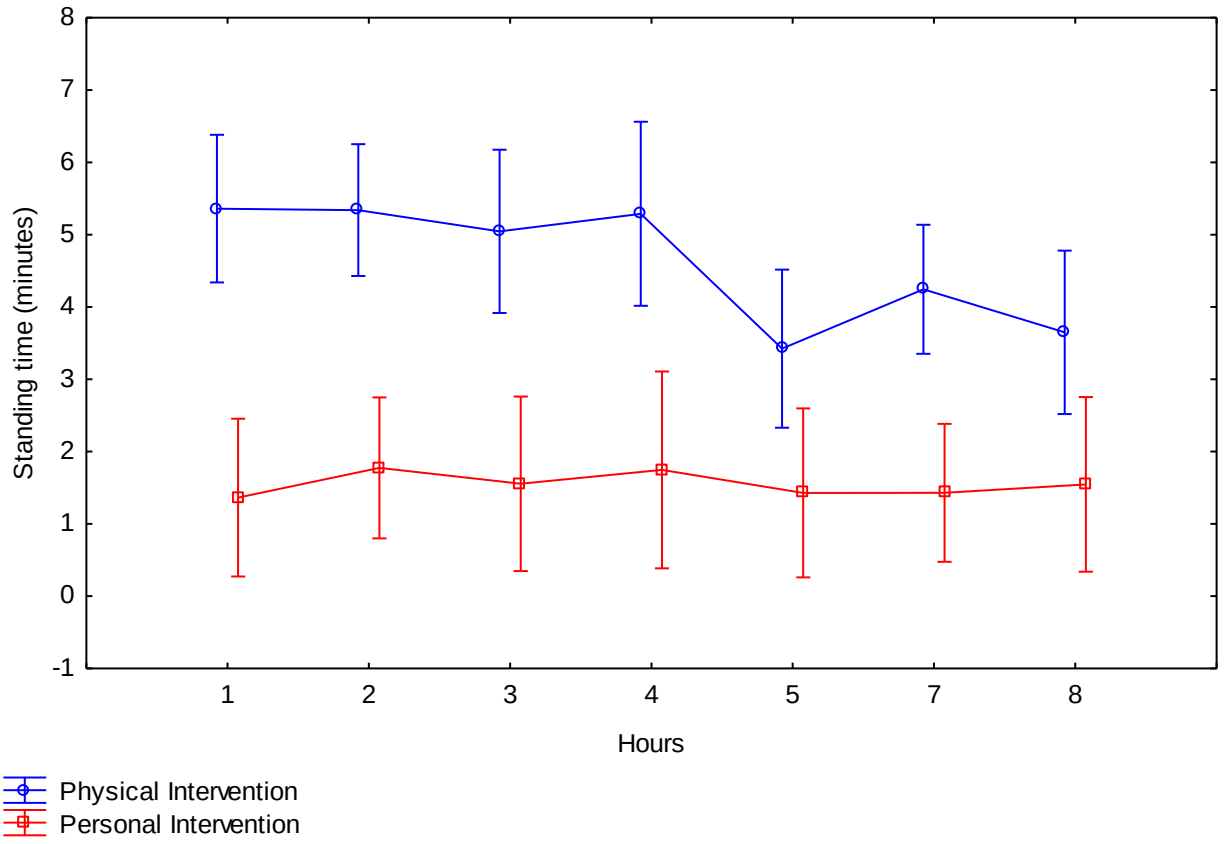

Figure 12: Average standing time for both physical and personal intervention over a 7hour working day (hour 6 is the lunch break and was excluded from the analysis), (the error bars denote 95% confidence interval).

Table 2 (page 47) of the ANOVA results shows that there is a high significant difference between the working hours of the two different interventions (p = 0.001). Upon further analysis the post-hoc analysis revealed that the effects were related to the time of day in the physical intervention, but not in the personal intervention (appendix 7, page 101). Participants in the physical intervention showed statistically significant differences an hour prior to lunch (hour 5) (p = 0.002). In addition, there is a statistically significant difference during the last hour of the working day (hour 8) (p = 0.001). In general, participants in the personal intervention stood less through the course of the working day (08h00 to 16h00).

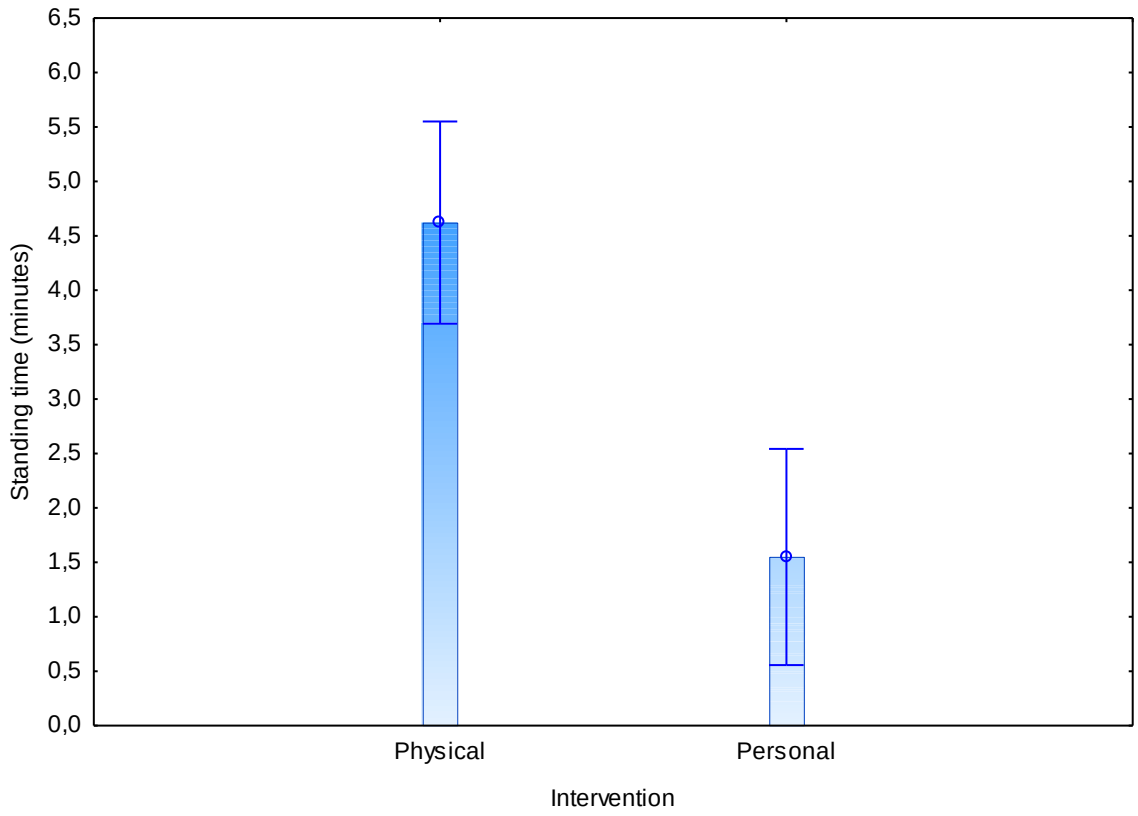

Figure 13: Comparison of the average standing time and conditions over a 7 – hour working day, (n= 15, the error bars signify 95% confidence interval).

Figure 13 shows that on average, participants in the physical intervention stood more often over the 7-hour working day in comparison to participants in the personal intervention. Moreover, the outcomes indicate a significant difference between the average standing time in both interventions ($p = 0.0003$).

4.3. Average standing time over the course of the weekday (Monday – Friday)

*Table 3: Analysis of variance of average standing time over the course of the week for both interventions (*denotes significance p<0.001).*

Effect	**Df**	**F**	**P**
Intervention Type	1, 13	17. 39026	**p<0.001***
Weekdays	4, 52	0,25848	0,903171
Weekdays* Intervention Type	4, 52	0,27893	0,890301

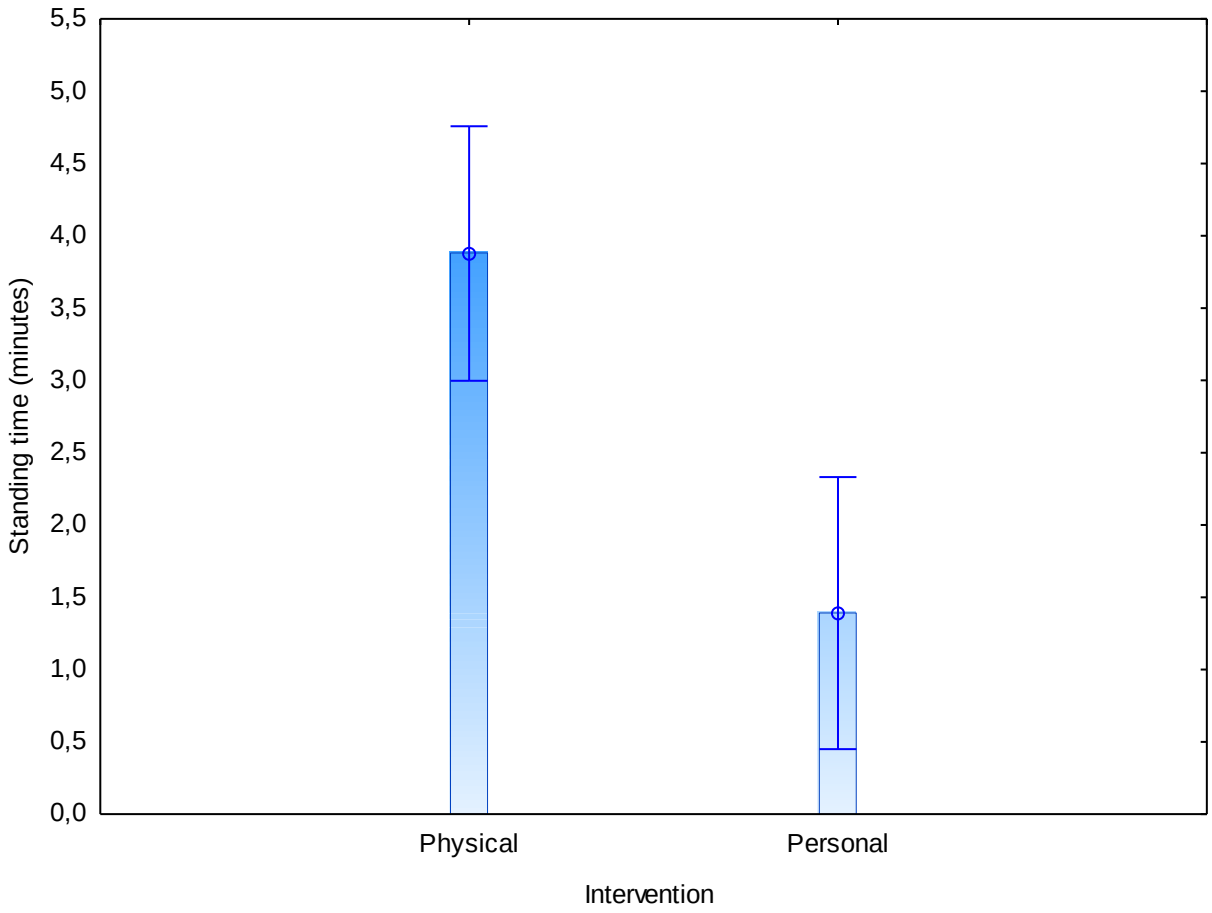

Figure 14: Comparison of standing time between the physical intervention and personal intervention over the course of the week (Monday to Friday), n= 15 (the error bars represent 95% confidence interval).

A general linear model analysis (table 3, page 50) revealed that there were significant differences between the two interventions (physical and personal), and that the physical intervention was significantly different to the personal intervention ($p = 0.001$). This means that participants in the physical intervention stood up more frequently than those in the personal intervention over the course of a week.

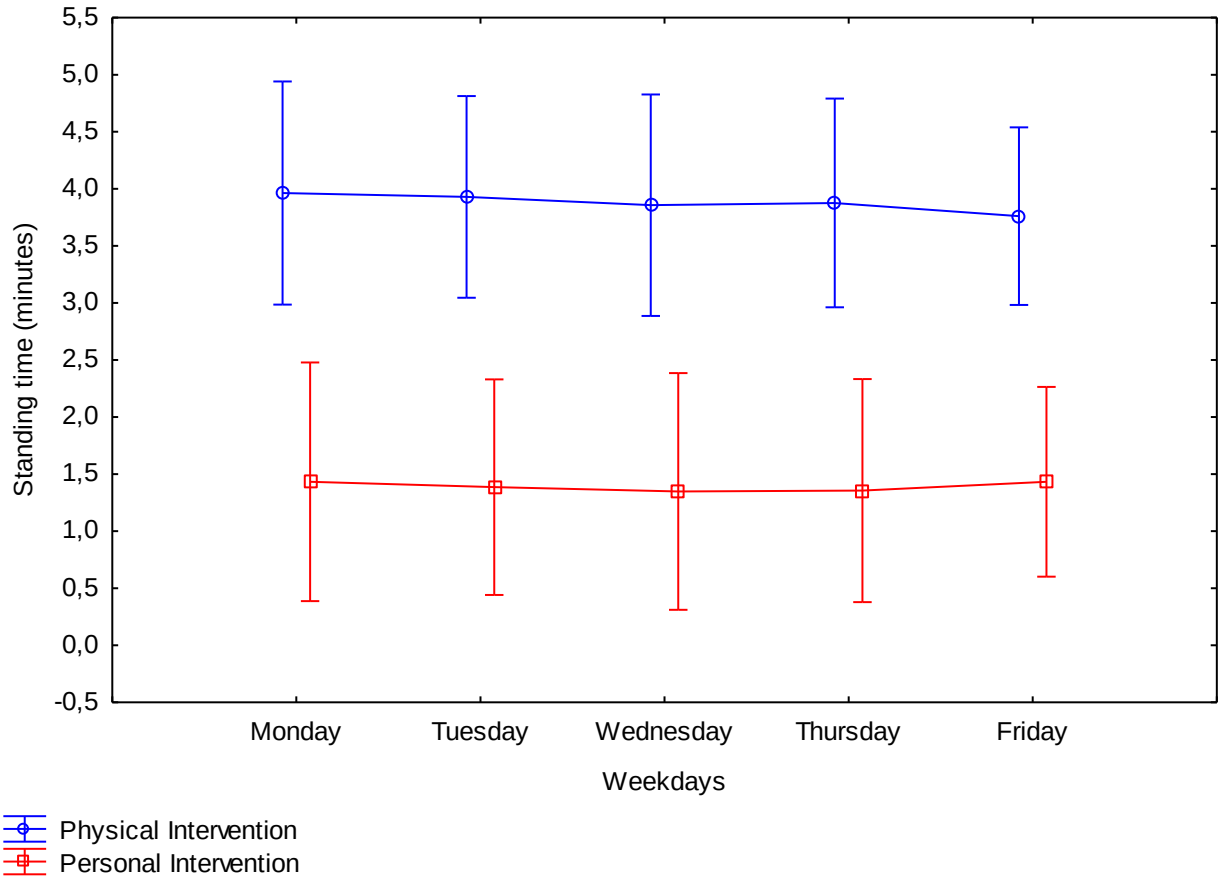

Figure 15: Comparison of the average standing time over the course of the week for the physical and personal intervention, (the error bars denote 95% confidence interval).

Figure 15 presents the comparison of the average standing time in the physical and personal intervention over the course of the week. Overall, there were no significant interactions found between the average standing times in the interventions throughout the week. This implies that participants' average standing time was not impacted by a particular day in the week.

Table 4: Summary of the intra and inter – individual differences results obtained from the physical and personal intervention.

		Intra-individual			Inter-individual		
Participant	**Intervention type**	**Mean (in min)**	**SD (in min)**	**CV**	**Mean (in min)**	**SD (in min)**	**CV**
Participant 1	personal	0.70	1.03	148%			
Participant 2	personal	1.19	1.49	125%			
Participant 3	personal	1.26	1.22	96%			
Participant 4	personal	1.27	1.61	127%			
Participant 5	personal	1.68	1.57	93%			
Participant 6	personal	2.09	1.93	92%			
Participant 7	personal	2.65	1.80	68%	1.55	1.52	98%
Participant 8	physical	2.13	3.50	165%			
Participant 9	physical	3.52	6.38	181%			
Participant 10	physical	3.87	7.67	198%			
Participant 11	physical	4.28	6.28	147%			
Participant 12	physical	4.53	4.01	89%			
Participant 13	physical	5.89	5.58	95%			
Participant 14	physical	6.21	6.75	109%			
Participant 15	physical	6.77	8.73	129%	4.65	6.11	131%

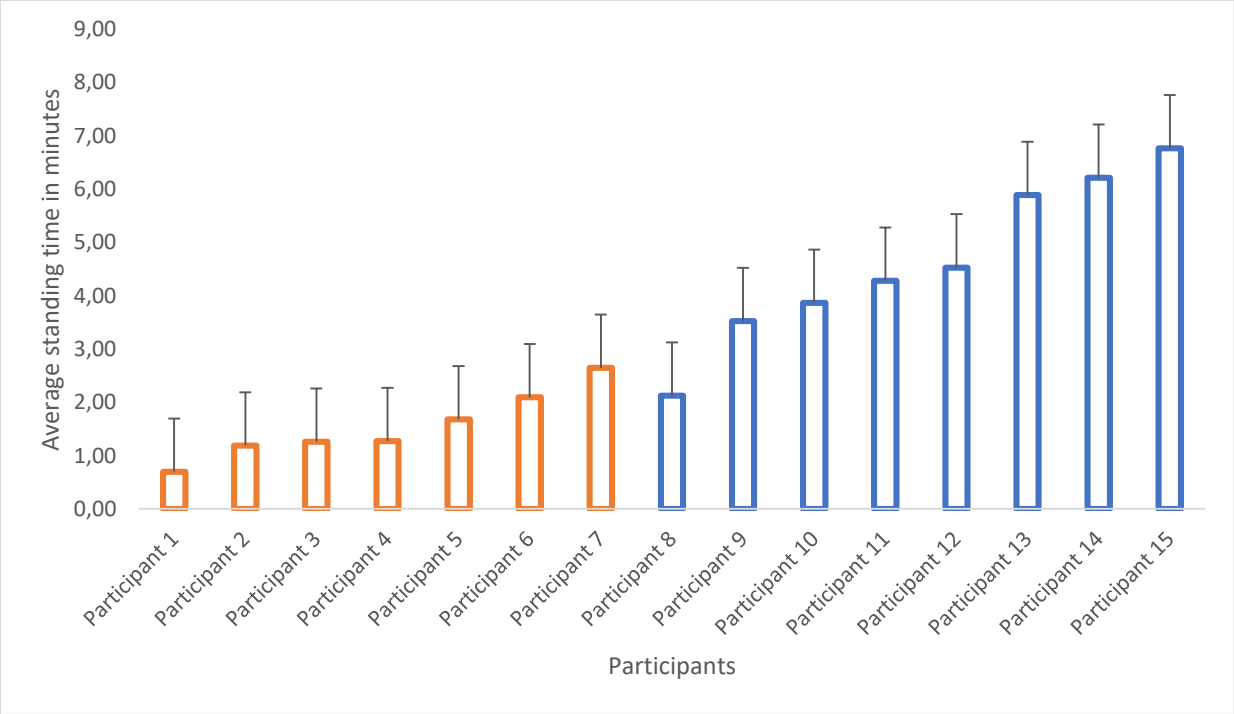

Figure 16: Average standing time in the inter - individual differences in the physical and personal intervention, n =15.

Figure 16 illustrates the results of the inter-individual difference shows that there is variation in the average standing time between the physical and personal intervention groups. Additionally, it can be seen that compliance varied across individuals; some individuals were more compliant than others. On the other hand, the results from the inter-individual differences show that there is a high coefficient of variance in the physical intervention (131%) in comparison to the personal intervention (98%). Distinctively, it can also be seen that the participant that was most compliant in the personal intervention, participant 7 (2.65 ± 1.80), has equivalent results to the participant that was least complaint in the physical intervention, participant 8 (2.13 ± 3.50). This implies that the physical intervention is more effective than the personal intervention in changing sitting behaviour in the workplace.

4.4. Effectiveness of intervention in reducing sitting time at work desk

An intervention that aims at reducing occupational sitting is effective when the sitting time decreases, and work performance is not impaired. While sitting time can be assessed directly (by the SenzoUnit sensor, see section 3.5.2, page 33), work performance cannot be measured directly thus being at the desk (whether sitting or standing) was used as an indicator for performance. The following section investigates:

1) How long participants were sitting before the interventions.

2) Whether the time present at the desk (desk occupancy) changed with the introduction of the interventions (indicator for performance), and whether this varied, with the intervention type (for details, see section data processing, page 39).

3) Whether sitting time was reduced compared to the baseline and whether this differs between the interventions.

*Table 5: Analysis of variance of average sitting time for the baseline and intervention over the course of 20 days (*significance p<0.001).*

Effect	**Df**	**F**	**p**
Intervention Type	1, 13	14, 4489	**0,002***
Baseline Phase and Intervention	1, 13	0, 3489	0,564868
Baseline Phase and Intervention * Intervention Type	1, 13	0, 1504	0, 704410

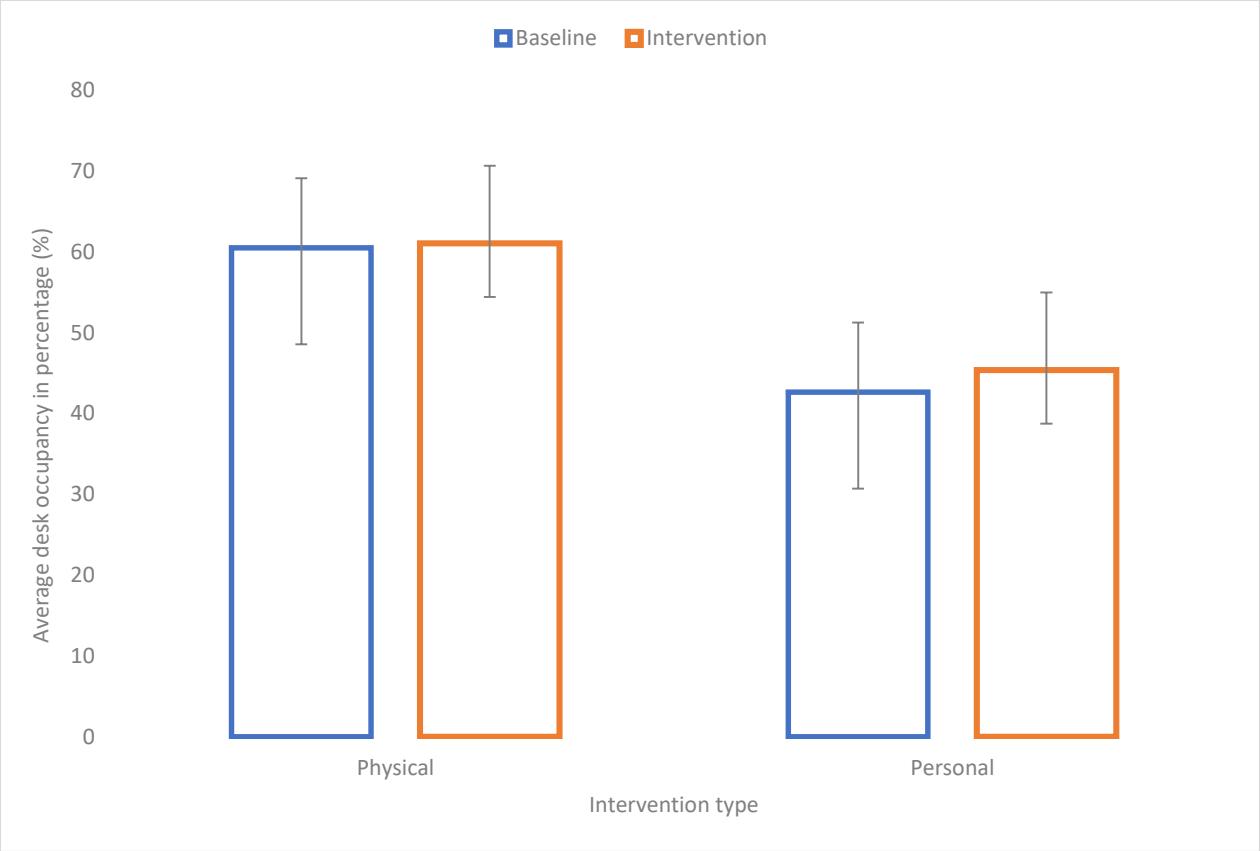

Figure 17: Average desk occupancy in percentage during the baseline and intervention for the different intervention types (physical and personal).

In the baseline phase, desk occupancy was higher in the physical intervention group than in the personal intervention (60.50% ± 8.61% compared to 42.65% ± 11.94%). This would be the result of the participant's job requirements resulting from the fact that they work in different divisions.

In neither of the intervention groups did desk occupancy changed with the introduction of the intervention. This means that work performance was not altered in either of the interventions.

For the physical intervention, desk occupancy remained the same (61.06% ± 9.61%) while simultaneously, individuals stood more often (see figure 1). This means that the intervention was effective in reducing sitting without compromising work.

The personal intervention did not reduce desk occupancy (61.06% ± 9.61%), but also did not reduce sitting (due to lack of compliance). This renders the personal intervention ineffective.

4.5. Effect of interventions on mood

Does the mood (positive and negative affections) change with the introduction of the intervention, and is this change different for the different interventions.

4.5.1. Positive Mood Schedule

The results presented below are the outcomes from the positive mood affect schedule which involves self-reported relation with the baseline phase and intervention of the study. The mood analysis was collected for three weeks in the baseline as well as three weeks in the intervention due to participants being reluctant to fill in the mood questionnaire.

*Table 6: Analysis of variance of the PANSA positive mood analysis over the course of three weeks for both the baseline and intervention (*significance p<0.001, n = 15).*

Effect	**df**	**F**	**p**
Intervention Type	1, 13	0.0548	0.818599
Baseline Phase and Intervention	1, 13	34.2920	**0.000056***
Baseline Phase and Intervention*Intervention Type	1, 13	0.4196	0.528398
WEEKS	2, 26	0.4827	0.622543
WEEKS*Intervention Type	2, 26	0.0152	0.984972
Baseline Phase and Intervention *WEEKS	2, 26	5.4885	**0.010270***
Baseline Phase and Intervention *WEEKS* Intervention Type	2, 26	2.3529	0.115022

The positive mood affect is lower in the baseline phase and higher in the intervention. Moreover, significant differences were found in the baseline phase and intervention (p = 0.001). This shows that introducing an intervention was viable in increasing ones positive state of well-being for both interventional groups.

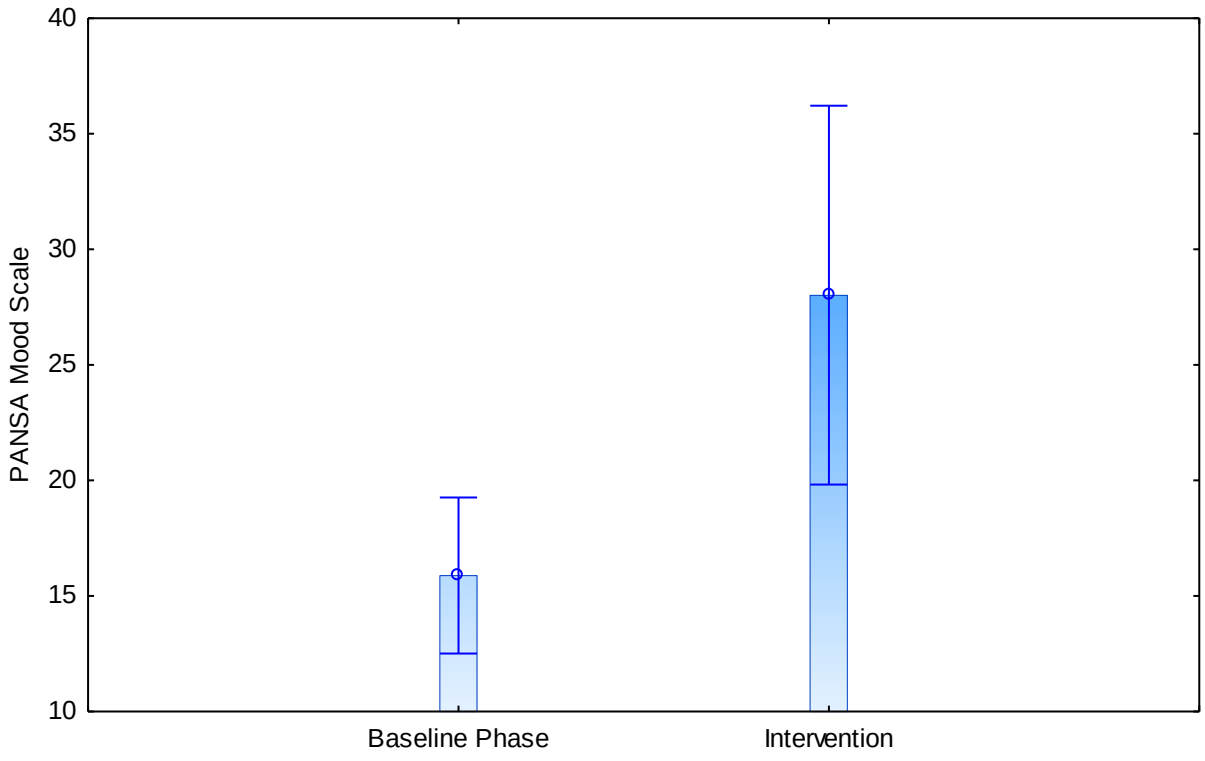

Figure 18: Positive effect mood analysis from the PANSA mood questionnaire for the baseline phase and intervention phase, (error bars indicates 95% confidence interval, which implies that there is a greater variation between the interventions).

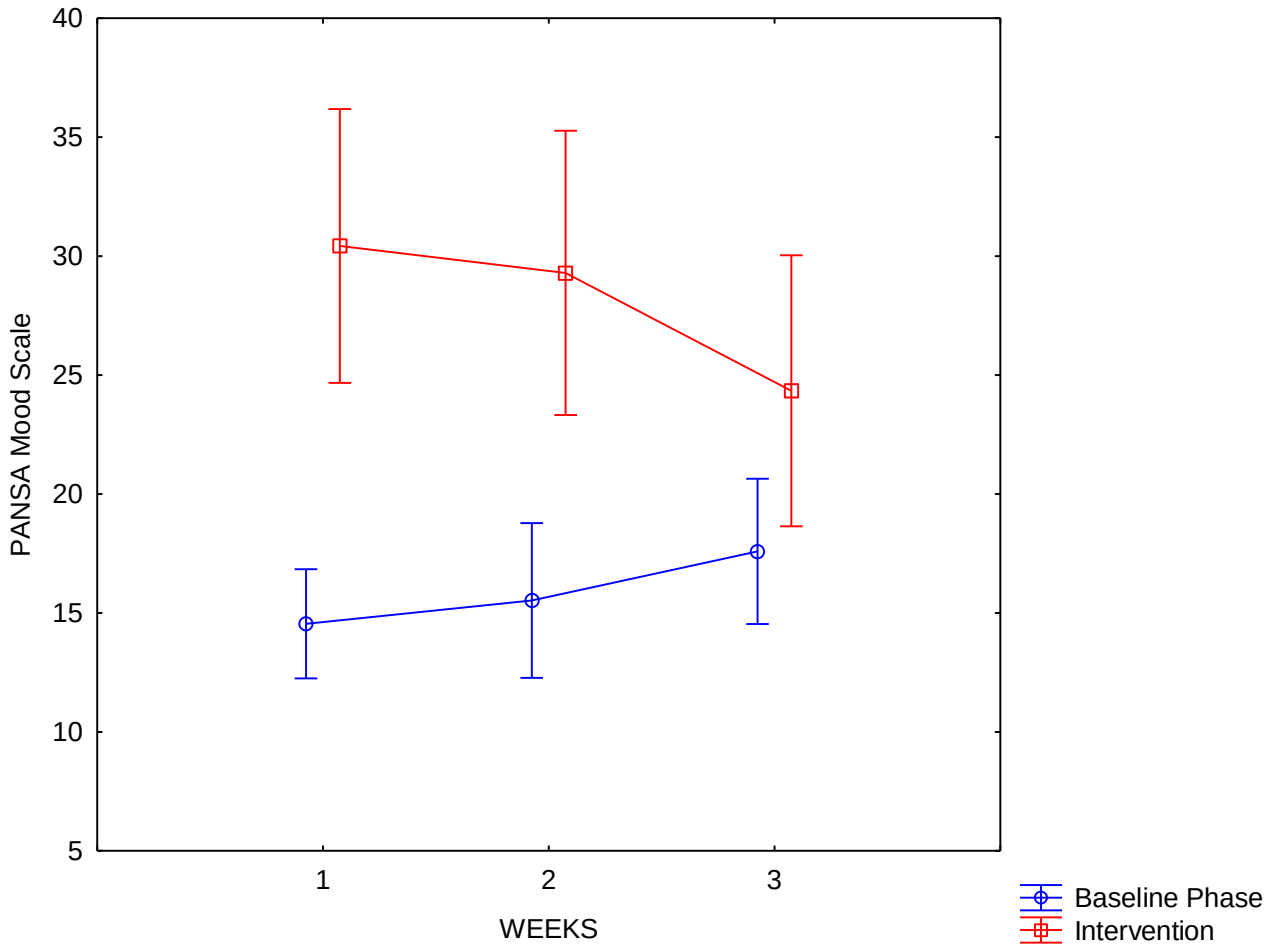

Figure 19: Positive effect mood analysis from the PANSA mood questionnaire for the baseline phase and intervention over three weeks, (the error bars denote 95% confidence interval) which infers that there is great variety between the baseline and intervention.

Over the course of three weeks, the intervention phase was successful in increasing the positive mood effect among individuals. Highly significant differences were found with the baseline phase and intervention phase over the weeks ($p = 0.01$). However, in the third week of the intervention the positive mood effect reduced. This could be the result of individuals no longer finding the intervention exciting, taking into account that the study was conducted for a period of 58days.

4.5.2. Negative Mood Schedule

The results presented below are the outcomes from the negative mood affect schedule which involves self-reported negative relation with the baseline and intervention.

Table 7: Analysis of variance of the PANSA negative mood analysis over the course of three weeks for both the baseline phase and intervention phase (denotes significance p<0.001, n = 15).*

Effect	df	F	p
Intervention Type	1, 13	0.0548	0.818599
Baseline Phase and Intervention	1, 13	34.2920	**0.000056***
Baseline Phase and Intervention *Intervention Type	1, 13	0.4196	0.528398
WEEKS	2, 26	0.4827	0.622543
WEEKS*Intervention Type	2, 26	0.0152	0.984972
Baseline Phase and Intervention*WEEKS	2, 26	5.4885	**0.010270***
Baseline Phase and Intervention *WEEKS*Intervention Type	2, 26	2.3529	0.115022

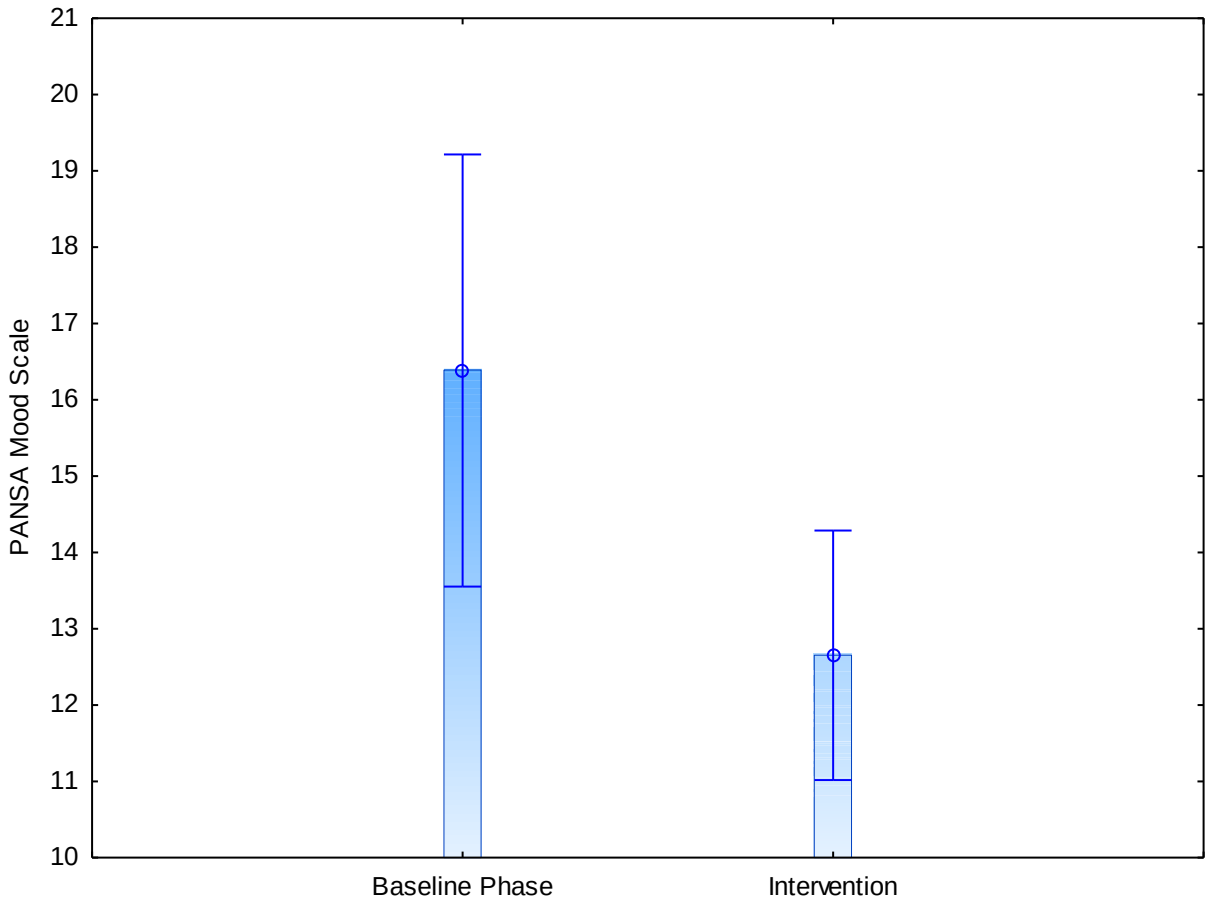

Figure 20: Negative mood effect analysis from the PANSA mood questionnaire for the baseline phase and intervention reflected over three weeks.

A high negative mood effect is shown in the baseline phase when compared to the intervention. There were significant differences found between the baseline and intervention ($p = 0.0001$). The reduction in negative mood affect could be the result of introducing an intervention in the workplace. Although there were significant differences between the baseline and intervention, there were no significant differences found between the two interventional groups (physical and personal intervention).

No major difference between mood effect and type of intervention were found, based on the findings of the current study. It can be distinguished, however, that the introduction of an

intervention overall had an impact on participants mood effect compared to not having an intervention at all as shown in the baseline phase (figure 20).

4.6. Response to hypotheses

Based on the results of the study, the first null hypothesis is accepted indicating that there was no change in desk occupancy during the baseline intervention. The second null hypothesis is also accepted indicating that there was no change in mood effect during the baseline intervention in both intervention groups. The third null hypothesis was rejected and the alternative hypothesis was accepted, which shows that there was change in standing time (compliance indicator) over the course of 58 days in the physical intervention. The fourth null hypothesis was accepted showing that that there will be no change in standing time (compliance indicator) over the course of 58 days in the personal intervention group. The fifth null hypothesis was rejected and the alternative hypothesis was accepted indicating that there was change in mood effect over the course of three weeks in both intervention groups (physical and personal intervention).

CHAPTER 5

Discussion

This chapter gives a vital explanation of the encompassing objectives that were generated to conduct the research study. The primary objective of the study was to determine the effect of different interventions on compliance and altering occupational sitting behaviour; furthermore, to assess how the interventions affected one's mood perceptions. The chapter will focus on unpacking the main findings from the results, in particular: sitting time (compliance indicator), desk occupancy, and mood effect.

The chapter constitute of the following sections: Section 5.1. **Effectiveness of intervention** describes which intervention was effective in reducing sitting time; Section 5.2. **Changes in intervention usage over time, indicates changes in intervention usage**; Section 5.3. **Sustainability of interventions** outlines how interventions are sustained over time; Section 5.4. **Intra- and inter-individual variability** indicates individual variation. Section 5.5. **Time of day effect** indicates any changes over the course of the day. Section 5.6. **Multicomponent intervention**. Section 5.7. **Indications for changes in performance**. Section 5.8. **Mood perception**, looks at which intervention aided in improving or impairing mood. Section 5.9. **Behavioural change**, describes how compliance impacts behaviour. Subsequently, this chapter links the results of the study with theoretical frameworks, and preceding literature on sedentary behaviour in the workplace.

5.1. Effectiveness of intervention

The current study found that the physical intervention was more effective than the personal intervention in changing sitting behaviour. The results indicated that there were significant differences in the average standing time between the two intervention types; physical intervention – sit-stand worktables - and personal intervention - stretches (as shown in figure 10, page 46). The findings show that compliance was higher in the physical intervention than in the personal intervention.

The physical intervention results of the current study are consistent with other studies, such as Pronk *et al*. (2012); Alkhajah *et al*. (2013); Chau *at al*. (2014); Gao *et al*. (2016); Mansoubi *et al*. (2016) and Chambers *et al*. (2019), which looked at the impact of sit-stand worktables on reducing sitting time in the workplace, and found that the installation of these worktables was successful in decreasing sitting time and increasing standing time. In another study by Schofield *et al*. (2009) sit-stand worktables were introduced for a week and in that week, there was a reduction in sitting time. However, the personal intervention results of the current study are not in accordance with those of other studies such as Pedersen *et al*. (2014) and Mailey *et al*. (2016). The current study did not find a decrease in sitting time upon introducing stretches in the workplace, whereas Pedersen *et al*. (2014) and Mailey *et al*. (2016) found that introducing short physical activity stretches resulted in a decrease in sitting time. These findings should be expected as participants in the study were automatically deactivated from their computer screens to engage in the short bursts of non-structured physical activity in the hope of reducing prolonged sitting time and increasing workday energy expenditure. These results shed some light on and support the advocacy for introducing sit-stand worktables in the workplaces, considering that compliance was lower in the personal intervention. It is worth noting that, although the physical intervention was an effective approach in reducing sitting time, they are expensive. Even so, it is reasonable to invest in them in the long run, as they provide a return on investments (they can be used for years) in the workplace, and the adjustability of the tables could help to reduce complaints of musculoskeletal discomfort among office workers, therefore they are definitely worth a try.

5.2. Changes in intervention usage over time

In the current study, it was found that participants in the physical intervention stood more frequently at the beginning of the intervention than towards the end of the intervention, whereas participants in the personal intervention stood less from the beginning of the intervention. It must be noted that both intervention groups were blinded regarding when the experiment would end. The results of the physical intervention provide evidence that shows that the idea of having sit-stand worktables in the workplace is exciting in the beginning, however, over time there is less utilisation. Similarly, Frost (2016), Barbieri *et al*. (2017) and Sharma *et al*. (2019) found that the novelty of utilising sit-stand worktables is exciting in the beginning, but that sustaining the usage

is challenging. In a study by Pronk *et al*. (2012), the findings of the study revealed that sit-stand worktables reduced sitting time in the intervention phase. In addition, the study also found that participants returned to their normal sitting habits (increase in sitting time) following the intervention (post-intervention). The findings from the current study along with those of preceding studies, give an indication that intervention usage changes over time. These results are important and will further assist with redesigning interventions to ensure that they focus on sustained utilisation and address possible barriers that may hinder utilisation.

5.3. Sustainability of interventions

There is a lack of literature that investigates the sustained usage of sit-stand worktables in real-world settings. Moreover, assessing compliance (desk usage) may be deemed difficult due to the variety of tasks that workers perform at work. The present study provided participants in both intervention groups (physical and personal) with computer-based prompts to remind participants to stand (55 minutes sitting and 5 minutes either working in a standing position or stretching). The requirement to stand 5 minutes of every hour left participants with the autonomy to either adhere to the study procedure or ignore the study procedures. Sharma *et al*. (2019) monitored behavioural change in the office with the provision of non-automated sit-stand worktables with a computer prompt software installed. Participants received a notification reminder from the computer prompt to switch between sitting and standing. The reminders were set to 30 - minutes sitting and 20 - minutes standing. The study found that desk usage (standing time) doubled in the intervention phase.

In another study conducted by Barbieri *et al.* (2017), participants were given sit-stand worktables with and without semi-automated position changes. The sit-stand ratio was 50 - minutes sitting and 10 minutes standing. In comparing the results of the present study with those of other studies, the results of the current study are similar to the findings of Barbieri *et al*. (2017) and Sharma *et al*. (2019) that the provision of sit-stand worktables with computer prompts is effective in reducing sitting time, increasing standing time and sustaining usage over time regardless of having different sit-stand schedules and table settings.

Although desk usage was sustained over time in the above-mentioned studies, the results of the present study showed that at day 27 there was a reduction in standing time (compliance) in the

physical intervention (sit-stand worktables). Sharma *et al*. (2019) found that sit-stand interventions were more effective in reducing sitting time in the first three months of the intervention. Over time, that is, after three months, standing time (compliance) fluctuated towards the end of the intervention. On the other hand, Barbieri *et al*. (2017) found no short-term or long-term changes in sitting behaviour. The findings of the current study concur with those of Sharma *et al*. (2019), that over time, there are changes in sitting behaviour. At this point, the findings from the current study along with previous studies show that over time it is expected that desk usage (compliance) will decrease due to participants losing interest since the idea of utilising the sit-stand workstation would no longer be novel and exciting.

Another aspect to note from the design of the current study is that the study achieved behaviour change in the workplace without taking away autonomy from participants. The study allowed participants to make their own decisions to adhere to the study procedure or not. Autonomy is important in workplaces, due to the fact that it allows participants to make their own decisions. Barbieri *et al*. (2017) conducted a study using semi-automated sit-stand worktables with computer prompts. Participants had the option of accepting the prompt or ignoring the prompt to allow the table to change positions. If the study had automated setups, behavioural change would be achieved; however, the autonomy would be taken away from participants, which is not desirable. These studies have shown that challenging participants with the autonomy to make their own decisions to change sitting behaviour in the workplace would be a genuine reflection of participants' compliance levels and that autonomy should not be taken away. Straker *et al*. (2013) highlights that autonomy, preference, and motivation are factors that impact compliance and behavioural change.

It is worth noting that different to the workplaces used in Barbier *et al*. (2017) the workplaces used in the present study did not have any automated settings that required any form of power supply to switch between sitting and standing positions. In the South African context, this is an important feature due to the limitations of power supply in the country. The counter-weight and hydraulic setup of the sit-stand worktables enabled participants to lift the tables from a sitting to a standing position with little effort.

5.4. Intra- and inter-individual variability

Many studies that investigate the effect of different interventions that aim to reduce occupational sitting behaviour have not paid much attention to the effect of individual variation, such as intra and inter-individual variation. In a study by Barreira *et al*. (2016) investigating individual variability in daily sitting time and moderate-vigorous physical activity (MVPA) within individuals, the study emphasised that individual variation is an imperative component to investigate, to determine whether variability exists within the average sitting time and moderate-vigorous physical activity among individuals. This information helps with acknowledging that individuals are different and as such performance will differ across individuals.

The current study additionally investigated compliance levels among participants to explore whether some participants were more compliant with the study interventions than others. The results show that there is individual variation in the average standing time in both intervention groups (as shown in figure 16, page 53). The variations within the intervention groups show that, to a certain extent some participants engaged meticulously with the study procedures (were compliant), whereas some participants were less compliant (unable to engage with the study procedures). These results should be expected, given that participants are working in different divisions, and this could have been related to the type of tasks that different participants execute at work. Graves *et al*. (2015) found that the type of task one is tasked with influences desk usage. It is important to note that the current study did not take into account the different types of tasks performed in the different divisions; therefore, conclusions regarding this cannot be drawn.

Furthermore, the results show that the participant that was most compliant in the personal intervention had similar results to the participant that was least compliant in the physical intervention. To expand the personal intervention – stretching requires a participant to step away from their workstation and be willing to perform the stretches outlined. Given that we are living in an age that promotes less physical activity, the personal intervention results may be interpreted that less can be expected from people, with regards to taking initiative to stretch. This comes as an interesting finding because it supports the narrative that the physical intervention is, in fact, more effective in decreasing sitting time in the workplace. Particularly, the results can be used as important guidelines in developing intervention in real-world settings.

It is important to note that in the present study, one of the participants (participant 9) was pregnant during the experiment. That being said the participant engaged thoroughly with the study procedures irrespective of her pregnancy. The intra-individual results of the participant also support that regardless of the participant's circumstance, the participant still took initiative in standing as per the study procedure. Research suggests that prolonged standing among pregnant women should be avoided as this may result in negative health implications.

The current study did not investigate personal factors that influenced compliance among participants. However, through face to face interactions with participants, the researcher found that participants in the physical intervention in the open-plan office reported working in a standing position was not a problem, because the moment one person stood up the rest of the team would also feel the desire to stand up. Some participants reported that the sit-stand worktables assisted them in creating a supportive atmosphere with regards to standing in the workplace. The physical intervention reports from participants are coherent as to why the physical intervention was more effective. Some participants in the physical intervention reported that the sit-stand worktables provided limited desk space and at times it would be difficult to adhere to the intervention. This was also stated by participants in a study by Chau *et al*. (2014) and Hadgraft *et al*. (2017) as one of the factors that was a barrier to people utilising the worktables.

5.5. Time of day effect

Research shows that performance levels vary across the day, especially in working environments that require prolonged attention. One of the most interesting aspects of the current study is the investigation of the standing time during each hour of the working day in both intervention groups, excluding the lunch hour. The study found that there was a time of day effect (in terms of desk usage) in the physical intervention before lunch (hour 5) and an hour before knocking off (hour 8) (figure 12, page 48). The reduced utilisation of sit-stand worktables before lunch (12:00 to 13:00) could be explained as participants looking forward to lunchtime and/or having less energy and as a result, standing less. The results after lunch may be explained by the post-lunch dip phenomenon, which explains that after lunch, humans experience a dip in energy, which results in poor performance. In a study by Chau *et al*. (2014), participants reported that the time of day influenced whether individuals use sit-stand worktables or not. In addition, Henderson *et al*. (2018)

investigated the systematic, ergonomic, safety, and health-related experiences of staff members within a university who had previously used sit-stand worktables. The study revealed that participants preferred using sit-stand worktables in the morning than in the late afternoon. Comparing the outcomes of this study with previous studies is challenging because, to the author's knowledge, little to none of the research available has objectively measured sit-stand desk usage across the working day. The results from Chau *et al.* (2014) and Henderson *et al*. (2018) only provide evidence of desk usage preference in the morning rather than in the late afternoon.

5.6. Multicomponent intervention

Looking at studies that have introduced multi-component interventions, as shown in the literature review, the current study adopted a similar approach and incorporated a multi-component intervention and using the behaviour change wheel model to design the study, with the goal of reducing/breaking prolonged sitting in the workplace. The multi-component intervention of the study included providing participants in both intervention groups (physical and personal intervention) with the same resources such as introductory ergonomics training, which detailed the health implications of prolonged sitting in the workplace and the benefits of alternating between sitting and standing. Both intervention groups also received regular computer prompts throughout the entire working day with different sit-stand regime instructions (see chapter 3, methodology, figure 5 and 6). There was also regular face to face interaction with the researcher, to check up on participants as well as to address any technical issues. Neither intervention groups received any form of feedback regarding their performance (compliance level). The only difference in resources between the two intervention groups was that the physical intervention group received sit-stand worktables, whereas, the personal intervention received stretching instructions.

The results from previous studies that have taken a multi-component intervention approach concur with the current study that sit-stand worktables are effective in reducing sitting time and increasing standing time. The current study did not investigate whether the interaction of the different elements of the intervention (ergonomics training, the computer prompts, and face to face interaction with the investigator) influenced the effectiveness of the physical intervention. Previous studies have shown that the provision of sit-stand worktables with ergonomics training is effective in reducing sitting time when compared to participants that did not receive ergonomics

training (Robertson *et al*., 2013). In the present study, both intervention groups received ergonomics training in the hope that participants would be motivated and comply with the study procedures. The results of the study do not concur with other studies, given that compliance remains low in the personal intervention over the 58-days of the experiment. This could be explained by the type of intervention.

5.7. Indications for changes in performance

The current study did not necessarily investigate whether the introduction of sit-stand worktables or stretches impaired or enhanced performance. Studies such as Robertson *et al*. (2013) have found that the provision of sit-stand worktables enhances performance. Other studies such as Husemann *et al*. (2009), argue differently. Tudor-Locke *et al*. (2014) found that working in a standing position has minimum distraction with the work task, further, it is unclear to what extent performance is impaired while working in a standing position. Despite all of this, sit-stand worktables offer an opportunity for reducing prolonged sedentary behaviour in the workplace.

In the current study, it was found that the introduction of different interventions did not have an impact on desk occupancy (as shown in figure 17, page 55). In the physical intervention, desk occupancy remained the same, this could be explained by the fact that using sit-stand worktables allows participants to remain at their desk and to continue with their desk tasks. This is in contrast to the personal intervention, which requires participants to step away from their desks and could potentially result in less productivity. The results of the study show that the physical intervention did not impair performance; however, it is also unclear whether performance was enhanced. The study found that desk occupancy did not change in the personal intervention, which is explained by the low compliance with the study procedures in the personal intervention (as shown in figure 10, page 46).

5.8. Mood effect

The results of the current study showed a high negative mood affect in the baseline before an intervention was introduced in the workplace (as shown in figure 20, page 60). Upon introducing the interventions, the study found that mood was positively affected by the intervention, which

implies that having incorporated an intervention in the workplace worked in the favour of participants as it brought about a positive mood affect (as shown in figure 18, page 57). However, the study shows that the enhancement in mood affect was not dependent on the type of intervention (physical or personal). This appeared in the result not demonstrating any significant difference between mood and type of intervention.

Congruent with other studies, Pronk *et al*. (2012) and Finch *et al*. (2017) providing participants with the opportunity to alternate between sitting and standing positions resulted in a positive change in their mood perceptions. Workers reflected feeling more interested and enthusiastic when they stood as compared to when they spend most of their working day in prolonged sitting positions. The results of the current study and previous studies could potentially assist organisations looking into incorporating wellness programs as a vital component of workplace policies. Introducing wellness programs can attempt to combat negative mood affect in the workplace, as it is shown that interventions have the potential to change workers' state of mind, e.g. feeling more enthusiastic. Moreover, wellness programs could assist organisations in exploring programs that touch on other factors that hinder occupational functioning in the workplace, and in developing programs that could assist with creating a positive atmosphere within the working environment (Ramakrishnan and Balgopal, 1992).

5.9. Behavioural Change

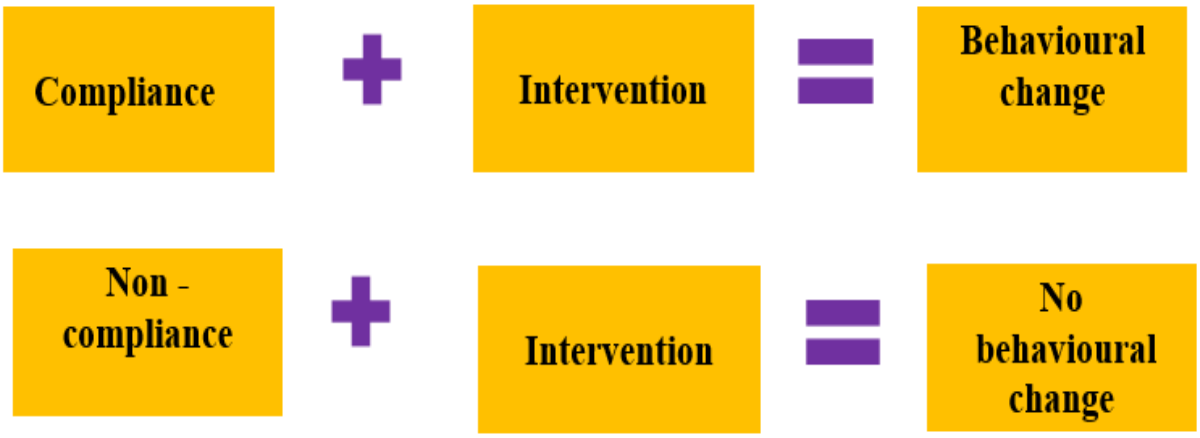

Figure 21: Compliance impact on behavioural change.

In order to change prolonged sitting behaviour in the workplace, the compliance phenomenon can be used to understand the process. One can see from the diagram that ideally if participants are compliant with the study interventions, it denotes that the interventions were effective and behavioural change is expected. In the event that participants are not compliant or there is low compliance then it essentially implies that the interventions were not effective and behavioural change cannot be expected. The outcomes of the study provide evidence that the physical intervention was increasingly effective in reducing sitting time, which implies that participants changed their sitting patterns upon introducing the intervention in the workplace in comparison to the personal intervention group. The results of the study also show that to a certain extent employing the behaviour change model (figure 1, page 16) as a way to develop the study interventions helped with changing behaviour in the workplace. The results also show that besides changing sitting behaviour in the two intervention groups, the study succeeded in targeting individual behavioural changes (figure 16, page 53). The ultimate outcomes of the intervention indicate that the study was effective in reducing sitting time in the two workplaces.

5.10. Reflection on the quality of the study design

The study aimed to investigate the effect of different interventions on compliance and altering occupational sitting behaviour among office administrators. The limitations resulting from the study design include that different divisions have different tasks, and therefore compliance may be implicated by factors such as workload and having to attend meetings. In other words, the likelihood of participants complying with the study procedure would have been limited. Another limitation of the study is the fact that the sample size of the research was small, due to limited access to sit-stand worktables. It would have been interesting to compare different divisions across the institution to assess compliance in the different divisions.

Delimitation of the study is that participants were required to sit for 55 minutes then stand for 5 minutes to either stretch or using the standing component of the sit-stand worktable. Whether the 55 and 5 minute intervals were appropriate is unknown, considering that there are no standard guidelines as to when participants should alternate between sitting and standing. Other studies, such as Buckley *et al*. (2015) and Gallagher *et al*. (2014), used tried out different sit-stand ratios. The current study decided on the 55 minute and 5 minute times so that the study did not interfere

with work, considering that this study was field-based. It is important to note that establishing sit-stand ratios in laboratories would be different, as field studies are more dynamic than research in a laboratory.

A strength of the current study is that the study investigated prior health issues such as lower back disorders, which are common among office administrators. The study investigated these health issues using the NORDIC musculoskeletal questionnaire to determine whether there were health issues that could potentially lead to participants not participating in the study. With participants reporting on lower back issues, participation was not compromised. Another strength is that participants were blinded regarding the end of the intervention. This was done to reflect on the true effectiveness of the interventions, by preventing bias in terms of participants changing their sitting behaviour towards the end of the intervention.

Making participants account for the time they spent away at their workstations because of commitments such as meetings was another strength of the study. This shows that field studies are dynamic, and individuals have different responsibilities.

Another strength of the study is the environment in which the study was carried out. The field-based study did not control any external factors that could potentially impact compliance. Another strength of the study is that the experiment was conducted for 3 months to observe changes in sitting and standing patterns (compliance indicator). The study contributed to a few studies that have assessed sitting behaviour over time in the workplace. Participants in the study were able to interact freely with the researcher and report other interesting findings relating to the study. This provided both the participants and researcher with learning and sharing opportunities to be mindful of when conducting studies of such nature in the future.

CHAPTER 6

Conclusion and Recommendations

6.1. Conclusion

In conclusion, the current study has led to additional knowledge being gained as to the effect of different interventions on compliance and alternating occupational sitting behaviour over time. Based on the current findings, the study has given an indication that installing sit-stand worktables is effective in reducing sitting time and in comparison to instructing participants to stretch and does not compromise performance in the workplace. These results are encouraging, and the conclusion that can be drawn in terms of which intervention to advocate for, is strongly to advocate for the installation of sit-stand worktables irrespective of the high costs. Given that the sit-stand worktables are well implemented in the working environment, they will offer great health and economic advantages over longer durations.

Through investigating individual variation, the study was able to pay attention to observe that compliance differs amongst individuals; some participants were more compliant to the study procedures than others. These outcomes were a learning experience for the researcher in terms of being mindful of factors that are likely to influence compliance in real working environments. In addition, there were no interactional effects found between the type of intervention (physical or personal) and mood effect. However, it was found that by participants simply engaging in an intervention their mood perceptions changed. This means that both interventions improved mood and organisations could use this to improve employee satisfaction.

6.2. Recommendations for further research

The present study aimed to compare different interventions aimed at the reduction of occupational sedentary behaviour over time in terms of compliance and effectiveness in changing occupational sitting behaviour. The results of the study add to a great body of knowledge; however, in so doing there are important facts that arise from the experiment. This could lead future studies to pay attention to the following:

1. The study found that compliance changes over time, and that this is particularly a key component in assessing the effectiveness of interventions overtime. The study recommends that future studies should look into assessing compliance on intervals over long terms studies.

2. The study acknowledges that the physical intervention that was carried out is an expensive intervention for the company. However, the study found that a cheaper alternative (personal intervention – stretching) was not effective in reducing sitting time due to lack of compliance. Therefore, future studies could investigate other low-cost interventions if companies cannot afford to purchase sit-stand worktables.

3. The present study did not provide participants with regular feedback regarding their compliance to interventions; therefore, it is recommended that future studies should investigate whether feedback influences compliance. The information on feedback could be added to the list of other factors that are likely to impact compliance (adherence to study interventions).

4. The study also recognises that people in different divisions are tasked with different tasks. Therefore, it is recommended that future studies upscale the number of divisions, and investigate how the type of task one is required to execute affects compliance. It is also recommended that future studies look into assessing how compliance differs in different divisions based on job description; for example, do people in different managerial positions comply differently than office administrators and clerks.

5. This study noticed that regular visits to the different divisions was labour-intensive for the researcher, therefore, it is worthwhile studying whether the regular visits and interaction with participants had an impact on compliance, and for future studies to look into an alternative multicomponent intervention that is less labour intensive for the investigator.

6. The study acknowledges that there was a time of day effect and recommends that future studies investigate ways in which this could be avoided.

6.3. Practical Relevance

This study serves to provide practitioners in workplaces with a guideline into selecting an appropriate intervention that is effective, as this allows for investigation of compliance over time, and sustained usage of sit-stand worktables. The physical intervention (sit-stand worktables) is expensive, though effective in reducing sitting time and not having an impact on performance. Whereas the personal intervention which is a cheaper alternative was not successful in reduction of sitting time. Having led a personal intervention that included computer prompts, and educational training on the importance of alternating between sitting and standing, the intervention was still revealed to be ineffective. This should be guidance that introducing stretches will not work due to low compliance, therefore, the money that could be used to provide cheap alternatives should be saved for sit-stand worktables that offer return on investments in the long term.

In practice, the study could be transferred into other office workplaces, as long as workplaces are provided with substantial information and support on how to use sit-stand worktables to ensure sustained utilisation and behavioural change over time. The study offers organisations that are looking into investing in the purchase of sit-stand worktables the relevant information to determine whether the worktables are being utilised or the company is operating on a loss due to low utilisation. Furthermore, organisations considering the implementation of sit-stand worktables in the workplace, would need to consider desk space in relation to the type of tasks that one would be assigned to. This will allow organisation to investigate whether desk space impacts use of sit-stand worktables. These findings and observations are important to prompt companies that are sceptical about buying sit-stand worktables to consider investing in sit-stand worktables irrespective of how expensive they are. For ergonomics consultants in South Africa, the study allows them to continue advocating for sit-stand worktables as they have proven to be more effective.

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Appendix 1

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

CONSENT FORM

Human Kinetics and Ergonomics Department

INFORMED CONSENT AND INDEMNITY

For research involving human participants

I, …… hereby agree to participate in the research study titled: ***Do different interventions that aim to reduce occupational sitting lead to different compliance and have an overall dissimilar effectiveness in changing sedentary behaviour overtime?*** I fully understand the nature of the above-mentioned research study, and that there are risks and benefits associated with the study. I have read and familiarized myself with the testing procedure that will take place during the duration of the study.

I agree to take part in the Department of Human Kinetics & Ergonomics research project specified above. I have had the project explained to me, and I understand that agreeing to take part means that:

1. Personal details will not be incorporated into any of the records, that the university will not have access to the raw data showing my results during the study.
2. Participation is voluntary, I have been given the explicit guarantee that I have the right to discontinue the project whenever without being harassed.
3. Pictures will be taken during the research study and altered for anonymity.
4. I am aware that I will be required to attach a sensor underneath my table as part of the study, as such give my consent to the researcher to attach the sensor.
5. I am also aware that I will have to complete an activity diary as part of the research study.
6. I understand that the HKE department is not liable for any injuries not related to the study due to non-compliance.
7. I have been given the information sheet regarding the research study, which I have fully understood and give consent to participate voluntarily.

PARTICIPANT PROVIDING CONSENT:

_____	_____	_____
(Print Name)	(Signed)	(Date)

WITNESS:

_____	_____	_____
(Print Name)	(Signed)	(Date)

PRINCIPAL RESEARCHER:

_____	_____	_____
(Print Name)	(Signed)	(Date)

Appendix 2

INFORMATION TO PARTICIPANTS

HUMAN KINETICS & ERGONOMICS

Tel: (046) 603 8472 • Fax: (046) 603 8934 • e-mail: thatokmalesa@gmail.com / s.zschernack@ru.ac.za

Dear Participant

Thank you for your interest in this master's research study. The research question is: ***Do different interventions that aim to reduce occupational sitting lead to different compliance and have an overall dissimilar effectiveness in changing sedentary behaviour?*** This letter serves to give you an insight into the research study, the aim of the study, the protocol, the equipment and the benefits or risks that you may be exposed to.

Purpose of study

The purpose of the study is to seek out an in-depth understanding of how different interventions lead to different compliance and have overall different effectiveness in changing occupational sitting behaviour overtime. Because humans adapt to different behaviours over time, this study will investigate how compliance differs over time. From the findings of the study, one would be able to assess how different sit–stand interventions lead to diverse compliance and behavioural change over time and thus give an indication of which intervention is more likely to be effective in reducing sitting behaviour. The findings will additionally contribute to the current literature on different sit–stand interventions and aid in developing effective interventions to break sedentary behaviour in real-world environments.

Study design

The study will take the form of a field-based study intervention (real world setting), using the non - repeated measurements design, that is, measurements will not be repeated. There will be an experimental group and a control group. You will either be in the experimental group or control group. The experimental group entails receiving ergonomics training and sit – stand worktables which allow workers to perform tasks either seated or standing, giving you the possibility to break from prolonged sitting at various intervals throughout the day. The control group entails receiving ergonomics training and you will be required to perform exercises. The study will be conducted at Rhodes University in different administrative divisions. The experimental site will be where the researcher would have attached the participant's work tables with sit – stand worktables as well as introduced exercises in the workplace.

Procedure

The study will consist of two interventions; physical intervention (sit –stand worktables) and a personal intervention (short bursts of physical activity - stretches). The study will be conducted for a period of five months. The first month will entail a pre-intervention phase whereby musculoskeletal symptoms will be assessed using the Nordic Musculoskeletal Questionnaire as well as assessing existing sitting patterns will be assessed using a sensor technology plugged underneath your table. The sensor technology will record real – time desk occupancy i.e. the amount of time spent at your desk and away from your desk. Your mood be assessed once a week using a mood tool questionnaire to assess how you are feeling during the research study. After completing the pre – intervention phase, you will be required to complete an intervention phase i.e. two months (physical intervention phase) or two months (personal intervention phase) depending on the group you would have been allocated to. The physical intervention phase will entail utilising the sit-stand worktable attached to a sensor that tracks utilisation of the sit – stand tables. You will also be asked to download a computer software to your desktop computer. The software will send pop – up messages to notify you when to stand up; providing you with an opportunity to alternate between sitting and standing for 5 minutes after working for 55 minutes. The second intervention phase, personal intervention, will consist of short bursts of physical activity stretches. In this intervention, you will be required to download a computer software to

your desktop computer. The software will send pop – up messages reminding you to take a break from prolonged sitting. During the break, you will be required to take four steps away from your desk and perform the outlined stretches every (5 minutes) after every 55 minutes of work done.

During the testing period, you will also be asked to complete an activity diary to reflect your work activities such as attending meetings outside your office and activities that you do during your micro break. Once a week you will be required to fill out the mood analysis tool questionnaire, this is to assess your mood during working hours.

Upon completion of the intervention phases, you will be required to complete a three weeks post-intervention phase to assess post sitting behaviour. Participants post sitting behaviour will be assessed using the sensors under their tables and completing the feedback section at the end of the activity diaries, to evaluate the significant effect of the different interventions in reducing prolonged occupational sitting behaviours in the workplace.

Possible Risks and Benefits

It is far-fetched that you will encounter any risks in this research study. Nevertheless, the slight risk may include:

1. From the sit-stand workstation: As you are most likely not familiar with the routine of interchanging between sitting and standing up you might experience feelings of tiredness or dizziness, and swollen legs from standing for 5 minutes.
2. Performing stretches: If you are not used to stretching you might feel sore. The risks are reversible that is you will be provided with an opportunity to try out the stretches prior testing.
3. Diary Entry: You may not feel confident to use the activity dairy due to thinking that your supervisor will have access to the activity dairy. Please note that all information provided to the researcher is strictly confidential.
4. Sensors: You may not feel comfortable having sensors recording desk occupancy. Please note that these sensors are not cameras and that all desk occupancy results are anonymous, and that the information will not be shared with your supervisor.

Benefits

Studies have shown that reduction of occupational sitting has direct health benefits. In essence, "being part of the study is good for you". More benefits of participating in this research study include getting an insight into the potential adverse health effects of sedentary behaviour in the workplace. You will also be contributing a body of knowledge to the Human Kinetic & Ergonomics Department with useful information regarding the effectiveness of different interventions that aid to reduce occupational sitting in the workplace. Another benefit includes exposure to the equipment that may not be in your exposure. Moreover, the university will benefit immensely as they could look into investing in the purchasing of the equipment for their employees.

Voluntary Participation

Participation is voluntary and will take place during normal working days. You may decide to withdraw from the study at any time by advising the researcher.

Confidentiality

During the data collection process, I will ensure that myself and the research assistant are the only people with access to your raw data. All information you provide in the study will be confidential. To maximize confidentiality, you will receive a code during the study to keep your identity anonymous. With all the information gathered in the research study, you will not be recognized separately in any way in any written reports of this research. Your identity will be protected (blocked) in the images that will be taken during the study. The images are taken for documentation purpose. You will get a detailed feedback about the study after data has been analysed.

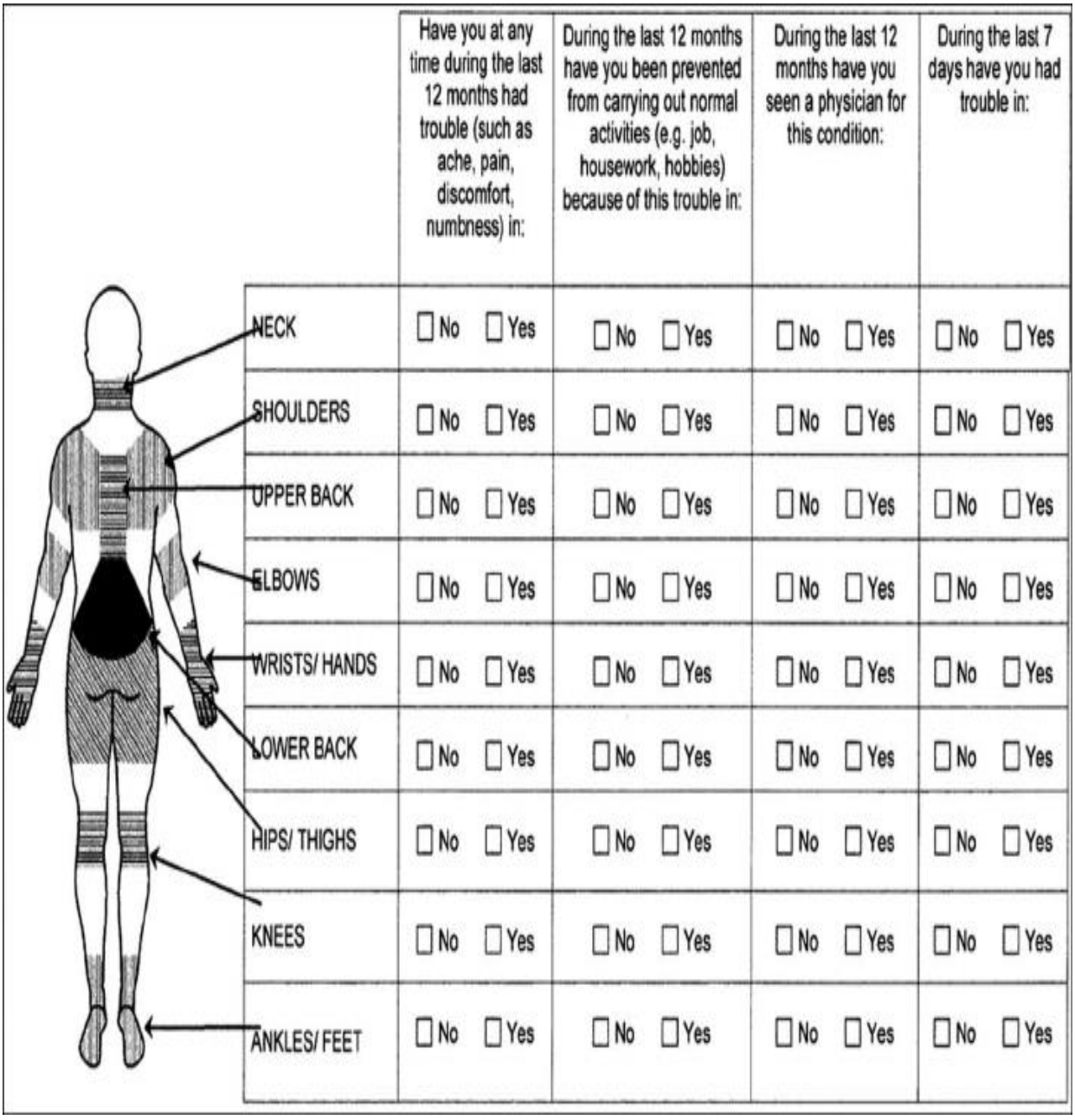
I hope that you will enjoy taking part in this study, if you have any questions, please feel free to contact me at the number listed below.

Thato Malesa
thatokmalesa@gmail.com
Researcher

Dr.Swantje Zschernack
s.zschernack@ru.ac.za
Supervisor

Appendix 3

NORDIC MUSCULOSKELETAL QUSTIONNAIRE

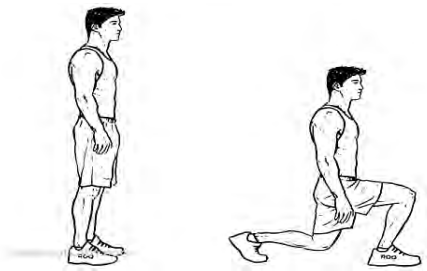


	Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:	During the last 12 months have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of this trouble in:	During the last 12 months have you seen a physician for this condition:	During the last 7 days have you had trouble in:
NECK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
SHOULDERS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
UPPER BACK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
ELBOWS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
WRISTS/ HANDS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
LOWER BACK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
HIPS/ THIGHS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
KNEES	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
ANKLES/ FEET	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes

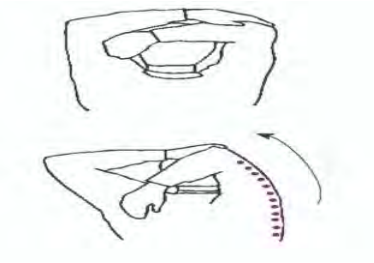
Appendix 4

SHORT BURSTS OF PHYSICAL ACTIVITY STRETCHES

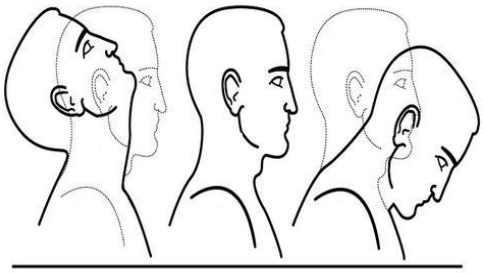
Forward lunge stretches



Supraspinatus stretches



Neck flexion/extension stretches



Leg Swings

Quadriceps stretches

Appendix 5

RHODES UNIVERSITY

HUMAN KINETICS & ERGONOMICS
Tel: +27 (0)46 6038468
Fax: +27 (0)46 6038934
Email: m.mattison@ru.ac.za

16 November 2018

Thato Malesa – g13M3573@campus.ru.ac.za
Swantje Zschernack – s.zschernack@ru.ac.za

Dear Thato and Swantje,

Final Ethical Clearance – Application HKE-2018-29

Your application for ethical clearance for the study titled *"Do different sit – stand interventions lead to diverse compliance and have an overall dissimilar effectiveness in changing occupational sitting behavior over time?"* (reference number HKE-2018-07) has been approved by the HKE Ethics Committee. This clearance is valid until the end of 2018. Since your data collection extends into 2019, please notify the HKE Ethics chair at the start of 2019, so that an extended letter for ethical clearance can be provided.

Please note that any significant changes made to the study and procedures need to be communicated to the HKE Ethics Committee (this includes changes in investigators), and another full review may be requested.

Upon completion of your study, please submit a short report indicating when and whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the HKE Ethics committee should be aware of.

Sincerely,

Miriam Mattison

M.C. Mattison
2018 HKE Ethics Chairperson
Department of Human Kinetics and Ergonomics
Rhodes University; Grahamstown
Tel: + 27-46-603 8468
Cell: +27-82 319 4626

Appendix 6

RHODES UNIVERSITY
Where leaders learn

Human Resources Division
Office of the HR Director
Administration Building, Grahamstown, 6139, South Africa
PO Box 94, Grahamstown, 6140
South Africa
t: +27 (0)46 603 8114
f: +27 (0)46 603 8046
e.l.govender@ru.ac.za

www.ru.ac.za

08 November 2018

Thato Malesa
Human Kinetics & Ergonomics
RHODES UNIVERSITY
thatokmalesa@gmail.com

Dear Thato

REQUEST TO CONDUCT RESEARCH WITH RHODES UNIVERSITY STAFF AND/OR STUDENTS

This letter is to confirm that your request to conduct research on ***"Do different sit – stand interventions lead to diverse compliance and have an overall dissimilar effectiveness in changing occupational sitting behavior over time?"*** topic has been approved by the Ethics Committee. In my capacity as HR Director, I do not have any objection should you wish to follow a coordinated approach by surveying and/or interviewing staff.

Yours sincerely

Loshni Govender
HR Director

Appendix 7

Post hoc tuckey test over the course of the day

Cell No.	Tukey HSD test; variable DV_1 (Average per hour of the day for 58 days) Approximate Probabilities for Post Hoc Tests Error: Between; Within; Pooled MSE = 1.9676, df = 22.598															
	Condition	HOURS	{1} 5.3595	{2} 5.3398	{3} 5.0452	{4} 5.2888	{5} 3.4238	{6} 4.2450	{7} 3.6491	{8} 1.3629	{9} 1.7743	{10} 1.5542	{11} 1.7472	{12} 1.4282	{13} 1.4292	{14} 1.5460
1	1	Hour 1		1,000 000	0,999 885	1,000 000	0,000 297	0,178 945	0,001 706	0,001 012	0,003 472	0,001 770	0,003 192	0,001 219	0,001 222	0,001 727
2	1	Hour 2	1,000 000		0,999 945	1,000 000	0,000 333	0,200 401	0,002 031	0,001 070	0,003 691	0,001 878	0,003 393	0,001 291	0,001 294	0,001 832
3	1	Hour 3	0,999 885	0,999 945		0,999 994	0,003 789	0,685 935	0,025 366	0,002 575	0,009 256	0,004 667	0,008 509	0,003 147	0,003 156	0,004 549
4	1	Hour 4	1,000 000	1,000 000	0,999 994		0,000 468	0,264 187	0,003 200	0,001 238	0,004 336	0,002 192	0,003 983	0,001 502	0,001 506	0,002 137
5	1	Hour 5	0,000 297	0,000 333	0,003 789	0,000 468		0,647 654	0,999 998	0,273 072	0,587 943	0,405 349	0,564 578	0,314 525	0,315 182	0,399 005
6	1	Hour 7	0,178 945	0,200 401	0,685 935	0,264 187	0,647 654		0,946 524	0,030 414	0,098 669	0,053 311	0,091 651	0,036 910	0,037 018	0,052 054
7	1	Hour 8	0,001 706	0,002 031	0,025 366	0,003 200	0,999 998	0,946 524		0,159 930	0,401 305	0,253 015	0,380 798	0,187 980	0,188 433	0,248 305
8	2	Hour 1	0,001 012	0,001 070	0,002 575	0,001 238	0,273 072	0,030 414	0,159 930		0,998 976	1,000 000	0,999 508	1,000 000	1,000 000	1,000 000
9	2	Hour 2	0,003 472	0,003 691	0,009 256	0,004 336	0,587 943	0,098 669	0,401 305	0,998 976		0,999 999	1,000 000	0,999 841	0,999 846	0,999 999
10	2	Hour 3	0,001 770	0,001 878	0,004 667	0,002 192	0,405 349	0,053 311	0,253 015	1,000 000	0,999 999		1,000 000	1,000 000	1,000 000	1,000 000
11	2	Hour 4	0,003 192	0,003 393	0,008 509	0,003 983	0,564 578	0,091 651	0,380 798	0,999 508	1,000 000	1,000 000		0,999 936	0,999 938	1,000 000
12	2	Hour 5	0,001 219	0,001 291	0,003 147	0,001 502	0,314 525	0,036 910	0,187 980	1,000 000	0,999 841	1,000 000	0,999 936		1,000 000	1,000 000
13	2	Hour 7	0,001 222	0,001 294	0,003 156	0,001 506	0,315 182	0,037 018	0,188 433	1,000 000	0,999 846	1,000 000	0,999 938	1,000 000		1,000 000
14	2	Hour 8	0,001 727	0,001 832	0,004 549	0,002 137	0,399 005	0,052 054	0,248 305	1,000 000	0,999 999	1,000 000	1,000 000	1,000 000	1,000 000	

Appendix 8

Post hoc tuckey test over 58 days period

Cell No.	Tukey HSD test; variable DV_1 (Average over 8 hours for 58 days) Approximate Probabilities for Post Hoc Tests Error: Between; Within; Pooled MSE = 6.0630, df = 184.28						
	Condition	DAYS	1 6.0536	2 8.5714	3 6.2667	4 4.8393	5 8.6071
1	1	Day 1		0,999970	1,000000	1,000000	0,999948
2	1	Day 2	0,999970		0,999999	0,623033	1,000000
3	1	Day 3	1,000000	0,999999		1,000000	0,999999
4	1	Day 4	1,000000	0,623033	1,000000		0,590818
5	1	Day 5	0,999948	1,000000	0,999999	0,590818	
6	1	Day 6	1,000000	0,999999	1,000000	1,000000	0,999998
7	1	Day 7	1,000000	1,000000	1,000000	0,999747	1,000000
8	1	Day 8	1,000000	0,952586	1,000000	1,000000	0,941501
9	1	Day 9	1,000000	0,947254	1,000000	1,000000	0,935315
10	1	Day 10	1,000000	1,000000	1,000000	1,000000	1,000000
11	1	Day 11	1,000000	0,990601	1,000000	1,000000	0,987344
12	1	Day 12	1,000000	1,000000	1,000000	0,999954	1,000000
13	1	Day 13	1,000000	0,999865	1,000000	1,000000	0,999776
14	1	Day 14	1,000000	0,999959	1,000000	1,000000	0,999928
15	1	Day 15	1,000000	1,000000	1,000000	1,000000	1,000000
16	1	Day 16	1,000000	0,999999	1,000000	1,000000	0,999998
17	1	Day 17	1,000000	1,000000	1,000000	0,999204	1,000000
18	1	Day 18	1,000000	0,222963	1,000000	1,000000	0,202532
19	1	Day 19	1,000000	0,718210	1,000000	1,000000	0,687980
20	1	Day 20	1,000000	0,999041	1,000000	1,000000	0,998553
21	1	Day 21	1,000000	0,386326	1,000000	1,000000	0,357589
22	1	Day 22	1,000000	1,000000	1,000000	0,996194	1,000000
23	1	Day 23	1,000000	0,701079	1,000000	1,000000	0,670319
24	1	Day 24	1,000000	0,243318	1,000000	1,000000	0,221604
25	1	Day 25	1,000000	0,423564	1,000000	1,000000	0,393583
26	1	Day 26	1,000000	0,170027	1,000000	1,000000	0,153325
27	1	Day 27	0,999427	0,006077	0,994223	1,000000	0,005207
28	1	Day 28	1,000000	0,211257	1,000000	1,000000	0,191610
29	1	Day 29	0,731044	0,000129	0,543272	0,999997	0,000116
30	1	Day 30	0,999990	0,018435	0,999719	1,000000	0,015991
31	1	Day 31	1,000000	0,089970	1,000000	1,000000	0,079993
32	1	Day 32	0,952586	0,000651	0,859428	1,000000	0,000552
33	1	Day 33	0,994632	0,002464	0,970247	1,000000	0,002100
34	1	Day 34	1,000000	0,133367	1,000000	1,000000	0,119560
35	1	Day 35	1,000000	0,084921	1,000000	1,000000	0,075420
36	1	Day 36	1,000000	0,321118	1,000000	1,000000	0,295140
37	1	Day 37	0,981660	0,001248	0,928068	1,000000	0,001057
38	1	Day 38	0,999997	0,023555	0,999884	1,000000	0,020496
39	1	Day 39	1,000000	0,055513	0,999998	1,000000	0,048926
40	1	Day 40	1,000000	0,051624	0,999997	1,000000	0,045444
41	1	Day 41	0,998787	0,004635	0,989959	1,000000	0,003963
42	1	Day 42	1,000000	0,364584	1,000000	1,000000	0,336687

Cell No.	Tukey HSD test; variable DV_1 (Average over 8 hours for 58 days) Approximate Probabilities for Post Hoc Tests Error: Between; Within; Pooled MSE = 6.0630, df = 184.28						
	Condition	DAYS	1 6.0536	2 8.5714	3 6.2667	4 4.8393	5 8.6071
43	1	Day 43	0,971722	0,000944	0,902219	1,000000	0,000799
44	1	Day 44	0,191610	0,000057	0,101404	0,982038	0,000056
45	1	Day 45	0,957511	0,000707	0,869804	1,000000	0,000599
46	1	Day 46	0,946395	0,000592	0,846870	1,000000	0,000502
47	1	Day 47	1,000000	0,176390	1,000000	1,000000	0,159211
48	1	Day 48	0,999993	0,019789	0,999780	1,000000	0,017181
49	1	Day 49	0,947254	0,000599	0,848584	1,000000	0,000509
50	1	Day 50	0,978788	0,001139	0,920231	1,000000	0,000965
51	1	Day 51	1,000000	0,685997	1,000000	1,000000	0,654836
52	1	Day 52	1,000000	0,783536	1,000000	1,000000	0,756135
53	1	Day 53	0,999926	0,011337	0,998740	1,000000	0,009782
54	1	Day 54	0,986400	0,001492	0,941888	1,000000	0,001264
55	1	Day 55	1,000000	0,088733	1,000000	1,000000	0,078872
56	1	Day 56	1,000000	0,063366	0,999999	1,000000	0,055963
57	1	Day 57	1,000000	0,211257	1,000000	1,000000	0,191610
58	1	Day 58	0,654836	0,000100	0,463322	0,999984	0,000092
59	2	Day 1	0,799800	0,000960	0,653157	0,999981	0,000834
60	2	Day 2	0,846755	0,001328	0,713328	0,999995	0,001154
61	2	Day 3	0,713297	0,000575	0,553566	0,999892	0,000500
62	2	Day 4	0,434503	0,000154	0,292246	0,995270	0,000139
63	2	Day 5	0,875210	0,001660	0,752695	0,999998	0,001444
64	2	Day 6	0,763003	0,000764	0,609263	0,999958	0,000664
65	2	Day 7	0,625846	0,000365	0,463508	0,999566	0,000319
66	2	Day 8	0,918225	0,002511	0,818054	1,000000	0,002194
67	2	Day 9	0,938230	0,003166	0,851871	1,000000	0,002768
68	2	Day 10	0,502514	0,000205	0,349691	0,997835	0,000182
69	2	Day 11	0,463397	0,000173	0,316232	0,996584	0,000155
70	2	Day 12	0,553065	0,000258	0,394718	0,998838	0,000227
71	2	Day 13	0,936637	0,003103	0,849071	1,000000	0,002712
72	2	Day 14	0,676371	0,000472	0,514431	0,999798	0,000411
73	2	Day 15	0,427626	0,000149	0,286625	0,994895	0,000135
74	2	Day 16	0,595258	0,000314	0,433987	0,999333	0,000276
75	2	Day 17	0,847756	0,001338	0,714672	0,999995	0,001162
76	2	Day 18	0,906249	0,002225	0,798990	0,999999	0,001943
77	2	Day 19	0,731976	0,000638	0,574060	0,999923	0,000555
78	2	Day 20	0,445745	0,000161	0,301507	0,995829	0,000145
79	2	Day 21	0,653128	0,000418	0,490655	0,999710	0,000365
80	2	Day 22	0,513989	0,000216	0,359730	0,998114	0,000192
81	2	Day 23	0,847369	0,001334	0,714152	0,999995	0,001159
82	2	Day 24	0,489894	0,000194	0,338770	0,997487	0,000173
83	2	Day 25	0,389929	0,000129	0,256392	0,992301	0,000117
84	2	Day 26	0,618746	0,000352	0,456572	0,999519	0,000309
85	2	Day 27	0,460549	0,000171	0,313842	0,996472	0,000153
86	2	Day 28	0,763576	0,000766	0,609927	0,999958	0,000666
87	2	Day 29	0,955085	0,004023	0,882905	1,000000	0,003521
88	2	Day 30	0,680425	0,000482	0,518644	0,999811	0,000420
89	2	Day 31	0,752241	0,000717	0,596878	0,999948	0,000623
90	2	Day 32	0,372061	0,000120	0,242397	0,990679	0,000110

Cell No.	Tukey HSD test; variable DV_1 (Average over 8 hours for 58 days) Approximate Probabilities for Post Hoc Tests Error: Between; Within; Pooled MSE = 6.0630, df = 184.28						
	Condition	DAYS	1 6.0536	2 8.5714	3 6.2667	4 4.8393	5 8.6071
91	2	Day 33	0,767475	0,000785	0,614466	0,999962	0,000682
92	2	Day 34	0,525219	0,000227	0,369656	0,998355	0,000201
93	2	Day 35	0,222755	0,000075	0,133443	0,955821	0,000071
94	2	Day 36	0,195523	0,000070	0,115078	0,941190	0,000067
95	2	Day 37	0,555613	0,000261	0,397045	0,998875	0,000230
96	2	Day 38	0,336346	0,000106	0,215050	0,986413	0,000098
97	2	Day 39	0,431135	0,000152	0,289489	0,995090	0,000137
98	2	Day 40	0,429750	0,000151	0,288358	0,995014	0,000136
99	2	Day 41	0,242545	0,000079	0,147078	0,964043	0,000075
100	2	Day 42	0,436821	0,000155	0,294148	0,995391	0,000140
101	2	Day 43	0,255514	0,000081	0,156148	0,968566	0,000077
102	2	Day 44	0,512851	0,000215	0,358730	0,998088	0,000191
103	2	Day 45	0,547297	0,000251	0,389474	0,998750	0,000222
104	2	Day 46	0,395004	0,000131	0,260405	0,992711	0,000119
105	2	Day 47	0,587393	0,000303	0,426543	0,999258	0,000266
106	2	Day 48	0,397921	0,000133	0,262720	0,992937	0,000121
107	2	Day 49	0,822621	0,001117	0,681747	0,999989	0,000971
108	2	Day 50	0,544672	0,000248	0,387096	0,998708	0,000219
109	2	Day 51	0,173420	0,000067	0,100523	0,925542	0,000065
110	2	Day 52	0,244612	0,000079	0,148517	0,964807	0,000075
111	2	Day 53	0,342344	0,000108	0,219585	0,987242	0,000100
112	2	Day 54	0,618256	0,000351	0,456096	0,999516	0,000308
113	2	Day 55	0,324870	0,000101	0,206434	0,984684	0,000094
114	2	Day 56	0,327252	0,000102	0,208215	0,985059	0,000095
115	2	Day 57	0,119460	0,000061	0,066372	0,864240	0,000060
116	2	Day 58	0,104537	0,000059	0,057280	0,838128	0,000059