SEDENTARY BEHAVIOUR IN A SAMPLE OF SOUTH AFRICAN OFFICE-BASED WORKERS

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A thesis is submitted to the Faculty of Health Sciences, University of the

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Declaration

I, Merling Phaswana, declare that this PhD thesis is my unaided work. It is being submitted for the Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University. Furthermore, it represents my own opinions and not necessarily those of the University of the Witwatersrand, Johannesburg.

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Name of the candidate Signature of the candidate

________ day of ______________ 20________ in______________________

Dedication

I dedicate this work wholeheartedly to my incredible wife, Mpho. Your unwavering support has been the cornerstone of my journey, and I am eternally grateful for your presence by my side. You have been my most extensive support system and my constant source of encouragement when I needed it the most. Your belief in the value of this project to my career and our lives has propelled me forward in ways I cannot express enough.

I want to express my deepest gratitude for your immeasurable love, patience, and unwavering support throughout the process. You have shouldered the burden with me during the crunch times of data collection and thesis writing, selflessly carrying us forward. Your unwavering dedication and sacrifice have touched me deeply, and I am forever grateful for your boundless generosity.

I cannot emphasize enough how vital your presence has been in achieving this milestone. Without you, none of this would have been possible. You have shown me what it means to be selfless, and your unwavering belief in me has given me the strength to persevere. Thank you from the bottom of my heart for being the anchor in my life and embodiment of love and support.

Conference Presentations Arising from this Study.

Merling Phaswana (5 September 2023). Ukumela Impilo Randomised Trial: Preliminary Findings of Height-Adjustable sit-to-stand Workstations on Health Outcomes of South African Office Workers. School of Therapeutic Sciences Research Day 2023. University of the Witwatersrand, Johannesburg, South Africa.

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Publications arising from this Study.

The PhD thesis is linked to the following five publications, presenting contributions from both the student and other authors. All authors, including the student, have granted their consent to include these works, as outlined in the Appendices.

1. Gradidge, PJL., **Phaswana, M.,** Wijndaele, K., Crowther N, J. and Draper, C.E. (2020) Standing up Against Office Sitting – A study protocol. South African Journal of Physiotherapy. 76 (1): 1-6. (Impact factor: 1.01) (Published) See Appendix 8 for agreement from co-authors to include this in the Thesis.

The candidate contributed to the study design and the development of the article until publication with author one.

2. Gradidge, P., **Phaswana, M.** and Chau, J. (2022) "'If money was no object': A qualitative study of South African university office workers' perceptions of using height-adjustable sit-stand desks", South African Journal of Sports Medicine, 34(1). doi: 10.17159/2078-516X/2022/v34i1a13881. (Impact factor: 0.69) (Published) See Appendix 9 for agreement from co-authors to include this in the Thesis.

The candidate collected the data, conceived the study design, analysed and interpreted the data, and drafted the manuscript with author one.

3. **Phaswana, M.,** Gordon, NF. and Gradidge, PJL. (2023). Sedentary behaviour, physical activity patterns, and cardiometabolic risk factors in South African office-based workers. American Journal of Lifestyle Medicine, 0(0). doi:10.1177/15598276231210479. (Impact factor: 1.9) (Published) See Appendix 11 for agreement from co-authors to include this in the Thesis.

The candidate collected the data, conceived the study design, analysed and interpreted the data, and drafted the manuscript. All authors read, edited, and approved the article's final version.

4. **Phaswana, M.** and Gradidge, PJL. (2023) Ukumela Impilo Randomised Trial: Preliminary Findings of Height-Adjustable sit- to- stand Workstations on Health Outcomes of South African Office Workers. BMC Research Notes, 16, 361 (2023). https://doi.org/10.1186/s13104-023-06642-2. (Impact factor: 1.89)

(Published) See Appendix 12 for agreement from co-authors to include this in the Thesis.

The candidate collected the data, conceived the study design, analysed and interpreted the data, and drafted the manuscript. All authors read, edited and approved the final version of the article.

5. **Phaswana, M.** Onagbiye, SO. and Gradidge, PJL. (2023) A qualitative investigation of office workers' experiences and early withdrawal from a height-adjustable, sit-to-stand desk intervention. BMC Journal of Implementation Science and Implementation Science Communications (Under Review). (Impact factor: 2.2) (*Under review).*

The candidate collected the data, conceived the study design, analysed and interpreted the data, and drafted the manuscript. All authors read, edited, and approved the article's final version.

Grants and scholarships received during this Study

1. Donor Name: South African National Research Foundation PhD Thuthuka Grant

Amount: R374000.00

Funds were used for:

- Procuring research equipment and consumables.
- Procuring statistical analysis tools.
- Attending the 10th Physical Activity Measurement Seminar. Møller Centre, Cambridge, United Kingdom.
- Assistance with transportation to participant's houses and offices.

2. Donor Name: Early Career Academic Development, University of the Witwatersrand

Amount: R25000.00

- Twenty thousand was used to procure the height-adjustable sit-to-stand workstation.
- The University of the Witwatersrand, Centre for Learning, Teaching and Development department used the reminder R5000.00 to organise writing workshops.

3. Donor Name: 2022 International Society of al Nutrition and Physical Activity (ISBNPA) scholarship

Amount: 1000 USD

These funds were used for virtual conference registration, forfeited due to the United States of America Embassy VISA backlog due to the covid 19 pandemic.

4. Donor Name: University of the Witwatersrand, Faculty of Health Sciences Research Committee Individual Research Grants

Amount: R13000.00

These funds were used to procure combo wireless keyboards and mouse to complement the sit-to-stand workstations in promoting proper ergonomics.

Abstract

Background

Sedentary behaviour is associated with cardiometabolic diseases amongst office-bound workers, primarily through extended sitting and engaging in low-energy-demanding activities during work hours. Similar to developed countries, South African workplaces are experiencing an increasing prevalence of obesity and related cardiovascular diseases, with sedentary behaviour and physical inactivity being the main contributors. However, there is limited data on the effectiveness of sedentary behaviour strategies in improving South African office-based workers' cardiometabolic risk markers.

Objectives

This study aims to assess the effectiveness of the height-adjustable sit-to-stand work on cardiovascular parameters in a cohort of office-based workers and to explore the perceptions of these workers about the feasibility and suitability of this intervention to reduce occupational sitting time.

Methods

A mixed-methods study design was used on office workers from the University of the Witwatersrand and a credit bureau company in South Africa. The qualitative papers used in-depth semi-structured interviews to explore office-based workers' perceptions and experiences using sit-to-stand workstations. The interview audio was recorded audio using Microsoft Teams (version 11, Microsoft Way, United States) and Phillips (DVT4010 Voice Tracer, Vienna, Austria). All transcripts were checked against the recordings to verify accuracy and credibility, and grammatical editing was adopted where necessary. For quantitative measures, participants were randomised into an intervention or control group to collect measures at baseline and 12 weeks in a cohort of South African desk-based workers. These biomarkers include anthropometry, sedentary behaviour and physical activity, sleep duration, blood pressure, glucose, glycated haemoglobin (HbA1c) and lipid profile. The cross-sectional paper quantified sedentary behaviour, overall physical activity, and the association with select cardiometabolic risk factors. The randomised control trial evaluated the short-term effects of height-adjustable sit-to-stand workstations on cardiometabolic risk markers. Descriptive and inferential statistics were used to describe and compare baseline and follow-up changes in the intervention.

Results

The height-adjustable sit-to-stand workstation was deemed feasible and well-accepted by our participants. Participants expressed that it motivated them to stand up and work and effectively alleviated discomfort associated with prolonged sitting. Most (68.0%) of the study participants were women, with a mean age of 40.2 ± 9.3 years. Our participants spend an average of 8 to 10 hours in sedentary behaviour. Both systolic (β: -0.234, p = 0.037 mmHg) and diastolic blood pressure (β: -0.250, p <0.001 mmHg) were inversely associated with accelerometery-measured light physical activity. However, there was no relationship between accelerometery-measured sedentary behaviour and cardiometabolic risk factors after analysis. The 12-week randomised control trial showed small improvements with blood pressure -0.26 (d =1.10 mmHg) and Light physical activity -0.26 (d=3.57 min/day). We observed trivial effects, with most of our cardiometabolic outcomes including body mass index (BMI) -0.11 (d=1.07 $kg.m^2$). Most participants withdrew early from workplace intervention due to the design and functionality of the height-adjustable sit-to-stand workstation.

Conclusions

This study adds to the limited evidence on environmental workstation modifications for reducing sedentary behaviour. Our findings show that South African office workers spend a substantial amount of time sitting during work hours and support the need for public health workplace interventions to mitigate the potential health risks associated with such sedentary behaviour. This study confirms that short-term height-adjustable sit-stand interventions effectively reduce workplace sitting time and promise to improve cardiometabolic health outcomes, suggesting that clinically significant effects might be noticed in long-term interventions. Therefore, future studies should consider individual preferences, workstation design, functionality, education, and motivation to ensure successful implementation, utilization, and compliance with sit-to-stand workstations.

Keywords: Sedentary behaviour, Physical activity, Cardiometabolic outcomes, Height adjustable sit-to-stand workstation, dropping out, discomforts, health benefits, office-based workers, South Africa

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List of Abbreviations

- BMI: Body mass index
- BP: Blood pressure
- cm: Centimetre (s)
- cm^2 - centimetres squared
- CVD: Cardiovascular disease
- DBP: Diastolic blood pressure
- HC: Hip circumference
- HICs: high-income countries
- HDL: High-density Lipoprotein Cholesterol
- hr/day: hours per day
- kcal: Kilocalories
- kg: Kilogram (s)
- kg/m^2 - kilograms per metre squared
- LMICs: Low- and middle-income countries
- LDL: Low-density Lipoprotein Cholesterol
- LPA: Light physical activity
- NCD: Non-communicable diseases
- m^2: Metre (s) squared
- MVPA: moderate-to-vigorous physical activity
- min/day - min per day
- PA: Physical activity
- SB: Sedentary behaviour
- SBP: Systolic blood pressure
- SES: Socioeconomic status
- SA: South Africa
- SSA: Sub-Saharan Africa
- TC - Total Cholesterol
- WC: Waist circumference
- WHO: World Health Organization
- WHR: Waist-to-hip ratio

Definition of terms

Cardiometabolic risk factors

Cardiometabolic risk factors are a group of health conditions that increase the likelihood of developing cardiovascular disease (CVD) and type 2 diabetes (1).

Cardiovascular disease

Cardiovascular disease (CVD) has been defined as a cluster of health conditions affecting the heart and blood vessels, such as coronary artery disease, heart failure, and stroke (2).

Light physical activity

Light physical activity (LPA) is any form of exercise or movement that is low in intensity and does not cause significant strain on the body (3).

Moderate to vigorous physical activity

Moderate to vigorous physical activity (MVPA) refers to a minimum recommendation of physical activity that requires moderate effort for at least 150 minutes a week and increases heart rate and breathing (4).

Obesity

Obesity is an excessive accumulation of fat that poses a health risk, with a BMI of 30 kg/m^2 or higher.

Physical activity

Physical activity is any bodily movement requiring energy expenditure and produced by skeletal muscles (3).

Sedentary behaviour

Recent research defines sedentary behaviour (SB) as awake, seated, recumbent, or lying-down activities that result in energy expenditures of 1.5 metabolic equivalents (5).

Chapter 1 Introduction

1.1 Overview

This chapter provides an overview of sedentary behaviour and cardiometabolic risk outcomes by analysing published research. A summary of the focus area, including the stated purpose, problem statement, and objectives from the introduction to the thesis. The literature review investigated the association between sedentary behaviour and related cardiometabolic outcomes in office workers. The focus then shifts to occupational sitting time, including previous workplace interventions to reduce sedentary time among office workers. Finally, the thesis's justification is elucidated concerning identified literature gaps.

1.2 Introduction

The worldwide incidence of overweight and obesity is consistently rising at a concerning pace (6). Of concern is that the prevalence of non-communicable diseases (NCDs) is on the rise and accounts for approximately 85% of mortality and morbidity rates in low to middle-income countries (LMICs) (7). The main concern is the rise in the incidence of these modifiable diseases and the risk of premature mortality. In fact, available research from South Africa indicates that the rapid increase in obesity and its associated ailments may be attributable to the adoption of unhealthy eating patterns, tobacco usage, excessive alcohol intake, lack of physical activity, and sedentary lifestyles, which favour excess fat accumulation (7, 8).

Sedentary behaviour is characterized by participating in awake sitting, recumbent, or lying-down activities that lead to energy expenditures of 1.5 metabolic equivalents (METS) or less (5). The significance of sedentary behaviour as a crucial public health concern has been lately recognized. There is an increasing body of evidence that demonstrates that excessive sitting has adverse associations with obesity and related diseases, resulting in increased mortality rates (9). Additionally, the global shift in technological advancement in the workplace has significantly contributed to the increased prevalence of sedentary behaviour (10). Currently, working adults spend approximately 75% or 6 hours of their workday seated (7), resulting in desk-based employees inevitably being exposed to increased sitting time due to occupational demands of sitting and working (11). Furthermore, desk-based workers spend more than 60 minutes in sedentary positions compared to their counterparts in labour-intensive occupations (12).

Despite the alarming rates of occupational sitting (13) and its association with obesity-related diseases, office-based employees spend most of their time seated (12). However, several studies have corroborated that interrupting sitting time with physical activity or standing breaks has been found to be beneficial in preventing and managing cardiovascular diseases (CVDs) in office workers (14-16). Although this approach has thus far been limited to high-income countries (HICs) for tackling sedentary behaviour in the workplace, it is plausible that a comparable strategy could have positive outcomes if implemented in LMIC. In addition, adherence to public health recommendations to promote increased physical activity and decreased sedentary behaviour will reduce the risk of cardiovascular diseases in LMICs.

The World Health Organization identifies the workplace as the ideal environment for promoting an individual's health (16)Considering that most working individuals are sedentary, interventions must be implemented to interrupt sitting time (17). As such, occupational environments can be modified by introducing active workstations, such as the height adjustable sit-stand desks, which permit breaks in sitting time (14). Mantzari and colleagues have also reported that the short- and long-term effects of a height-adjustable standing desk are feasible in addressing sedentary behaviour and cardiometabolic risk factors among workers (15). Interventions have indicated that height-adjustable sit-stand desks neither enhanced nor impaired work performance (18). However, to the researcher’s knowledge, multi-component strategies have not been applied in the South African workplace. This is the first study to bridge research gaps on active workplace intervention in addressing sedentary behaviour associated with cardiometabolic diseases and lifestyle behaviours in LMICs. This research explores the effects of a 12-week adjustable height-adjustable standing desk on anthropometry, blood pressure and selected cardiometabolic outcomes in office-based workers.

1.2.1 Problem statement

Non-communicable diseases have emerged as a significant public health threat in South Africa, eclipsing even HIV/AIDS and tuberculosis in their sheer numbers.

Among these, cardiovascular diseases take the top spot, casting a long shadow over the nation's future, with projections of a 30% spike in premature death rates by 2030 (24, 25). Furthermore, the global burden of NCDs has drastically changed in recent decades (19), with projections indicating an impending rise in death rates among the workforce in South Africa (20).

The prevalence of sedentary lifestyles, independent of physical activity levels, puts adults at heightened risk for cardiometabolic disorders (21). This lack of movement, exacerbated by desk-bound jobs and technological advancements, silently drives down productivity, increasing absenteeism, disability claims, and employee turnover (22). Companies face mounting costs as they scramble to implement wellness initiatives and mitigate the health consequences of an increasingly sedentary workforce.

Unhealthy dietary choices, readily available sugary beverages and processed fast foods in workplace canteens significantly contribute to the development of cardiometabolic diseases (23). In addition to other factors such as smoking (cigarette and e-cigarette), excessive alcohol consumption, job strain and demands, mental health, stress, and rotating work shifts (20).

In these contemporary times, workers have become increasingly sedentary and restricted to their desks due to technological advancements(14).
Although workplace interventions to enhance employee health have been effectively implemented in developed countries (24), such evidence remains scarce in South Africa (25, 26). This study bridges this gap by investigating the link between sedentary behaviour, obesity markers, cardiometabolic factors, and behavioural risk factors in South African office workers. By understanding the unique determinants of NCD risk in South African workplaces, we can pave the way for targeted interventions that promote employee well-being, boost productivity, and, ultimately, create a healthier future for the nation's workforce.

1.2.2 Justification of the study

Modifying office settings with height-adjustable desks has been associated with reduced sitting time and improved health outcomes (27, 28). These studies demonstrated that using height-adjustable height desks in office workers reduced sitting durations and increased standing time. Consistent with these findings, a recent study reported that using a height-adjustable desk effectively reduced daily sitting time by 48 minutes per 16-hour waking day (29). Similarly, a systematic review said the effectiveness of sedentary behaviour interventions on cardiometabolic risk factors, although there was no consistency in which cardiometabolic risk markers showed improvement across interventions (30). These findings support the potential of height-adjustable desks to positively impact anthropometry, blood pressure, and cardiometabolic outcomes in office-based workers.

However, there is a lack of evidence on the effectiveness of height-adjustable sit-to-stand workstations in mitigating sedentary behaviour and cardiometabolic risk factors within low- to middle-income nations, including South Africa (31). This is particularly concerning since, similar to developed countries, a significant portion of South Africa's workforce is predominantly sedentary (32). Approximately 4.6% of the population, mainly urban dwellers, spends an average of ≥ 8 hours per day sitting (33). However, further research is essential to understand the effectiveness of height-adjustable desks on the health outcomes of South African office-based workers. This proposed study is justified by the existing literature, which suggests that the use of height-adjustable desks has the potential to reduce sitting time, increase energy expenditure, and positively impact health outcomes. Therefore, this study could contribute to the growing body of research highlighting the need to reduce sedentary behaviour and incorporate physical activity into the daily routine, even among individuals with sedentary occupations.

1.2.3 Aims and Objectives

This study aimed to determine whether an intervention of work-based intermittent standing will influence cardiometabolic markers in office-based workers.

The objectives of the study were:

1. To conduct a pilot study to assess the feasibility and efficacy of the sedentary behaviour randomized controlled trial among South African office workers.
2. To determine baseline measures of sedentary behaviour, anthropometry, blood pressure, and cardiometabolic disease factors (lipid profile, blood

glucose, and glycated haemoglobin (Hb1Ac)) of South African desk-based workers.

3. To compare and evaluate the effectiveness of a 12-week intervention of either (1) a sit-stand desk workstation or (2) a control group in sedentary behaviour, anthropometry, blood pressure, and cardiometabolic diseases of South African desk-based workers.
4. To understand and explore factors associated with participants' high dropout in the 12-week randomised controlled trial in South African desk-based workers.

1.3 Outline of this Thesis

This thesis follows an article-by-publication format. Each study is discussed in its chapter, and an overview of each chapter is provided below.

Chapter 1 (Introduction and literature review) defines sedentary behaviour and cardiometabolic diseases among South African office-based workers. The relationship between cardiometabolic disease risk factors and sedentary behaviour is analysed critically. This chapter clearly explains the problem statement and the research gaps in the literature concerning South African office workers.

Chapter 2 (general methodology): A concise summary of the thesis's general methods. We considered that there is a published protocol detailing the PhD's quantitative and qualitative aspects. We included an overview of the PhD methodology without self-plagiarism.

Chapters 3-7 (Articles) included in the thesis are illustrated in Figure 1.1.

Chapter 3 (protocol paper): This chapter outlines the general methodology of the thesis, particularly the study designs and tools used in the data collection. It is important to note that the methods described here were prior to the COVID-19 pandemic and that the pandemic imposed few alterations to the study (34).

Chapter 4 (pilot study): This chapter answers the first objective. It is a qualitative study aimed at understanding the feasibility of height-adjustable sit-to-stand workstations on addressing sedentary behaviour and cardiometabolic outcomes in South African office-based workers (31).

Chapter 5 (Cross-sectional study): This chapter answers the second objective, which is a quantitative study. The randomised control trial (RCT) baseline measures of South African office-based workers were collected before the randomisation process (35).

Chapter 6 (Preliminary results of the RCT): This chapter answers the third objective, a quantitative study. The randomised control trial (RCT) three months follow-up measures of South African office-based workers (36).

Chapter 7 (Reasons for dropping out): This chapter answers the last objective of the study. It is a qualitative study to understand participant experiences and reasons for dropping out of the height-adjustable sit-to-stand workstation intervention.

Chapter 8 (Conclusion): This chapter summarizes and critically analyses all study findings, highlighting the strengths and limitations of the thesis research. This thesis also summarizes the implications of the findings from five novel studies for future research recommendations.

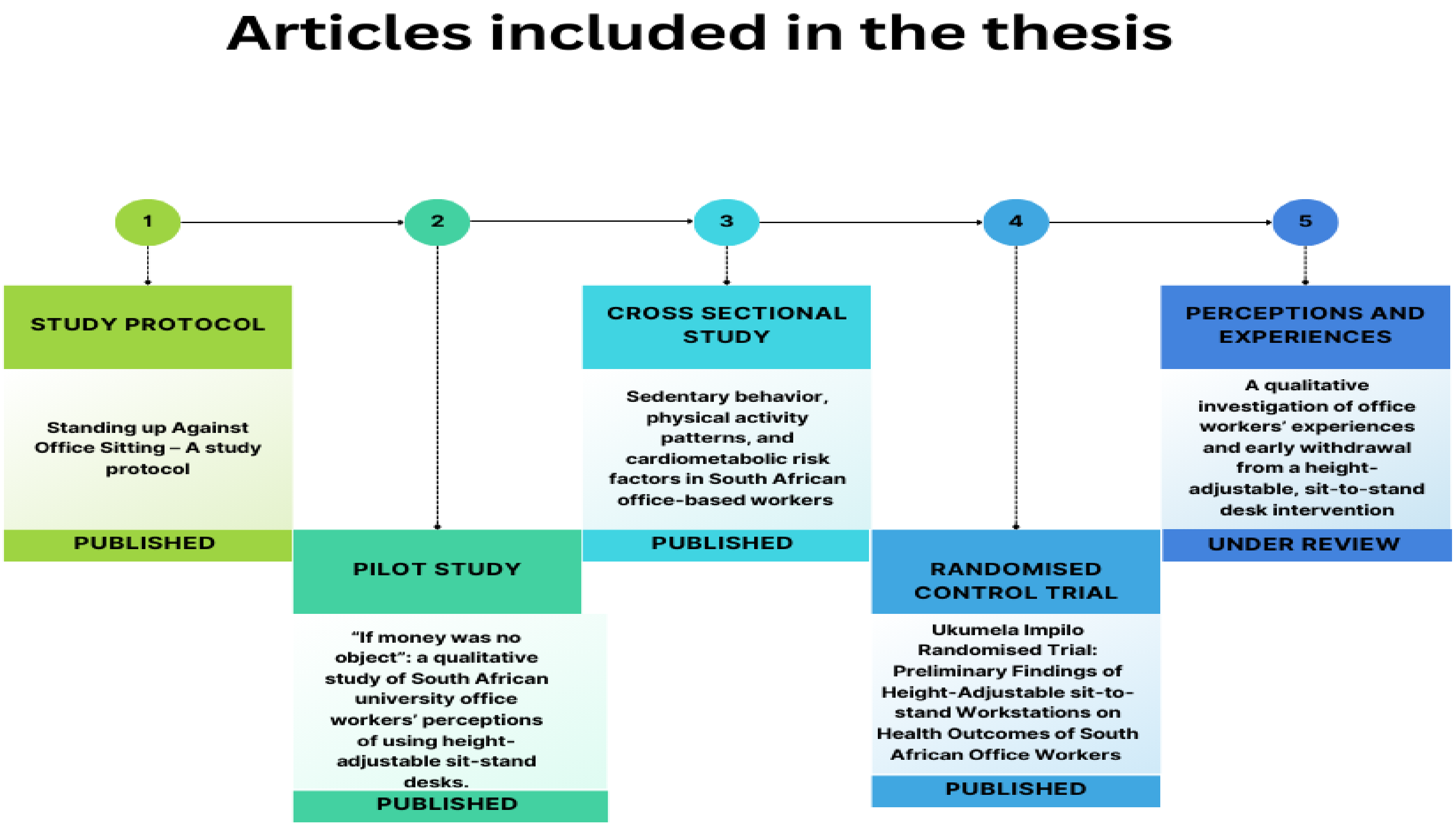

Figure 1.1 Outline of the thesis

1.4 Conceptual Framework

Office workers often fall victim to hidden health risks and sedentary behaviour, trapped in the monotonous cycle of excessive emails and overloaded inboxes. In addition, desk-based employees are conventionally required to sit at their desks while working. Consequently, the task of changing behaviours by interrupting prolonged periods of sitting while working while standing is not a common practice (37). The Transtheoretical Model (TTM) provides a robust framework for comprehending and facilitating behaviour change (38). has been adopted in this thesis see Figure 1.2.

Imagine a staircase where each step represents a stage in the TTM's journey towards embracing healthy behaviours:

1. **Pre-contemplation:** During this stage, individuals are deeply rooted in their inactive way of life and have not yet started contemplating any modifications. Highlighting the adverse effects of extended periods of sitting, such as weight gain and reduced energy levels, can inspire individuals to rise and engage in physical activity.
2. **Contemplation:** Looking downward, people start contemplating the benefits of physical involvement. By showcasing colleagues' accomplishments in good health and underscoring the profound capacity for change, individuals may be inspired to pursue even higher levels of success.
3. **Preparation:** Equipped with a range of action plans and self-monitoring procedures, they begin their initial careful efforts. Motivating individuals to intersperse their sedentary periods with brief intervals of physical activity and offering readily available exercise choices promotes their progress.
4. **Action:** Finally, they have commenced their motion! Acknowledging their achievements and offering ongoing support, they overcome initial challenges and establish their recently acquired active routines.
5. **Maintenance:** After achieving the highest point, the goal is to sustain that position. Relapse prevention strategies are employed to reinforce persons' awareness of the benefits they have achieved and offer help in managing challenging situations.

The appeal of the TTM lies in its inherent flexibility. By tailoring interventions for each step, we can effectively address individual office workers' specific needs and motivations. The effectiveness of this personalised approach has been proven in tackling health concerns such as a lack of physical activity, quitting smoking, and the control of long-term diseases (39).

Although the potential of the TTM concerning office-based workers and cardiometabolic outcomes has not been investigated, it is highly promising (37). By utilising its knowledge, we can create treatments that disrupt sedentary behaviour, fostering a healthier and more dynamic office atmosphere for everyone.

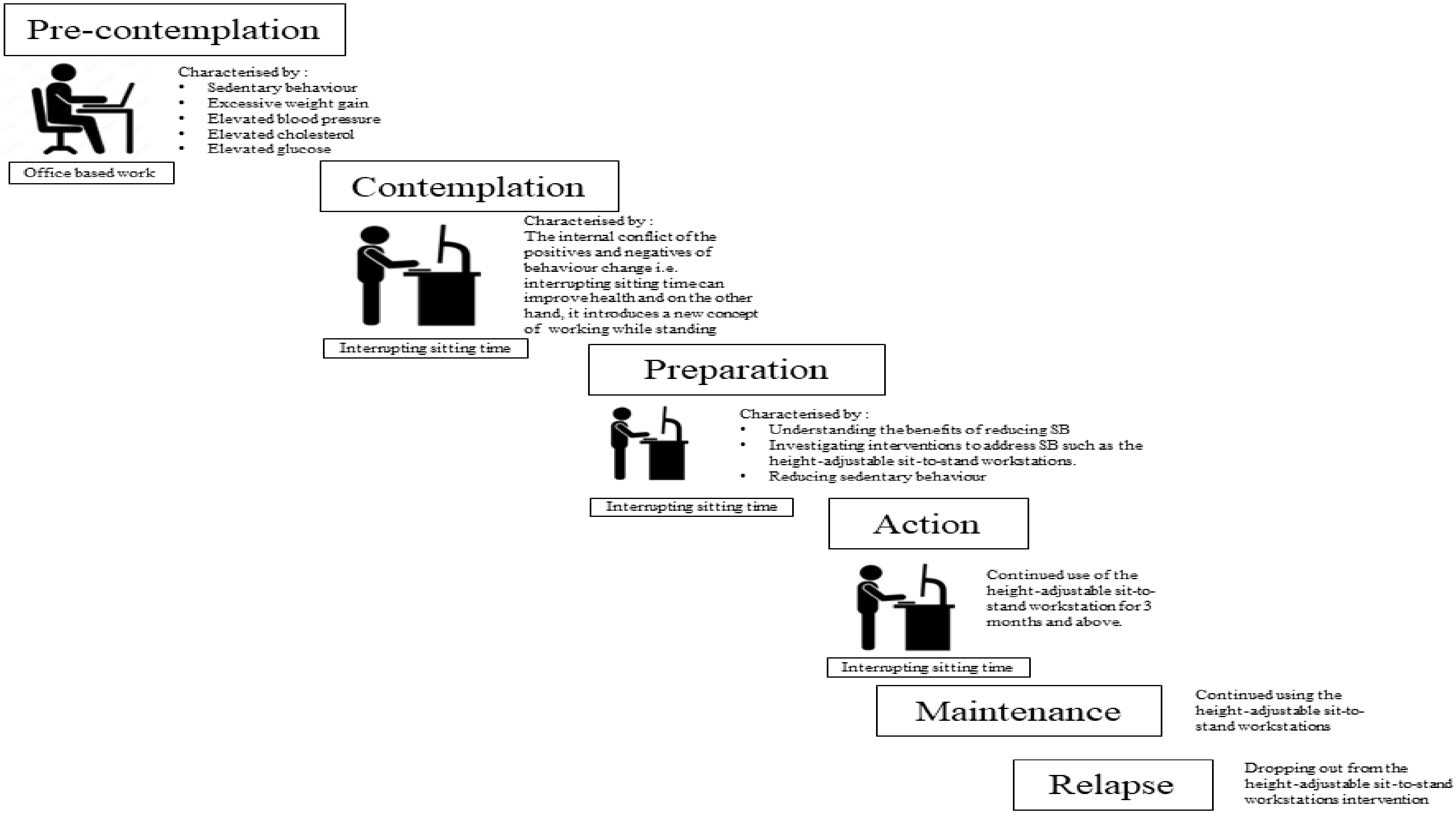

Figure 1.2 Conceptual framework

1.5 Sedentary behaviour.

1.5.1 Definition of sedentary behaviour.

Over the last decade, there has been a shift in the conceptualization of sedentary behaviour. The term "sedentary behaviour" originally denoted those who exhibited minimal physical activity, namely those who engaged in the least amount of physical activity while in a seated position (40). Moreover, Owen and colleagues (41) proposed that sedentary behaviour occurs in the three primary domains of occupation: desk-based work and sitting for meals, transportation such as driving a car or commuting using public transportation, and leisure time such as watching television or television viewing. Sedentary Behaviour Research Network in 2012 advocated the standardisation of employing sedentary terminology so that it may be relevant across all ages and disciplines (42).

The Sedentary Behaviour Research Network conducted a terminology consensus statement to provide multidisciplinary researchers, practitioners, and industries with standardized definitions (5). The term "sedentary behaviour" has lately been defined as participating in awake sitting, recumbent or lying-down activities that require energy expenditures of 1.5 metabolic equivalents or less (5). A second reason for standardizing the definition of sedentary behaviour was to clarify the distinction between sedentary behaviour, sitting time, and physical inactivity, as these terms are frequently used interchangeably (43). Physical inactivity can be characterized as a state in which an individual fails to engage in a sufficient amount of physical exercise to meet the established criteria for physical activity. This evolution in understanding and terminology equips us with a sharper tool to tackle the complexities of sedentary behaviour. By acknowledging its pervasiveness across various domains and clearly defining it concerning other concepts, we can design more targeted interventions and pave the way for healthier lifestyles for all.

1.5.2 Prevalence of sedentary behaviour.

In recent years, there has been a substantial accumulation of epidemiological data indicating a correlation between sedentary activity and cardiometabolic diseases such as hypertension, obesity, type 2 diabetes, and increased lipid profiles, as well as global all-cause and CVD mortality (44). In a national survey, the United States (US) adults reported an average of 9.5 hours/day being sedentary, observed that men and older adults tended to report a higher amount of sedentary time compared to their female counterparts (45). Hadgraft and colleagues (46) conducted a randomized controlled trial on government office workers in Australia and found that sedentary behaviour increased by an average of 79%. They further illustrated that more sitting time was accumulated during days (69%) compared with a non-workday (56%).

The sedentary behaviour of South Africans has been widely recorded, and there is a clear correlation between this behaviour and the increasing rates of obesity and obesity-related disorders (32). A recent qualitative study by Gradidge and colleagues (2022) showed that South Africa, similar to developed countries, has office-based workers who are exposed to prolonged sitting (≥ 8 hours) a day (31). This is particularly important in contemporary society as traditional manual labour becomes more reliant on machinery, and access to mobile applications increases susceptibility to sedentariness in South Africa (32). Based on the utilization of accelerometry measures to assess sedentary behaviours and physical activity, it has been observed that the typical duration of sedentary behaviour among adults can vary between 7.7 and 11.5 hours per day, corresponding to approximately 60 percent of the total waking hours for adults (47). Moreover, 47 percent of the overall sedentary time, or roughly 4.3 hours per day, was accrued during occupational and recreational time (45). In South Africa, 13.3 percent of the population exhibited high sedentary behaviour (8 hours/day), and the average daily sedentary time was 173 minutes (48).

A study found that a significant majority of individuals, specifically 82%, allocated their sedentary leisure time engaging in sedentary pursuits such as watching television, films, or utilizing computers (18). Workers in modern office settings spend

66% of their workdays sitting, with 25% spent in sessions lasting 55 minutes or more (49). Increased sedentary behaviour at work and transportation may lead to increased sedentary behaviour in South Africa.

1.5.3 Measures of sedentary behaviour

There are various ways to measure sedentary behaviour, which can be classified as subjective or objective. Subjective measures require participants to assess their sedentary behaviour through recall behaviours over a particular period, including questionnaires, diaries and logs (50). Subjective measures are commonly used despite their low validity due to social desirability and recall biases ((51) and their low practicability in large sample populations (52). The International Physical Activity Questionnaire (IPAQ) has been extensively used on a global scale for the subjective assessment of physical activity and sedentary behaviour (53). Another popular self-report instrument is the Workforce sitting questionnaire (WSQ), which aims to evaluate the frequency of work attendance over a seven-day period (54). Because sitting at a desk all day can add up to a significant amount of wasted time, researchers have developed several surveys to assess levels of sedentary behaviour in different domains. Wijndaele and coworkers created a self-administered questionnaire called the sedentary behaviour questionnaire (SIT-Q-7d) to quantify sedentary time over the previous week (55). Comparing the SIT-Q-7d to an external standard showed acceptable validity (rs = 0.26).

Accelerometers are now the gold standard objective measure of PA and SB due to their accuracy, convenience, relative affordability, and usability (50). Devices like these, which can be worn on the wrist or hip, are able to measure the acceleration due to motion precisely. Consequently, they enable individuals to compute both the overall duration of physical activity and periods of immobility (56). The ActiGraph GT3X is a monitor that can be worn on the hip and has proven to be a reliable tool for researchers studying sedentary behaviour and physical activity (57). The utilization of Axivity AX3 monitors has been observed in large-scale surveillance investigations, such as the UK Biobank studies (58). White and coworkers found that the wrist-worn monitor demonstrated a high level of concordance with the gold standard doubly labelled water method in predicting total energy expenditure. Specifically, they observed a correlation coefficient (rho) of 0.90 ($p < 0.05$) in the dominant wrist and a correlation coefficient of 0.91 ($p < 0.05$) in the non-dominant wrist (59).

1.5.4 Sitting time.

Prolonged sitting time is a marker for sedentary behaviour and has been shown to increase the risk of all-cause mortality (60). In addition to this, prolonged sitting has also been shown to have a significant impact on daily levels of energy expenditure. There is mounting evidence that prolonged sitting across diverse settings, including workplaces, vehicles, recreational pursuits, and even in front of the television, has demonstrated adverse on metabolic health, cardiovascular risk factors, and musculoskeletal discomfort (61). Several studies have consistently shown that the majority of the working population spends more than half of their wake time in sedentary postures (14). Furthermore, sitting for long periods at work is a significant contributor to overall sedentary behaviour among the working population, especially when compared to sitting during leisure time (11). Interventions targeting reduced sitting time during work hours, such as incorporating scheduled breaks for sit-to-stand transitions while working, have been proposed as effective strategies to address this concerning trend (62).

As a marker for sedentary behaviour, prolonged sitting has emerged as a significant risk factor associated with increased all-cause mortality (53). This sedentary lifestyle impacts daily energy expenditure and has been extensively linked to various adverse health outcomes. Prolonged sitting across diverse settings, encompassing workplaces, transportation, recreational activities, and sedentary leisure pursuits, has adversely affected metabolic health, cardiovascular risk factors, and musculoskeletal discomfort (54).

Studies consistently reveal that a substantial portion of the working population spends a significant portion of their waking hours in sedentary postures (14). Specifically, occupational settings contribute significantly to overall sedentary behaviour, surpassing leisure-related sitting durations (11). Interventions targeting reduced sitting time during work hours, such as incorporating scheduled breaks for sit-to-stand exercises, have been proposed as practical strategies to address this trend (55).

1.5.5 Health consequences of sedentary behaviour.

There is a growing body of research indicating that prolonged periods of sedentary behaviour are associated with an increased risk of various chronic health problems and overall mortality, irrespective of the overall volume of physical activity performed (44). The detrimental impacts on one's health linked to a sedentary lifestyle, namely extended periods of sitting, have been well shown in observational studies and retrospective analyses of data from large cohorts (52). A meta-analysis to investigate the sedentary behaviour and physical activity levels across a sample of more than one million participants ages 18 to 90 (39, 52). The study revealed that individuals who engaged in prolonged periods of sedentary behaviour had a heightened susceptibility to elevated risks of overall mortality and metabolic risk factors, regardless of their physical activity levels. However, this association was not observed in those who engaged in more than 75 minutes of vigorous-intensity physical activity daily. Similarly, a recent systematic review focused on addressing sedentary behaviour and cardiovascular disease risk factors during the Covid-19 lockdown in adults found that prolonged sitting is strongly associated with postprandial hyperglycaemia, triglyceridemia, hyperlipidaemia and hypertension, thus resulting in an increased risk of coronary artery diseases (63).

In contrast to the well-established relationship between physical activity and overall well-being, investigations into the connections between sedentary behaviour and chronic ailments are comparatively recent and have made substantial progress in the last ten years (32). Straker highlighted a growing solid body of evidence linking the cumulative amount of SB, extended periods of sitting in different domains, and the frequency of interruptions in sitting to adverse health consequences and disease outcomes (53). These findings agreed with a systematic review of longitudinal studies on the prevalence of obesity and other non-communicable risk factors (30). Sitting for more than 11 hours per day raises the risk of morbidity by 40 percent and a 15 percent increase in the risk of mortality from various causes (54). Similarly, a study reported that more than 7 hrs/day of uninterrupted sitting is linked with a fifty percent mortality risk across all causes (55). They further suggested the importance of independently targeting physical activity and sedentary behaviour, particularly in the workplace.

Previous research has established a correlation between extended periods of sitting and negative health consequences. However, it has been proposed that including intervals of standing or engaging in low-intensity physical activity during sedentary periods may have advantageous effects on metabolic well-being (56). While evidence supports the effectiveness of interrupting sitting time and promoting activity in reducing overall sitting time (53), the precise number of interruptions necessary to ensure optimal health remains uncertain. Future interventions aimed at addressing sedentary behaviour should prioritize the establishment of awareness regarding the consequences associated with engaging in sedentary behaviour. Furthermore, educating and providing individuals with environmentally tailored strategies to promote overall physical activity is essential to addressing sedentary behaviour (64).

1.6 Epidemiology of obesity in South Africa.

The prevalence of obesity is on the rise in LMICs, such as South Africa, due to the rising technology advancements in the workplace and the adoption of sedentary lifestyles (40, 41, 44). The prevalence of obesity in Africa is influenced by factors such as physical inactivity, sedentary behaviours, and the consumption of high-calorie processed foods (44). A comprehensive meta-analysis investigating the prevalence of adult obesity and its related risk factors in Africa from 1992 to 2012 demonstrates a concerning escalation in the occurrence of obesity among African adults, necessitating urgent attention (65). This may have been due to the cultural perception of weight in Africa, where increased weight gain was once viewed as a sign of prosperity (66). This is consistent with SADHS (2019) reporting an increase in obesity in South African men (from 29 to 31 percent) and women (from 56 to 68 percent) between 1998 and 2016, with a 7 percent increase in mean BMI in women and a 1 percent increase in men (67).

Consequently, the 2022 global nutrition report has conveyed that the prevalence of obesity among the population of South Africa exceeds the African regional average of 9.2% for males and 20.8% for females (68). The persistent increase of obesity in African regions suggests that public health interventions implemented to address and mitigate the impact of the burden of obesity have been ineffective. The research mentioned above indicates that engaging in sedentary behaviour is a distinct risk factor for obesity and selected co-morbidities in populations outside the United States (30, 69). The relationship between obesity and its associated comorbidities and sedentary behaviour remains poorly understood in South Africa. In South Africa, a study examining the factors linked to overweight and obesity in four out of the five BRICS nations found a positive correlation between obesity and specific morbidities (70). Evidence indicates that short and long-height adjustable sit-to-stand workstation interventions effectively improve office workers' weight (29, 46). Similarly, a systematic review examining the effectiveness of interventions targeting sedentary behaviour in the workplace concerning cardiometabolic risk factors indicates the potential for reducing cardiometabolic risk markers such as body mass index (30). Consequently, future research should focus on bridging this knowledge gap by investigating strategies to combat sedentary behaviours associated with obesity and related diseases in the adult population.

1.6.1 Classification of obesity.

The African population has shown a higher incidence of obesity and associated co-morbidities, which have been found to be associated with a BMI equal to or more than 30.0 $kg{\cdot}m^2$ (71, 72). Furthermore, there is a correlation between obesity and a heightened susceptibility to obesity, type 2 diabetes, and cardiovascular disease (73). Waist circumference is a simple and inexpensive yet effective proxy indicator of central obesity and visceral fat and a much stronger determinant of CVD risks compared with BMI (74). Nevertheless, it is important to note that employing a combination of these approaches may yield a more accurate assessment of abdominal obesity compared to relying just on a single method. The definition of obesity encompassed individuals with a body mass index equal to or greater than 30 kg.m-2, regardless of gender (4). Central obesity was defined by a waist circumference greater than 102 cm for males and 88 cm for females (75). The classification of obesity is depicted in Table 1.1.

Table 1.1 Classification of Body Mass Index and Waist Circumference.

Classification of disease risk based on Body Mass Index (BMI) and Waist Circumference (WC)			
	BMI (kg · m $^{-2}$)	Men, ≤102 cm Women, ≤88 cm	Men, >102 cm Women, >88 cm
Underweight	<18.5	-	-
Normal	18.5-24.9	-	-
Overweight	25.0-29.9	Increased	High
Obesity, Class			
I	30.0-34.9	High	Very high
II	35.0-39.9	Very high	Very high
III	≥40.0	Extremely high	Extremely high

[a] The presence of dashes (-) indicates that no additional risk was assigned at these specific BMI values, which were very high. Elevated waist circumference (WC) can also indicate heightened health risks, even among persons with normal body weight (76).

1.7 Epidemiology of hypertension.

Hypertension emerged as the primary contributor to NCDs, resulting in roughly 8.5 million fatalities globally in 2015 (77). A systematic found that the global prevalence of hypertension was estimated to be over 1.4 billion individuals. (84). Furthermore, projections indicate that this figure is expected to surpass 1.6 billion by 2025. Similarly, the global incidence of hypertension among the adult demographic was recorded at 31.1% in the year 2010 (78). It was also noted that LMICs had a higher prevalence rate of 31.5% compared to HICs, where the prevalence rate was 28.5%. The elevated incidence of hypertension has been seen throughout the African continent (79).

Preliminary evidence indicates that South Africa has the highest incidence of hypertension and heart disease among urban black populations compared to rural black populations (80). In recent years, there has been a transition from rural to urban areas in pursuit of better employment opportunities in corporate settings (81). This results in increased occupational sitting and adoption of sedentary behaviours and puts them at a greater risk of developing hypokinetic diseases, particularly hypertension. Hypertension is a prevalent medical condition in South Africa and constitutes the primary motive for seeking primary healthcare services (80). Notably, around 51% of the South African population remains uninformed of their blood pressure status (85). In addition, existing evidence suggests that most hypertensive individuals are unaware of their condition. As a result, these individuals are not on treatment, and those in treatment are not well controlled (82, 83).

Sedentary behaviour and sodium consumption are risk factors for hypertension, although the effects of sedentary behaviour on hypertension have not been established (79). Similarly, sedentary behaviours are associated with increased CVDs such as obesity, hypertension and diabetes. A study revealed that hypertension is more prevalent in populations that sit for more extended periods of time than others (84).

1.7.1 Classification of blood pressure

Hypertension is widely recognized as a significant modifiable risk factor contributing to the onset of CVDs and a leading cause of early mortality on a global scale (78). The mortality rates in those aged 40 to 89 are twice as high for increases in systolic and diastolic blood pressure of 20 mmHg and ten mmHg, respectively, compared to the mortality rates attributed to cardiovascular and vascular illnesses (85). In a clinical setting, accurate blood pressure measurement ensures proper diagnosis and treatment (4). Hypertension is characterized by a systolic blood pressure reading of 140 mmHg and a diastolic blood pressure reading of 90 mmHg (4). A study showed that twenty percent of South Africans have high blood pressure (86). Table 1.2 illustrates the classification of blood pressure.

Table 1.2 Measures of blood pressure

Blood pressure stage	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)
Hypotension	<80	<60
Normal	< 120	< 80

Elevated	120-129	80-89
Stage 1 hypertension	130-139	90-99
Stage 2 hypertension	≥140	≥100

BP should be categorised into the highest level of BP, whether systolic or diastolic

1.8 Epidemiology of Diabetes in South Africa

Diabetes has emerged as a significant global health challenge, exhibiting a substantial surge of nearly 100% within the past thirty years (87). Moreover, diabetes is recognized as the primary contributor to mortality on a global scale, resulting in an estimated annual death toll of around 1.5 million individuals (87). In 2020, the global prevalence of diabetes was about 463 million adults, and it is projected to rise to 700 million by 2045 (88). Evidence substantiates the escalating prevalence of diabetes in Africa, with particular emphasis on its pronounced impact in northern Africa, influenced mainly by Egypt and southern Africa and predominantly driven by South Africa. The estimations presented in this study were observed to be greater than the global average, while estimates for other regions were predominantly lower (99). The prevalence of diabetes in South Africa exhibits gender disparities, with rates ranging from around 11 to 13% among women and 7.9 to 8% among males. Additionally, a considerable proportion of both women (64%) and men (66%) are classified as pre-diabetic. The likelihood of developing diabetes increases with age, higher BMI, and residence in rural informal or urban formal areas. A matter of significance pertains to the escalated incidence of diabetes throughout the previous two decades (92).

Several studies have demonstrated a persistent correlation between sedentary behaviour and the development of diabetes (14, 47, 89). These studies confirm that sedentary behaviour is strongly associated with an elevated risk of developing CVD, Type 2 diabetes, and mortality from all causes among adult populations. Similarly, a systematic review investigating the relationship between sedentary time and breaks in sedentary time and cardiometabolic biomarkers in the adult cohort found favourable association between overall sedentary behaviour and poor insulin sensitivity (90). In addition, this study found a 39% reduction in random glucose in a trial to reduce sitting time compared to increasing low-intensity PA. The current evidence has demonstrated a clear association between sedentary behaviour and diabetes in developed countries. However, limited knowledge is known in developing countries, particularly South Africa.

1.8.1 Measurement of Diabetes

The diagnosis of diabetes is commonly conducted through the examination of an individual's blood glucose levels following an overnight fast or a glucose tolerance test performed under identical circumstances. The measurement of glycated haemoglobin (HbA1c) is the prevailing benchmark examination to monitor the extended-term regulation of blood glucose levels in individuals diagnosed with diabetes. The World Health Organization (WHO) has recently proposed the use of HbA1c as an additional diagnostic test for identifying diabetes in individuals who have not yet been diagnosed. Table 1.3 illustrates the diagnostic criteria for Diabetes Mellitus (1).

Table 1.3 Diagnostic Criteria for Diabetes Mellitus

Normal	Prediabetes	Diabetes Mellitus
Fasting plasma glucose 5.55 mmol·L^{-1} (<100 mg·dL^{-1})	IFG =Fasting plasma glucose 5.55 mmol·L^{-1} (100 mg·dL^{-1} – 6.94 mmol·L^{-1} (125 mg·dL^{-1})	Symptomatic with casual glucose 11.10 mmol·L^{-1} (≥200 mg·dL^{-1})
	IGT=2-h plasma glucose 7.77 mmol·L^{-1} (140 mg·dL^{-1}) – 11.04 mmol·L^{-1} (199 mg·dL^{-1}) during an OGTT	Fasting plasma glucose 6.99 mmol·L^{-1} (≥126 mg·dL^{-1}) 2-h plasma glucose 11.10 mmol·L^{-1} (≥200 mg·dL^{-1}) during an OGTT

Impaired fasting glucose (IFG) (at least eight h); Impaired glucose tolerance (IGT); Oral glucose tolerance (OGTT) test. Glycated haemoglobin (HbA1c).

1.9 Hyperlipidaemia in South Africa

Hyperlipidemia has been identified as the primary underlying cause of CVD, resulting in more than 2 million morbidities and 30 million instances of disability globally (91). Moreover, a higher total cholesterol level is also associated with an elevated CVD risk. The under-reporting of dyslipidemia in Sub-Saharan Africa has been noted. However, South Africa has recorded a prevalence rate of 93.5% (92). Despite these alarming rates, the causes of increased lipid profile have not been established; however, a recent study has shown that dyslipidemia may develop secondary to cardiometabolic risk factors, particularly obesity, hypertension, and diabetes (93). Similarly, the South Africa Dislipidemia Guideline Consensus Statement 2018 urged public health interventions to address dislipidemia to focus on lifestyle management, such as reducing sedentary behaviour, increasing physical activity, and making dietary modifications (93).

Evidence shows a significant association between sedentary behaviour and cardiometabolic risk factors, including high lipid profiles (94). A study found that the incorporation of light physical activity during inactive periods has been demonstrated to have an association with blood lipids, specifically high-density lipoprotein (HDL) and triglycerides (TG) (95). Furthermore, this study found that physically active adults had lower TC, TG, and LDL levels and higher HDL than their sedentary counterparts. Conversely, a recent study has revealed that a higher level of leisure-time PA is positively related to improving HDL in a cohort with CVD risk (96). Hadgraft and colleagues conducted a systematic review and meta-analysis, wherein they observed that reducing sedentary behaviour and promoting physical activity have minor improvements in several cardiometabolic biomarkers, particularly HDL, in office workers (46). Therefore, it is essential to adequately quantify the correlation between lipid profiles and sedentary behaviours in office workers to implement effective workplace interventions to mitigate the increased incidence of CVDs.

1.9.1 Classification of hyperlipidemia

Cardiovascular diseases are the second leading cause of mortality in South Africa (91). Klug and colleagues encouraged the South African Heart Association and the Lipid and Atherosclerosis Society of Southern Africa guidelines by recommending cholesterol screening for all adults aged 20 since they risk developing CVDs (97). High cholesterol was defined as total cholesterol ≥ 5.2 mmol/L or the use of medication to manage hypercholesterolemia (93). Table 1.4 shows the diagnostic criteria for Lipid Profiles.

Table 1.4 Diagnostic Diagnostic Criteria for Lipid Profiles

Lipids	Optimal (mmol/L)	Intermediate (mmol/L)	High (mmol/L)
Total Cholesterol	< 5.2	5.3 – 6.1	≥ 6.2
High-density lipoprotein (HDL)	< 1.55	1.03 – 1.54	≥ 1.03
Low-density lipoprotein (LDL)	< 3.36	3.36 – 4.10	≥ 4.11
Triglycerides	< 1.69	1.69 – 2.24	≥ 2.25

High-density lipoprotein (HDL), Low-density lipoprotein (LDL), Millimole per liter (mmol/L) and less than (<) and greater than or equal to (≥). Contributors of sedentary behaviour and obesity-related cardiometabolic diseases in the workplace

1.9.2 Physical inactivity

Physical inactivity is a significant health hazard associated with obesity and cardiometabolic diseases (98). It is worth noting that South Africa has the third position among African nations regarding physical inactivity, as shown in a study. It has been observed that a significant proportion of the South African population, specifically 57.4%, fails to adhere to recommended physical activity standards, with males being more active than females (99, 100). South Africa remains afflicted by the prevalence of NCDs. As a result, the prevalence of NCDs has a detrimental effect on economic development due to the resulting decrease in productivity and income (49). Non-communicable diseases continue to pose a significant burden in the South African population, with 51% of all deaths in 2016 being attributed to NCDs (82).

However, physical activity has been identified as critical in reducing multiple diseases' risk, progression, and severity (101). Based on existing knowledge, the World Health Organisation recommends that individuals participate in a minimum of 150 minutes of physical activity each week, of at least moderate intensity, in order to maintain good health and mitigate the potential hazards associated with NCDs and mental health conditions (102). However, these guidelines do not distinguish between the three main domains of PA. In addition, existing evidence has been predominantly limited to benefits derived from leisure PA rather than occupational PA (103), where most working adults spend most of their time (104).

1.9.3 Dietary patterns in the workplace

The increased prevalence of cardiometabolic risk factors in South Africa can be attributed to the significant dietary changes, resulting in the lower socio-economic strata consuming high-energy-dense foods and refined foods such as carbohydrates and saturated fats (105). The correlation between the intake of sugar-sweetened drinks (SSBs) and highly processed protein and the prevalence of obesity, diabetes, cardiovascular disease, specific forms of cancer, and elevated death rates has been seen in developing nations (106). As a result, several countries like South Africa reported the effectiveness of SSB's taxation policies in mitigating the increased consumption of SSBs by increasing the prices (107, 108). Similar trends have been observed, with a decrease in the number of taxed beverages purchased since the implementation of the tax policy as compared to no changes in the non-taxable beverages (109). Interestingly, households with lower socioeconomic status bought more taxable beverages than households with higher socioeconomic status. Therefore, implementing the Health Promotion Levy might positively impact South Africans' overall health and reduce obesity.

Consequently, workplace cafeterias and informal street food vendors precipitate the consumption of cheap processed foods and beverages (110), posing increased health risks to workers, such as obesity and related cardiometabolic diseases. Montero-Salazar and colleagues found that a higher intake of ultra-processed food exhibited a robust correlation with the development of coronary atherosclerosis, resulting in increased cardiovascular disease risks in a cohort of Aragon Workers (111). Similarly, a study of migrant Chinese workers found that high fiber consumption improved cholesterol (112). It is worth noting that occupational stress can adversely affect dietary patterns, leading to the consumption of energy-dense food and drink products consumed in high volumes during increased stress (113). Since employees spend most of their wake time in a working setting, the workplace is ideal for public health intervention and lifestyle modification. Furthermore, a study suggested that the consumption of unhealthy food in the workplace can be addressed by providing subsidised healthy meals during lunch breaks and educating the team on healthy diets (114).

1.9.4 Sleep behaviour

Sleep is an essential function affecting mental health, physical health, social well-being, and productivity in workers and has been widely recognized as a contributing factor to high mortality and morbidity rates (115). The United States American National Sleep Foundation recommends that adults sleep 7-8 hours per night to attain optimal health benefits (116). A correlation exists between short sleep duration and adverse health outcomes, such as obesity, hypertension, diabetes, and cardiovascular illnesses (117), while long sleep duration is associated with poor socioeconomic status (118). Similarly, insufficient sleep duration increases the risks of depression and anxiety in young adults (119). Literature has shown that racial and ethnic groups play a vital role in predicting sleep duration, suggesting that socioeconomic status has a link with sleep quality and duration. In South Africa, for instance, African adults had longer sleep durations (≥ 10 hours per night) than adults of other ethnic groups (the minority, which includes Indians, Asians, and Caucasians) who have shorter sleep durations (<6 hours per night) (120, 121). Therefore, understanding differences in sleep needs and beliefs is paramount, taking into consideration the South African population (122).

Although previous research has mainly focussed on shift workers, employees are prone to increased sedentary behaviour, irregular work schedules, and work-related stress, contributing to increased sleep disturbances and impacting overall sleep quality, resulting in increased risks of adverse health outcomes (24). Similarly, workers use alarm clocks during working days to break up their sleep time and enable them to balance between sleep and day durations. Takaesu and colleagues reported that weekday sleep duration for office workers may be insufficient, resulting in sleep over compensation over the weekend or during off days (123). In addition, modern society must address occupational stress among individuals employed in office settings to mitigate the potential hazards associated with physical and mental illnesses while improving productivity. Therefore, it is crucial to understand the impact of extended sleep duration during non-working and non-working days aimed at compensating for working days' sleep deficits, which affects overall physical and mental health (119, 123).

1.9.5 Smoking and alcohol consumption

Cigarette smoking is associated with lower body weight, while cessation is related to initial weight gain (124). However, the increase in weight is temporary and usually plateaus or returns to pre-smoking levels of body weight. Our previous work (125) demonstrates that smoking has a negative correlation with alterations in fat-free muscle mass, indicating that smoking is associated with decreased muscle mass. Exhibits a pronounced effect as an appetite suppressant and enhances energy expenditure, which explains the lower body weight of active smokers versus non-smokers (126). Snuff, an unregulated and freely available tobacco product, is commonly used in African populations and has been shown to protect against abnormal levels of high-density lipoprotein cholesterol (HDL), mainly through the action of nicotine (127). In contemporary times, e-cigarettes are emerging and growing in popularity, commonly known as ‘vaping’. This is another unregulated substance that is thought to assist with smoking cessation. However, nicotine delivery into the body is high and rapid, and little is known about its influence on body composition (128). Research has indicated that a higher frequency of alcohol use is associated with lower body mass, while drinking heavily on one occasion increases visceral adiposity (129). Existing evidence shows that there is a negative association between increased alcohol consumption and changes in waist circumference, which aligns with the results of a longitudinal study conducted in Denmark (125, 130). This is likely due to the thermogenic effect of alcohol.

1.9.6 Epidemiology of non-communicable diseases in South Africa

Recent research findings highlight that black South African women exhibit the highest prevalence of obesity in the Sub-Saharan African region. This trend signals an expected rise in obesity rates and related health issues, particularly within developing countries like South Africa, concerning NCDs (131). The obesity epidemic is strongly linked to NCDs, with global rates increasing significantly from 40% to 70% over the last decade (132, 133). Epidemiological studies consistently connect obesity to increased mortality rates due to cardiometabolic diseases worldwide (134, 135). Notably, in South Africa, cardiometabolic diseases and cardiovascular diseases (CVD) now surpass communicable diseases as the leading causes of death related to NCDs (136).

Global efforts aimed at altering lifestyle behaviours include strategies like reducing sodium intake in processed foods, curbing physical inactivity, moderating alcohol consumption, addressing sedentary behaviour, implementing sugar-sweetened beverage taxes, and enacting anti-tobacco regulations to combat cardiometabolic diseases (133, 136). Despite these initiatives, sedentary behaviour continues to rise, contributing significantly to the global burden of NCDs.

Recent meta-analyses underscore a connection between prolonged sedentary behaviour and increased mortality rates among less active middle-aged and older adults (137). Engaging in 30 to 40 minutes of moderate to vigorous physical activity (MVPA) daily could alleviate these heightened mortality rates. Evidence suggests that reducing sedentary behaviour and increasing physical activity, particularly MVPA may mitigate the risk of adverse cardiometabolic health outcomes (30). Recent research revealed that office workers spending an average of 6 to 8 hours per day in sedentary activities face increased susceptibility to hypertension and vascular dysfunction, heightening the risk of cardiovascular disease, irrespective of their physical activity levels (138). It increases the risk of cardiovascular disease in adults irrespective of their physical activity levels. A meta-analysis also highlights the association between interrupting sedentary behaviour with light-intensity movement and improved adiposity and cardiometabolic risk factors in adults (139).

1.10 Interventions to address sedentary behaviour associated with cardiometabolic diseases in the workplace.

Morris and colleagues were the first to identify the link between sedentary behaviour and cardiometabolic risk factors (140). According to their research, double-deck bus drivers in London had a higher incidence of coronary heart disease when compared to bus conductors and postmen. The main difference was the level of physical exertion required to perform one's occupational duties, with conductors and postmen being more active than drivers, who typically stayed seated throughout the workday. Since then, the research has changed its emphasis from promoting physical activity to devising strategies to reduce extended periods of sitting (141). This suggests a need to independently target both workplace physical activity and sedentary behaviour to increase physical activity, which might not be as impactful in addressing the increased morbidity and mortality rates compared to decreasing sedentary behaviour (41, 142). Similarly, Gray found that workplace interventions such as height-adjustable sit-stand desks may decrease sedentary behaviour during working hours, permitting frequent changes in posture and improving workers' well-being (10). These interventions represent a proactive approach to curbing sedentary behaviour within workplace settings.

Several studies have explored multi-component workplace interventions decreasing sedentary behaviour and promoting physical activity among individuals working in office settings. It remains unclear whether different workplace interventions, including computer prompts, treadmill workstations, cycling workstations, electronically adjustable sit-to-stand desks, adjustable sit-to-stand workstations and stepping workstations, effectively reduce sedentary behaviour and promote physical activity (143). Therefore, further studies should evaluate and compare the effectiveness of these strategies in addressing occupational sitting by promoting light activities. A recent systematic review evaluated 34 short and long-term workplace interventions to reduce occupational sitting time at work (141), reporting that the height-adjustable sit-to-stand workstation in working environments effectively reduces prolonged sitting. Alkhajah and colleagues noted significant decreases in occupational and total daily sitting time with a three-month intervention (144). Furthermore, they discovered that HDL cholesterol levels increased post-intervention.

Similarly, a study reported significant reductions in workplace sedentary behaviour, non-work day, and total sedentary behaviour following four weeks of intervention (14). Previous research has suggested that interrupting sitting time with 2-minute bouts of activity every 20 to 30 minutes might provide significant health benefits in employed adults (145, 146). Increased breaks are positively associated with lower BMI, blood pressure, insulin, and lipid metabolism (46).

Public health focus has shifted to improving and prolonged sedentary time and related cardiometabolic outcomes of office-based workers (143). Nevertheless, there is a lack of comprehensive research on the impact of workplace sedentary behaviour interventions on cardiometabolic risk factors. A recent systematic review has revealed promising results on the efficacy of workplace intervention targeting sedentary behaviour in lowering cardiometabolic risk indicators (30). They further suggested that long-term sedentary behaviour intervention might yield clinically significant improvements in cardiometabolic outcomes. Similarly, previous studies have shown that height-adjustable sit-to-stand workstations are feasible for enhancing work performance and reducing sedentary behaviour and effective for improving cardiometabolic health (15, 29, 147, 148). These studies suggest that implementing workplace interventions as a behaviour change modality effectively interrupts prolonged sedentary behaviours and improves cardiometabolic health.

Studies have shown that short- and long-term use of height-adjustable sit-stand workstations among sedentary office workers effectively reduces sitting time and improves cardiometabolic risk factors (14). Additionally, comprehensive analyses of aggregated data indicate that interventions targeting office workers to decrease sedentary behaviour and enhance physical activity are moderately associated with improved cardiovascular health indicators, including body weight, waist circumference, blood pressure, insulin levels, and high-density lipoprotein cholesterol (46). However, there is a noticeable lack of interventions to reduce sedentary behaviour and promote physical activity in African workplace settings, unlike those observed in high-income countries (14, 29). This observation underscores the need for tailored interventions to enhance cardiometabolic outcomes in Africa (31).

A recent systematic review has revealed that height-adjustable sit-to-stand desk interventions effectively reduce some cardiometabolic outcomes in office workers (46). Dunning and colleagues investigated the impact of interrupting extended periods of sitting with low-intensity activities on the cardiometabolic health outcomes of adults with sedentary occupations using text messages (149). This study contributes to the growing body of research highlighting the need to reduce sedentary behaviour and incorporate physical activity into the daily routine, even among individuals with sedentary occupations. To our knowledge, height-adjustable sit-stand workstations have not been adopted in Africa, particularly for office-based workers.

1.11 Literature search strategy

1.11.1 Information sources

A computer-assisted database search was conducted in the primary bibliographic databases of the health sciences, including Scopus, PubMed, PsycINFO, and EMBASE, to identify potential research articles. Supplementary sources were uncovered through alternative databases, including Google Scholar, self-service Internet searches, and secondary resources like the South African National and international ETD platforms.

1.11.2 Literature search

The following keywords were used: “workplace, work setting, intervention, randomised controlled trial, sedentary behaviour, physical activity, height adjustable sit-to-stand workstation, sit-to-stand desks, Interrupting sitting, treadmill desk office-based workers, obesity, cardiometabolic outcomes, cardiovascular risk factors, hypertension, type 2 diabetes mellitus.” The literature search included randomised controlled trials (RCT), cluster randomised controlled trials (cluster RCT), quasi-RCT, prospective intervention design, and single-case interventions addressing sedentary behaviour and cardiometabolic risk factors in office-based workers. Table 1.5 illustrates the database search strategy.

Table 1.5 Database search strategy

1. Workplace	2. Obesity
3. Work setting	4. Treadmill desk
5. Intervention	6. Cardiometabolic outcomes
7. Randomized controlled trial (RCT)	8. Cardiovascular risk factors
9. Sedentary behaviour	10. Hypertension
11. Physical activity	12. Type 2 diabetes mellitus
13. Height-adjustable sit-to-stand	14. Interrupting sitting time
15. Sit-to-stand desks	

1.11.3 Data extraction

The researcher independently conducted the literature search. The research from the databases was pooled, and duplicates were removed. Also, the reference lists of appropriate full-text articles were hand-searched for further relevant articles.
Only papers published in English until 2023 were considered, and the search period lasted from January 2020 to December 2023. The results were exported to the Endnote reference manager 20 (Clarivate, London, United Kingdom).

1.11.4 Data synthesis

All articles were screened using titles or abstracts and full-text articles to determine study eligibility. The extracted information was presented as author(s), year of publication, study design, setting, place and country, population (gender, age), sample size, intervention (type of intervention), length of the intervention, and the findings.

The literature review has centred on the work conducted by office workers in the past decade, emphasizing the association between sedentary behaviour and cardiometabolic risk factors has been presented in Table 1.6.

Table 1.6 Workplace interventions to address sedentary behaviour and cardiometabolic risk markers.

Author and year	**Country**	**Type of Study**	**Sample size**	**Setting**	**Purpose**	**Intervention**	**Length of the intervention**	**Findings**
Alkhajah and colleagues. (2012), (144)	Australia	Quasi-experimental design	32	University, office workers	To examine the efficacy of an intervention to reduce office workers' sitting time.	Sit-stand desks	12 weeks	↓ Total workplace sedentary time by − 137 min ↑ High-density lipoprotein cholesterol
Chau and colleagues, (2014) (14)	Australia	Randomized control trial	42	Corporate, office workers	To examine the effects of sit-stand workstations on office workers' sitting time at and after work.	Sit-stand workstations	Four weeks	↓ Sitting time by 73 min/workday ↑ standing time by 65 min/workday

Bouchard and colleagues,(2016) (149)	Canada	Pre-post design	22	Government , office workers	To test the feasibility of sharing treadmill workstations among office workers.	Treadmill desk	3 Months	↓ Diastolic blood pressure ↓ Systolic blood pressure ↓ Significant sitting time by [1267 min (95% Confidence Interval (CI) 1189–1286)].
Danquah and colleagues ,(2017) (146)	Denmar k	Cluster RCT	317	Municipality and corporate office workers	To test the effectiveness of multicomponen t work-based intervention in reducing sitting time and improving the	Computer Prompts and sit-stand desks	3 Months	↓ Significant sitting [48min (95% CI: -62 to -34)]. ↑ Standing time by [43 min (95% CI: 30 to 56] ↑ Fat-free mass of 0.79 kg.

					weight of office workers.			
Healy and colleagues, (2017) (49)	Australia	Cluster RCT	231	Government, office workers	To evaluate short and long-term impacts on cardio-metabolic health indicators of the Stand Up Victoria intervention.	Sit-stand workstations	3 and 12 Months	↓ Significant sitting time by −99.1 min/8-hour workday. ↓ Prolonged sitting time at work by −72.6 min/8-hours workday ↓ Clustered cardiometabolic risk ↓ HOMA2-%S ↓ Plasma glucose

MacEwen and colleagues, (2017) (150)	Canada	RCT	25	Corporate, office workers	To reduce workplace sitting time among healthy office workers	Sit-stand desks	12 weeks	↓ Sitting time (344 ± 107 to 186 ± 101 min/day) ↓ Total sitting time (645 ± 140 to 528 ± 91 min/day) ↑ standing time (154 ± 108 to 301 ± 101 min/day, *P* < .05)
Dunning and colleagues, (2018) (151)	South Africa	Repeated RCT	12	University and corporate office workers	To determine whether text messages affect objectively measured sedentary behaviour and	Text messages prompts	1Tenweeks	There is no intervention effect for the amount of work time spent sitting

					cardiometabolic health in office workers			
Zhu and colleagues, (2018)(152)	USA	An experimental non-randomised study	36	Corporate, office workers	To evaluate workplace sitting time, cardio-metabolic biomarkers, and work productivity.	Sit-stand desks and common area treadmills	4 and 18 months	↓ Sitting time by 52.6 ± 68.3 min/8-hours workday ↑ standing time by 17.7 ± 54.8 min/8-hours workday ↓ prolonged sitting by ≥ 30 min/8 hours workday ↓ Weight ↓ Insulin ↓ Total cholesterol

								↓ Low density lipoprotein cholesterol
Mantzari and colleagues,(2018) (15)	UK	RCT	430	Hospitals and corporate settings, office workers	The present study demonstrated the feasibility of delivering an intervention to participants to reduce their sitting time at work.	Sit-stand desks	12 weeks	↑ standing time ↓ the prolonged sitting time during work hours ↑ the prolonged sitting time during non-working days
Mainsbridge and colleagues, (2018) (84)	Australia	Experiment	228	Government institutions, Office workers	To evaluate the effects of an e-health solution on interrupting prolonged occupational sitting time.	e-health solution	12 months	↓ prolonged sitting ↓ Systolic blood pressure in 9 months (1.0 to 3.4 mmHg; $P < 0.01$)

								↓ Diastolic blood pressure in 12 months (4 to 5 mmHg all P < 0.01)
Arrogi and colleagues, (2019) (148)	Belgium	RCT	28	University, office workers	To evaluate the validity of an intelligent chair and corresponding Smartphone app, to measure sitting time and sitting interruptions against camera-derived observation and activPAL	Smart chair and smartphone app	2 hours	The chair and app provided reliable measures of desk-based sitting. Chair and app might be useful self-monitoring tool

Nooijen and colleagues, (2020) (153)	Sweden	Cluster randomised controlled trial	263	Corporate-setting, office workers	To assess the effectiveness of multi-component interventions to increase physical activity or reduce sedentary behaviour among office workers	Motivational counselling using cognitive behavioural therapy (CBT). Access to a commercial gym (6 months) Sit-stand desks	6 Months	No significant improvements were observed with either sedentary behaviour or physical activity in this cohort
Edwardson and colleagues (2022) (29)	UK	Cluster randomised controlled trial	756	Government institutes, office workers	To evaluate the effectiveness of a height-adjustable desk, interventions on physical	Sit-stand desks and the SMART Work and Life (SWAL).	3 and 12 months	Daily sitting time at 12 months was significantly lower in the (SWAL −22.2 min/day; SWAL

					behaviours and physical, biochemical, psychological, and work-related health and performance outcomes.			plus desk −63.7 min/day). The SWAL plus desk intervention was more effective than SWAL at changing sitting time (−41.7 min/day, −56.3 to −27.0 min/day, P<0.001).

*Randomised control trial (RCT); the SMART Work and Life (SWAL); cognitive behavioural therapy (CBT); Confidence Interval (CI)

1.12 The height adjustable sit-to-stand workstation was used in the current study.

This environmental component encompassed modifications, the height-adjustable sit-to-stand workstation (Jumbo sit-stand desk) depicted in Figure 1.3 was used in the present study. This environmental component encompassed modifications to the physical setting with the intention to facilitate interrupting sitting and promoting general well-being. The height-adjustable sit-stand workstation allowed office workers to vary their posture throughout the workday between sitting and standing for a period of the intervention (14). Participants also receive written and verbal instruction on the correct ergonomic posture for both sitting and standing upon installation of the workstations. written and verbal instruction on the correct ergonomic posture for both sitting and standing upon installation of the workstations.

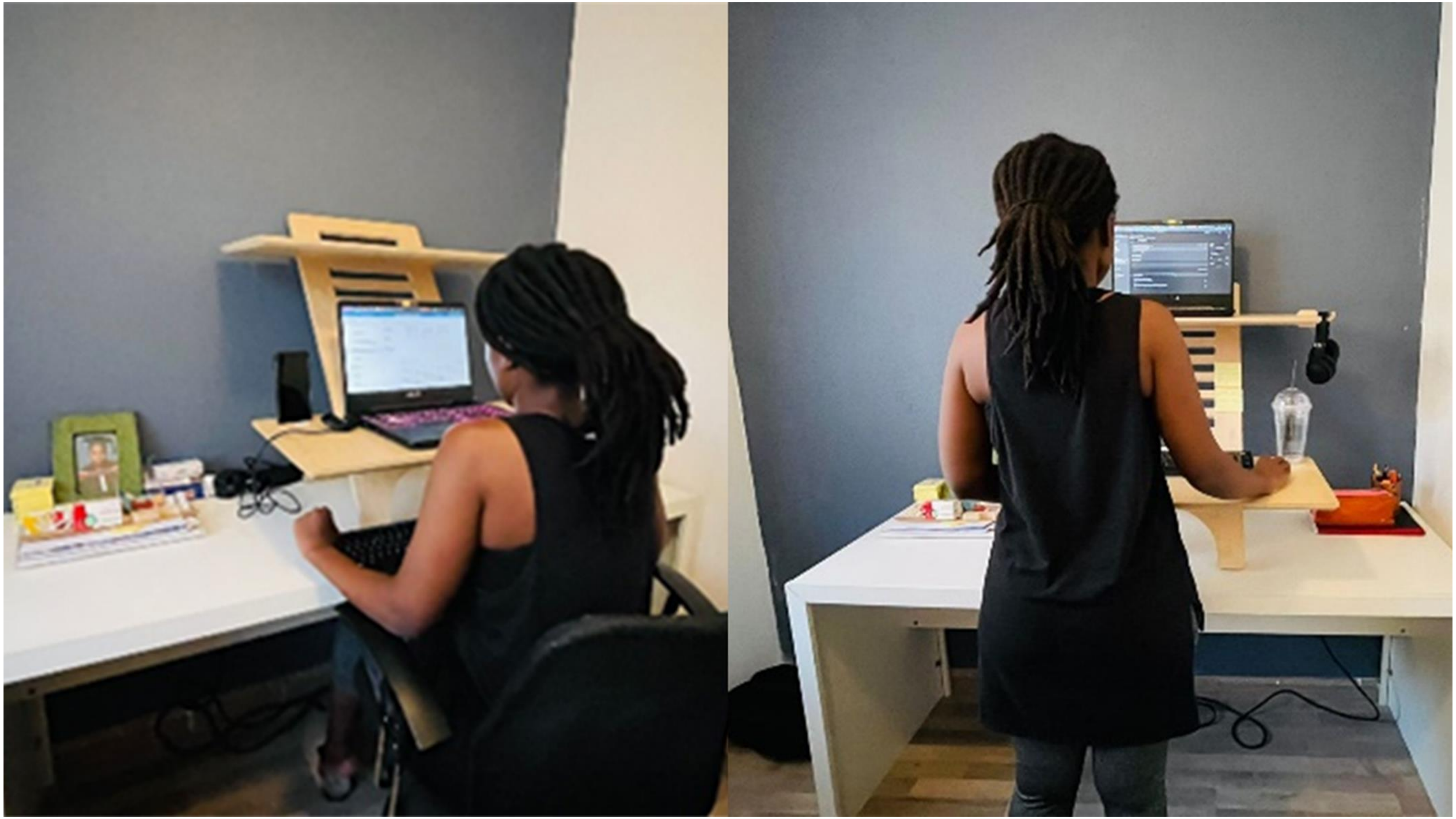

Figure 1.3 Height adjustable sit-to-stand workstation

1.13 Gaps in literature

Sedentary behaviour is increasing globally, posing a significant public health challenge (138). However, limited attention has been given to investigating sedentary behaviour within specific domains, as seen by the scarcity of large-scale studies in this area. Moreover, evidence suggests that engaging in sedentary behaviour is linked to a higher likelihood of developing chronic diseases while also displaying a negative correlation with physical activity levels (47, 141). However, in the last two decades, workplace interventions mainly focused on promoting physical activity, with a secondary focus on reducing sedentary behaviour (142). There has been a notable increase in workplace interventions to reduce sedentary behaviour and improve health outcomes in recent times (143). Sedentary behaviour guidelines have not been quantified, which makes it difficult to recommend the frequency or duration (154). Therefore, the public health message and guidelines have focused on recommending sitting less.

The existing corpus of literature indicates that breaking extended periods of sitting has positive implications for one's health. However, there is a debate over whether substituting sedentary time withstanding alone is sufficient to yield these advantages (89, 155). However, existing evidence on the efficacy of sit-stand workstations in mitigating sedentary behaviour by incorporating light activities in office workers has been conducted in developed countries (1, 14, 16). These studies have improvements in mitigating occupational sitting time and its potential impact on the development of chronic illnesses. Despite the burden of obesity and related cardiometabolic outcomes in African countries, South Africa is at the forefront (156, 157). To the best of our knowledge, there is a paucity of evidence regarding the effectiveness of height-adjustable sit-to-stand workstations in mitigating sedentary behaviour and cardiometabolic risk factors within low- to middle-income nations, including South Africa (31). This is of concern considering that, similarly to developed countries, a significant proportion of the workforce in South Africa spends most of their waking time in sedentary occupations (32).

Chapter 2 General Methodology

2.1 Study design for the thesis

This chapter will present the overview of methodological approaches employed in this study to address the research question. To better understand sedentary behaviour in a sample of South African office-based workers, the triangulation convergence mixed methods approach was used. Divergent strengths and weaknesses of quantitative and qualitative approaches were converged using this design (158).

2.2 Study setting

Preliminarily, the research was designed to be conducted exclusively at a credit bureau situated in Johannesburg, South Africa, as detailed in Chapter 3 (study 1). The offices were a combination of open plan (all employees) and individual plan (management) to designate intervention champions for each business unit. The student and supervisor collected data in person from 2019 to the beginning of 2020 before South African National Lockdown restrictions at the credit bureau company. However, due to the covid 19 pandemic, this company was closed their physical offices and adopted the working-from-home policy like many other companies in the country and globally. The student and supervisor requested approval from the Human Research Ethics office to continue with the study among office workers (administrators) at the University of the Witwatersrand and the credit bureau company, given that most private companies post the COVID-19 pandemic either fully embraced remote work or alternated between working from home and the office on specific days. As a result, this study was conducted at the University of the Witwatersrand, Johannesburg, South Africa and a credit bureau in Johannesburg, South Africa, respectively. This study followed a hybrid model in data collection for four years, 2019 and 2023. This company offers commercial, consumer, insurance and personal credit management solutions in eight African countries. After the National Lockdown restrictions were lifted from 2020 to 2023, the study adopted a home visits approach to follow participants from their homes across the Gauteng province.

Detailed study settings specific to the publications can be found in the individual results chapters to avoid repetition.

2.3 Study population and sampling.

The study population included University of the Witwatersrand and credit bureau employees as well as full-time office-based workers in all Parktown campuses and Braamfontein. The total number of desk-based employees at the University of the Witwatersrand and a credit bureau was 600 males and females. The participants comprised full-time staff members who were stationary in office settings a minimum of four days per week, held a permanent or fixed-term contract until the conclusion of the research, and were 18 years of age or older. The study population is described in the methodology sections of the individual chapters to avoid repetition.

2.3.1 Inclusion criteria

- Aged ≥18 years
- Office-based employees at the University of the Witwatersrand and a credit bureau company with access to telephone or mobile, email and internet.
- Participants who were able to walk or stand for at least 10 min.
- The ability to communicate in English.
- Male and female employees.

2.3.2 Exclusion criteria

- Pregnant women were not part of the study due to physiological changes occurring, particularly concerning changes in maternal body composition.
- All employees with non-ambulatory or have a diagnosed medical or chronic condition that affects their ability to stand for 10 min or more.

- Due to contraindications, participants were not physically be able to work in the standing position.

The sample size for the randomised control trial was determined based on findings from previous work by Gradidge and colleagues (2015), demonstrating a 7 percent rise in BMI among a group of black South African women over a decade, the sample size for the randomized controlled trial was established (127). To achieve a power of 90% and a significance level of 5%, the minimum sample size required was 23 participants per group, assuming a comparable rate of increase in the control groups and a decline of approximately 1 percent in the intervention groups over six months. The intended sample size per group was thirty-five in order to accommodate dropouts (49). Therefore, baseline assessments included BMI to include participants in the intervention groups; a decrease in body weight would be associated with a mitigation of cardiometabolic diseases.

2.4 Data collection

2.4.1 Qualitative studies

MP collected the qualitative data over three years (1st of December 2020 to March 2023). Semi-structured interviews were used to collect data for studies two and five. Data was collected in person for the observations and the interviews. MP used a semi-structured interview to guide her sessions for the interviews and to remain consistent in asking the interviewees the same questions. The interview guide allowed the interviewees to add topics that were not in the guide and also allowed them to share their experiences and recommendations. MP and PJG developed a set of questions for a semi-structured interview guide for the two qualitative studies. All the interviews were one-on-one, mainly in Microsoft Teams, and a few took place in the participant's office with the door closed. The interviews ranged from 10 to 60 minutes and were audio-recorded with permission. Qualitative study chapters used semi-structured interviews to collect data until saturation and followed data credibility and trustworthiness in qualitative research in this thesis. Further details specific to the publications can be found in the individual results chapters.

2.4.2 Quantitative studies

Chapter 3, the study's protocol, details the quantitative papers' data collection. Quantitative papers were presented as a cross-sectional study (baseline measures) and a randomised control trial (3 months longitudinal study) in chapters 5 and 6, respectively. Further details specific to the publications can be found in the individual results chapters.

2.5 Reflexivity

After documenting her research process, MP wrote down her thoughts and potential biases after every interaction with the participants. After reading each interview transcription for the first time, she also wrote a reflection, documenting what she thought had emerged and any notable features of her interview style or how the person behaved. MP, with the guidance of PJG, continued to interrogate how her presence was influencing the data being collected, particularly given that she knew all the participants in the study, and they had been her point of interaction. These notes and insights were used during data analysis to ensure the content analysis reflected the participants' experience.

2.6 Data Analysis

The qualitative studies Chapter 4 (Pilot study) and Chapter 7 (A qualitative study) used Atlas ti to analyse all transcribed and anonymised transcripts.

Quantitative studies Chapter 5 (a cross-sectional study) and Chapter 6 (12 weeks randomised control trial) used Statistica 13.1 (StatSoft, Tulsa, USA) to analyse the data. Chapter 3 details the analysis of the RCT.
Furthermore, statistical analysis is described in the methodology sections of the individual results chapters.

2.7 Ethical considerations

Ethical clearance was granted by the Human Research Ethics Committee, the University of Witwatersrand (Medical) (ethics certificate number: M190224) (see Appendix 1). Their respective Human resource department requested permission to collect data from the University of the Witwatersrand and credit bureau company workers (see Appendix 2). The University of the Witwatersrand (Medical) permitted this study in a cohort of university office-based workers towards the end of 2021. Potential participants were informed about the research once ethical permission had been granted. A consent form and information sheet were given to participants who volunteered to participate in the study (see Appendix 3 & 4). Participants in the qualitative studies were also asked to sign an audio recording consent form to allow the researchers to record using Microsoft Teams (version 11, Microsoft Way, United States) and Phillips (DVT4010 Voice Tracer, Vienna, Austria) (see Appendix 5). Confidentiality was maintained by ensuring that codes were used rather than the participants' identities. The participants were free to withdraw at any time without any repercussions. Only the researcher and her supervisor can access the raw data stored in a secure designated area.

Chapter 3 Study One: Standing up Against Office Sitting – A study protocol

Numbering has been amended from the published article and co-author agreement to allow the student to include the manuscript (study one) in the Thesis (See appendix 7).

3.1 Introduction

The global impact of preventable cardiometabolic and non-communicable diseases remains excessively high. However, low- to middle-income countries (LMICs) such as South Africa bear the greatest burden (159). Insufficient physical activity is still the main behavioural risk factor driving the increase in preventable diseases in South Africa. The demands on employee productivity are high, resulting in prolonged sedentary behaviour, particularly among clerical workers (160). Sedentary behaviour is defined as "awake" activities with limited energy expenditure while sitting/reclining/lying (5). Continuous time in sedentary activities is associated with an increased risk of cardiometabolic diseases and inflammatory markers independent of moderate-to-vigorous physical activity (46). Domains of sedentary behaviour include sedentary time during the occupation, transport and outside of working hours (160). Workers in office-bound occupations are at increased risk of being sedentary for most occupation-related domains (27). A study demonstrated that employed individuals use motorised transport for an average of 0.63 ± 0.68 hours/day (160). This study demonstrated that participants who sat for more than 80% of the workday had higher sitting times during motorised commuting compared with those who sat for < 58% of the workday (1.07 ± 0.98 versus 0.35 ± 0.27 hours/day, respectively, $p<0.0001$) (160). The adult working population in high-income countries has been found to accumulate sedentary behaviour at work, during recreational time at home, and during travel time (27). Compounded by sedentary activities outside of work, this accumulated sedentary behaviour may increase the risk for cardiovascular disease, type 2 diabetes and all-cause mortality beyond certain thresholds, even adjusting for physical activity (161). Even in LMICs, worker productivity is increasingly reliant on technology-based solutions with little need to move from the seated position for any tasks, which encourages sedentary behaviours (32). The implications include limited employee productivity, mental health concerns, financial strain, and increased absenteeism. It is, therefore, important to address sedentary behaviour in the workplace.

Previous research in high-income countries has demonstrated reductions in cardiovascular disease risk amongst obese office workers following an intervention study to address high sitting time by introducing sit-stand desks rather than introducing more physical activity (49). This study was a multi-component intervention, including organisational, environmental (sit-stand desks) and individual components, and observed significantly better improvements in glycaemic control and insulin resistance in the longer-term (12 months) compared with the short-term (3 months) (49). Other studies have shown that environmental interventions such as sit-stand desks, electric height adjustable workstations and active workstations (treadmill and cycle ergometer workstations) resulted in lower sitting time and improved work-related activities (143, 162). Different from guidelines, healthy messages help influence individuals into a feasible behaviour pattern (163). For instance, public and occupational health guidelines to lower sedentary time are made more acceptable through appealing messaging such as "move more and sit less during the day" (164). Evidence shows that workplace interventions to reduce sedentary behaviour can be facilitated by healthy messaging to improve behaviour modification (49, 165).

Commonly, the messages aim to persuade individuals that physical activity is appealing and achievable. These supplementary messages can take many forms and be disseminated through various messaging processes.

However, there is still a paucity of evidence on the effect of workplace health programmes reducing sedentary behaviour (46). Thus far, only one LMIC intervention study has demonstrated a drop in sedentary behaviour among office workers using tailored mobile text messages to interrupt sitting time (151). These messages reminded the study participants in the intervention group to stand up and take regular short walks and were sent every 20 minutes during working hours in the working week for the 10-week trial. This pilot study did not show a change in anthropometry and cardiometabolic disease markers. Indeed, there is an urgent need to address the cardiovascular disease risk profile of South African workers (166) and the place of employment may offer the opportunity to develop programmes to improve worker health and wellness (159, 167).

This study aims to assess the effectiveness of standing desks and healthy messaging (from authors) on the risk of cardiovascular disease and sedentary behaviour in a cohort of office-based workers and to explore their perception of the effectiveness of this intervention in lowering sedentariness in the workplace. This manuscript will provide information on the framework used to answer the intended study aims.

3.2 Methods

3.2.1 Study design, setting, participants and selection

The study will use a mixed-methods study design. Phase 1 of the study is a 12-month single-blind randomised controlled trial (RCT). Phase 2 will explore participant perceptions of the effectiveness of the intervention in the workplace.

In the first phase, the study participants will be assigned to an intervention group for 12 months or a control group. They will be randomised into one of two groups: (1) combined standing desk-healthy messages or (2) a control group.

The randomisation will be conducted by a qualified biostatistician independent from the core research team.

Potential for contamination will be minimised by adhering to various evidence-based approaches (168), (i) participants will be randomised by business unit, (ii) participants will be requested not to share details of the intervention, (iii) researchers will be asked not to share details of the intervention and (iv) a sufficient number of research assistants will be recruited, each allocated to a single business unit. The RCT will be single-blinded so that the first and second authors (assessors) are blinded to the group allocation of the study participants.

All adult office workers (18-65 years) from a specific credit and information management company based in Johannesburg (South Africa), working at least 50% of the workday at their desk, five days/week, will be invited to participate by the human resources analyst concerned with employee health and wellness through email and telephonic invitations. Inclusion criteria include access to telephone/mobile, email/internet desk or workstation within the setting, ability to communicate in English, and ability to walk or stand for at least 10 minutes. Exclusion criteria include participants who are pregnant, non-ambulatory, and have a diagnosed medical or chronic condition that affects their ability to stand for ten minutes or more. Further, participants with other contraindications working in the standing position and not working at the study site will also be excluded. The company's total staff is 300, and all employees are housed in the same building. The building has three floors, with each respective floor sub-divided securely by business units, thus restricting the movement of staff in the setting.

The sample size for Phase 1 of the study will be determined based on available resources and the assumption that at least 60 participants per group, adjusted for dropout, will provide > 90% power to detect a significant difference ($p<0.05$) in sedentary behaviour between the groups (169).

For Phase 2, semi-structured focus group discussions, conducted by Author 1, Author 2 and research assistants, are planned with six groups of participants selected by participation in the intervention; each group will have six to eight participants. The principle of saturation in its purest sense (as in Grounded Theory methodology) will not be applied (170). However, the authors will apply the principle of saturation in that it is anticipated that the sample size will be adequate to provide sufficiently rich data and that a greater sample size would not yield a significant amount of new information (171).

3.2.2 Intervention

The combined standing desk-healthy messages group (group 1) will be provided with an adjustable sit-stand desk. The desk is designed for placement on top of the participants' existing workstation, providing the opportunity to transition from sitting to standing without interrupting productivity. Research assistants, qualified in exercise science, biokinetics, or physiotherapy, will set up the 'participants' workstations in the most appropriate ergonomic position. The correct configuration will, therefore, be individualised for each study participant. The research assistants will visit participants weekly to examine the setup, monitor usage, and encourage standing-based work. The participants will be asked to break up extended sitting time by accumulating bouts of standing activity, short intermittent bouts of ≥ 10 minutes initially and then progressing to longer bouts of ≥ 30 minutes over the course of the intervention (172). Regular communication on the benefits of interrupting sitting will be emailed to the participants. The combined standing desk-healthy messages group will also receive health-promoting messages from the authors focused on lifestyle behaviour modification through email, short message services, and telephone communication once a week during working hours. The participants in the control group (2) will continue using their "traditional" workstations as usual.

3.2.3 Measures

3.2.3.1 Phase 1

Data for the RCT will be collected at baseline, 3-months (short-term), six months (medium-term), and 12 months post-intervention (long-term) using validated measures and standardised assessments (See appendix 6).

3.2.3.1.1 Body composition

Total body weight (kg) will be measured to the nearest 0.1 kg using a calibrated digital weighing scale (Omron HN-288, Hoofddorp, Netherlands), and standing height will be measured to the nearest millimetre using a calibrated portable stadiometer (Seca 213, Seca Corp, Hamburg, Germany). The participants will wear minimal clothing and not wear shoes during the measurements. Trained student researchers and Author 2 will conduct the measurements. Body mass index ($kg.m^{-2}$) will be calculated and classified as underweight (<18.5), normal-weight (≥18.5 and < 25 $kg.m^{-2}$), overweight (≥25 and < 30 $kg.m^{-2}$) or obese (≥30 $kg.m^{-2}$) (173). Using a flexible but inelastic measuring tape, the waist circumference will be measured horizontally at the narrowest part of the trunk while the participants are standing with arms at the side, relaxed abdomen, and feet together (173). Similarly, the hip circumference measurement will be taken at the widest circumference of the proximal thigh, just under the fold of the gluteus, with feet separated slightly (173). Central obesity is a waist circumference ≥ 80 cm for females or ≥ 94 cm for males (174).

3.2.3.1.2 Blood pressure

The Omron M7 (Intelli IT (HEM-7322T-E), Omron, Kyoto, Japan) will be used to record brachial blood pressure (BP). The device has been validated for determining systolic and diastolic BP (175). Three measurements will be taken after the participant has rested (≥5 minutes) in the seated position with an appropriately sized cuff around the right upper arm, supported at the level of the heart (173). The average of the last two BP measurements will be recorded.

Hypertension will be diagnosed as resting systolic BP ≥ 140 mm Hg and/or a resting diastolic BP ≥ 90 mm Hg or taking antihypertensive medication. The undiagnosed participants will be advised to seek medical attention.

3.2.3.1.3 Blood samples

A finger prick test will be used to collect non-fasting capillary blood samples. Random glucose will be measured with HemoCue Glucose 201RT System (HemoCue, Ängleholm, Sweden), and random total cholesterol, high-density lipoprotein cholesterol, and serum triglycerides will be measured with the CardioChek Plus analyser (Polymer Technology Systems, Inc.). The CardioCheck Plus analyser demonstrates good clinical agreement with a reference analyser, ranging from 95% to 98% (176). Glycated haemoglobin (HbA1c) will be tested using the HemoCue HbA1c 501 system (HemoCue, Ängleholm, Sweden) (177). The HemoCue HbA1c 501 system correlates with laboratory HbA1c tests (rho=0.995, p<0.001). The HemoCue Glucose 201RT system compares with laboratory methods (coefficient of variances <6.5%) (178, 179). A diagnosis of diabetes is considered as having random plasma glucose of 11.1 $mmol/L^{-1}$, HbA1c reading ≥6.5%, or evidence of diabetic medication. Abnormal total cholesterol will be considered as ≥4.5 $mmol/L^{-1}$ or medication for the management of hypercholesterolemia. Participants undiagnosed for elevated total cholesterol or blood glucose will be advised to seek medical attention.

3.2.3.1.4 Accelerometery

The small, lightweight, and wrist-worn Axivity accelerometer, version AX3 (Axivity Ltd., Newcastle-upon-Tyne, United Kingdom), will be used to collect free-living sleep, sedentary behaviour, light physical activity, and moderate-to-vigorous physical activity data. The AX3 has been used in large-scale surveillance studies such as the United Kingdom (UK) Biobank study (180). This wrist-worn monitor shows excellent agreement with the gold standard doubly labelled water for estimating total energy expenditure (rho=0.90, $p<0.05$ in the dominant wrist, rho=0.91, $p<0.05$ in the non-dominant wrist) (59). The AX3 will be initialised to capture triaxial acceleration data at 100 Hz with a dynamic range of +/-8g. Participants will be asked to wear the device on their wrist for all hours of the day, over 7 days, except for water-related activities that are not considered "water-resistant" (e.g., bathing and swimming). Data processing and analysis methods are described elsewhere (180). Data captured by the AX3 will be processed and analysed using an open-source software project developed and used by The UK Biobank Study (https://github.com/activityMonitoring/biobankAccelerometerAnalysis), and the Open Movement AX3 open-source software (OmGui Version 1.0.0.39, Open Movement, Newcastle University, UK).

3.2.3.1.5 Tools

Participants will be asked to complete an appropriate questionnaire to identify self-reported sociodemographic characteristics (age, salary band, position in the company, highest level of education and smoking status), sedentary behaviour, diet and beverage consumption, mental health and absenteeism.

Self-reported sedentary behaviour in the previous seven days will be quantified using the SIT-Q-7d questionnaire. The questionnaire includes self-reported sedentary time in 5 main domains and sleep and nap time. The domains have sedentary time during meals, travel, work, recreation, and other non-specified sedentary time. The SIT-Q-7d is acceptable for use in epidemiological studies, with criterion validity for domain-specific variables ranging from 0.22 to 0.76.

Habitual consumption of vegetables, fruits, whole grains, dairy, and meats and poultry over the past year will be determined using a self-reported dietary intake questionnaire (38). A beverage intake questionnaire (BEVQ-15) quantifies the amount of unsweetened beverages, sugar-sweetened beverages, and alcohol consumed by the participants, with validity between 24-hour food item recall and BEVQ-15 ranging from rho values 0.69 to 0.76, $p<0.001$ (181). The estimated kilocalories per drink will be calculated.

The Centre for Epidemiological Studies Depression Scale (CES-D-10) is a validated questionnaire (rho=0.81 to 0.94, $p<0.05$ (182)) that estimates the mental health status of employees, specifically eliciting symptoms of depression in the past seven days (183). The tool includes items on the effect of depression, somatic symptoms, and positive effects. A 4-point lickert scale is used for each item, ranging from "rarely or none of the time" to "all of the time".

Cardiorespiratory fitness The Queens College 3-minute step test will be used to estimate cardiorespiratory fitness (VO_{2max}). The agreement between this step test and measured VO_{2max} is high (rho=0.75, $p<0.001$). The step test uses a 41.3 cm step with a stepping rate of 24 steps/minute for men and 22 steps/minute for women for a period of 3 minutes (173). Within 5 seconds of the participant sitting, a research assistant will measure the post-exercise heart rate (HR). Maximal oxygen uptake (VO_{2max}) will be calculated for men (VO_{2max}= 111.33 – (0.42 x HR) and women (VO_{2max}= 65.81 – (0.1847 x HR).

3.2.3.2 Phase 2

All study participants involved in the combined standing desk-healthy messages intervention and who did not drop out of the RCT will be invited to participate in semi-structured focus groups at intervention follow-up to evaluate their perceptions of the intervention - receiving the healthy messages and/or using the standing-desks, and their perceptions of the effectiveness of using these interventions in the workplace. Six focus groups are planned, with six to eight participants per group. Given that this intervention group will be approximately 60 participants and that not all participants will make themselves available for a focus group, the intention to invite all participants to participate in a focus group accounts for at least a 60% positive response rate. Although the challenges associated with recruitment for focus groups can sometimes make it difficult to stratify focus groups, an attempt to stratify them based on participants' responses to Phase 1 will be made. During the focus group discussions, participants will be asked to comment on facilitators addressing extended sitting time whilst working and to discuss the most suitable methods to improve health in their place of work. The focus groups will be approximately 45-60 minutes in duration.

For this project's qualitative component, the following "big-tent" criteria of qualitative quality will be considered and applied: a worthy topic, rich rigour, sincerity, credibility, resonance, significant contribution, ethical, and meaningful coherence (171). At this stage of the study, it can be argued that it addresses a worthy topic (the prevention of NCDs in an LMIC) and could significantly contribute to the literature on this topic in South Africa. Furthermore, in relation to rich rigour, appropriate sampling, data collection and data analysis methods have been planned, and ethical considerations are discussed below. Sincerity, credibility, resonance, and meaningful coherence are criteria that are not really applicable at this stage of the research, given that this is a protocol paper and does not yet report on study findings. These criteria are particularly relevant for the interpretation of findings and how these findings are presented.

3.2.4 Data analysis

All data for the RCT will be analysed using Stata SE (ver.14, Stata Corp, USA). Descriptive statistics will be used to compare outcome data at baseline and change from baseline to follow-up between the intervention and control groups. Paired t-tests will be utilised for within-group comparisons over time, or their non-parametric equivalents, depending on data distribution. Comparison between groups will be made using analysis of variance or the non-parametric equivalent. Multivariable linear regression models will be used to determine if any of the baseline study variables modulate these effects on the outcome variables (change in BMI, lipids, blood pressure, HbA1c, VO_2 max and sedentary behaviour). Significance will be accepted at an alpha level of $p \leq 0.05$. The Consolidated criteria for Reporting Qualitative Research (COREq) checklist will be used for reporting on the methodology, research team, study design and analysis and study findings (184).

3.2.5 Ethical considerations

The study has received ethical approval from the Human Research Ethics Committee, University of the Witwatersrand (ethics certificate number M190224), and relevant authorities in the company and is registered as a trial with the Pan African Clinical Trial Registry (PACTR201911656014962). The South African Medical Research Council has reviewed and awarded a Self-Initiated Research Grant for the study. Participants will be asked to sign informed consent before participating in the RCT. Study participants will be required to give written consent prior to participation in the focus group discussions. In addition, written consent will be sought from study participants for the recording of the focus group discussions. Study participants will be reminded that participation in the study is voluntary and that freedom to withdraw will not result in negative consequences.

3.3 Discussion

Workers in office occupations are at increased risk of cardiovascular disease due to prolonged sedentary behaviour (185). One approach to health promotion for the employed population is to address sitting at the workplace. A review of interventions shows that cardiovascular health can be improved through interventions that reduce sedentary behaviour (145, 162). The findings of this study will add to a limited body of evidence on addressing sedentary behaviour in the workplace and will be used to inform health-promoting policies and to develop models for disease prevention in the sub-Saharan African workforce. Further, by addressing cardiovascular disease risk in the workplace, overall work-related job performance, productivity, and absenteeism may be improved.

3.4 Limitations

The study will be conducted in one setting, and although the study population is diverse in terms of gender, age and socio-economic status, the external validity may be limited.

Chapter 4 Study Two: "If money was no object": a qualitative study of South African university office workers perceptions of using height-adjustable sit-stand desks

Numbering has been amended from the published article, and appendices have also been renamed. (See Appendix 9) for the declaration and co-author agreement to allow the student to include the manuscript (study two) in the Thesis.

4.1 Introduction

Sedentary behaviour is a growing global public health concern; elevated levels of sitting time are associated with all-cause mortality and cardiovascular disease risk factors, especially among people who are not sufficiently active (141). There is no consensus on the term, defining sedentary behaviour as participating in awake sitting, recumbent or lying-down activities that result in energy expenditures of ≤ 1.5 metabolic equivalents (5). Obesity and related comorbidities have strong links with sedentary behaviour, particularly in low-income and middle-income countries (LMICs) such as South Africa, where populations continue to shift into obesogenic urban environments and adopt sedentary lifestyles (186). Recent data demonstrate that the prevalence of South Africans sitting ≥ 8 hours per day is approximately 4.6% of the population, mostly among urban dwellers (33). Office workers in South Africa are vulnerable to high sitting time during vocational hours (32), that are similar to high-income countries (HICs) where employees are sedentary for at least two-thirds of the workday (160, 187).

A recent systematic review has reported that interventions for reducing sitting in office workers have found small improvements in cardiovascular health, particularly with systolic blood pressure (−1.1 mm Hg), body composition (body weight: -0.6 kg; body fat percentage: −0.3%; waist circumference: −0.7 cm, and lipid profile (high-density lipoprotein cholesterol: 0.04 mM) and insulin (−1.4 pM) using pooled data (46).

Interventions in free-living environments, including workplaces, that target sedentary behaviour alone or in conjunction with physical activity are effective for improving cardiometabolic risk biomarker profiles (46). However, many sedentary behaviour interventions have been carried out in high-income countries and Eurocentric populations.

The evidence indicates that sit-stand workstations are effective in workplace strategies in HIC settings (46) while little is known about the feasibility of this strategy in LMIC contexts, possibly due to the comparatively longer duration of interventions conducted in HICs (46). For example, an Australian workplace intervention that included environmental modifications (sit-stand desks), messaging to encourage behaviour adjustment, and health coaching observed significant reductions in occupation-related sitting time and cardiometabolic biomarkers at 3- and 12-months (154, 188).

South African workers (n=1954) recruited from 18 companies were estimated to have a high prevalence of non-communicable diseases due to the growing obesity epidemic in the country (189). Hene and colleagues also reported that 66.8% of workers in their study were overweight, while 77.4% were insufficiently physically active (190). What is lacking, however, is a comprehension of how tools to disrupt occupation-related sitting are feasible for workers in South Africa. To our knowledge, strategies using sit-stand desks have not been applied in the South African workplace, particularly in a university context. Therefore, we sought to target this knowledge gap by exploring the perceptions of South African university office workers regarding the feasibility of sit-stand desks to reduce sedentary behaviour at work.

4.2 Methods

4.2.1 Setting, design, participants and recruitment

This study was conducted at the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa. This study aimed to assess the feasibility of an environmental modification to promote less sitting using sit-stand desks.

On the 20th of November 2020, all office staff from one building in the Faculty of Health Sciences were invited by email to participate in this study. Of n = 32 potential participants working in the office during the COVID-19 lockdown, n=11 responded to the invitation and completed an online pre-screening survey. The email invitation included a participant information sheet and consent form. Ethical approval was obtained from the University of the Witwatersrand (ethics certificate number M190224). All participants provided written consent.

The inclusion criteria included adults (age above 18 years) with access to a desk or workstation within the office, the ability to communicate in English, the ability to walk or stand for at least 10 minutes, and individuals who worked in the office for at least three days a week.

The sit-stand workstation consisted of a height-adjustable workstation (JUMBO DeskStand™, DeskStand, South Africa) that allowed office workers to vary their posture throughout the workday between sitting and standing for two weeks. The participant's workstation was set up by one of the investigators (MP) in the most proper ergonomic position in relation to the participant's height and needs. Upon installation, participants were educated on the benefits of standing-based work and interrupting sitting time. Participants were provided with training on how to set up the workstation optimally for their individual job roles. The participants were asked to break up sitting time by accumulating bouts of standing activities of at least 10 minutes initially and then progressing to longer bouts of 30 minutes or more as the study progressed (54).

4.2.2 Data collection procedure

Participants were first asked to self-report their estimated time spent sitting (hours) in various domains of sitting, during work, commuting and at home using an adapted version of the Workforce Sitting Questionnaire (WSQ) (191). The WSQ is reliable and has been validated for use in office-based workers (191).

The semi-structured interviews took 10-30 min and were all recorded and conducted in English. Interviews were conducted by one researcher (MP) using a semi-structured interview guide (Appendix 9) via Microsoft Teams or in person between the 1st of December 2020 and the 19th of February 2021, as preferred by the participants during the COVID-19 pandemic (192). Recorded audio files from the discussions were transcribed verbatim. All transcripts were checked against the recordings to verify accuracy and credibility, and grammatical editing was adopted where necessary.

4.2.3 Data credibility and trustworthiness

The authors have followed and adopted the Eight "Big-Tent" criteria for excellent qualitative research in conducting this pilot study, and these include a worthy topic, rich rigour, sincerity, credibility, resonance, significant contribution, ethical and meaningful coherence (171). Exploring the perceptions of using height-adjustable sit-stand desks was considered a worthy topic to inform environmental sedentary behaviour interventions in the South context. Regarding rich rigour, the authors followed an established methodology for data collection, processing, and analysis. The authors observed sincerity, which confirmed that the interviews were transcribed correctly and processed using recognised software (Atlast.ti) and that there was agreement on the themes and sub-themes to ensure optimal trustworthiness. Credibility was confirmed by presenting the themes that could be anchored to participant quotations. The exemplar quotations are presented systematically to visually resonate with the participants' perceptions of using the height-adjustable sit-stand desks. Concerning significant contribution, the authors describe the conceptual relevance of interrupting sitting time during office hours and the importance of informing further studies of environmental tools to reduce sedentary behaviour in the South African workplace. Ethical approval was obtained as described. Finally, meaningful coherence for this study was realised by ensuring robust methodology consistent with previous research on sedentary behaviour interventions in the workplace (192).

4.2.4 Data analysis

Recordings were transcribed and de-identified by a professional service. All transcripts were read at least twice by each researcher and then coded line by line using a thematic analysis approach with Atlas.ti 9 (9.1.5.0, Atlas.ti Scientific Software Development GmbH). Two researchers (MP and PJG) read and coded the imported textual data to identify emergent themes. Discrepancies were discussed, and revisions were made until full consensus was achieved.

4.3 Results

4.3.1 Descriptive statistics

The participants (n=11) were mostly female (91%) and had a mean age 40.5 ± 12.6 years (Table 4.1). The majority had tertiary qualifications (91%), and 81.8% (n=9) were paid a monthly salary ≥ R20000. The estimated self-reported sitting time ranged from 8.5 to 13.5 hours per day, with occupation-related sitting time contributing 76.2% to overall sitting time.

Table 4.1 Demographic characteristics (n=11).

Characteristic	N (%) or mean ± SD or median (interquartile range)
Age (years)	40.5 ± 12.6
Female	10 (90.9)
Highest level of education	
Completed high school	1 (9.1)
Diploma/ College certificate	1 (9.1)
University degree	3 (27.3)
Postgraduate degree	6 (54.4)
Monthly income	
Prefer not to answer	1 (9)
<R15000	1 (9)
R15000-R19999	0 (0)
R20000-R24999	4 (36)
R25000-R29999	2 (18)
≥R30000	3 (27)
Estimated sedentary behaviour	

Occupational sitting (hours/day)	8 (6-8)
Sitting during commuting (hours/day)	1 (0.5-1.5)
Sitting at home (hours/day)	2 (2-5)
Total sitting time (hours/day)	10.5 (8.5-13.5)

4.3.2 Table 4.2 presents the themes with illustrative quotes.

Table 4.2 Themes with illustrative quotes

Theme	Illustrative quotes
Overall impressions	It was a positive one, eh, user friendly, you know, you'd like, it was user, it was easy to use, easy to move around with the thing. To move the screens it was not hard work, if I am making any sense at all. (Participant 1B89, female, aged 47 years)
Enablers	I always, always try and keep like, if it's an invisible upright posture, I was trying to keep an upright posture even when I'm driving but my like, you know, rear mirror you know, being tilted a little bit higher up to force you to sit upwards and when I'm sitting at my table that kind of stuff ah, I'll be typing something and that kind of stuff in them in that moment represent we read over to make sure everything is fine, then I'll sit up straight like that. (Participant A11, male, aged 24 years)
Obstacles/barriers	I would have liked it if it had a one grade lower for the position of the laptop. So, I know that its design….it is not designed for laptop it is designed for a monitor but even at my eyelevel I did find myself having to adjust quite a bit, because it was slightly higher than what I was used to. Not slightly higher, it was slightly higher than what eyelevel would be, but like I am talking centimetres here, because usually, you know, I am quite used to looking down at something. So that gradient from normally looking down and then all of a sudden eyelevel

	and slightly higher than eyelevel, it is a bit of an adjustment. So, if it had, you know those that where you can adjust the levels of the platform, if it had it one lower that would have been perfect, from that bottom rung. (Participant 1D53, female, aged 37 years)
Use of sit-stand workstation sitting vs. standing	I used little shelves and like you said that novel hook was very nice, my phone I never needed to look for it because it's always under paper. (Participant 1B12, female aged 66 years) I stand a lot during the day so when you get a chance to sit down you take it (Participant 87C, female, aged 24 years)
Readiness to continue using height adjustable sit-stand desks.	Look if money was no object, so if money was no object, and these things were for free, yes, I would. And I'd probably I mean, if you could walk me into a factory or a store that had all these ergonomic stuff in and I could just take off the shelf and test it and put it on my desk, then probably what I would, I would set up my home station as well. My home station right now as a dining room table. And a dining room chair where the cushioning has gone, so I would set up, if money was no object, I'd set up home to be able to be flexible and move around. And then work, office work, I would definitely also set up permanently to be able to move around and do stuff. (Participant 1E64, female, aged 52 years)

Overall impressions

Impact on ability to work.

All participants commented on the workstations bearing on their ability to carry out vocational tasks. The participants reported that reading and responding to electronic mail was more comfortable in the standing position, while typing activities were best suited to the seated position.

Ease of use

Participants expressed enjoyment about using the workstation during the study period, specifically commenting on the improved work productivity and the innovative approach to office work. In support, some participants felt that the workstation helped reduce work-related boredom and fatigue.

Enablers.

Motivators.

While most of the participants had never experienced using an adjustable sit-stand desk, many described seeing comparable products advertised. They expressed a desire to experiment with using it in their own personal work environment.

Participants agreed that sitting for extended periods during work hours resulted in musculoskeletal pain in the lumbar and cervical regions of the spine. They were therefore interested in using the workstation and a treatment modality to manage the occupation-related pain.

Discussions revolved around the potential application of the unit in the workplace and their individual administrative duties. While most participants felt that they were encouraged to take part, some participants agreed it was an opportunity to reorganise their immediate work environment.

Perceived physical health benefits.

Multiple participants recognised the health benefits prompted by the adjustable sit-stand desk. The interruption of sitting time was perceived as an evidence-based approach to supporting suitable seated and standing ergonomics despite lengthy periods of sedentariness.

Perceived work benefits

For many of the participants, the adjustable sit-stand desk aided in improving their concentration during work responsibilities. Throughout the interviews, the participants discussed the improved job performance with using the desk, and few described the concept of skeletal muscle memory to adopt the routine of alternating sitting and standing behaviour.

Perceived behaviour modification

Participants talked about the influence of the adjustable sit-stand desks on their sitting and standing behaviour. They had various ideas about how the desks made them aware of the duration of sitting time and believed that they felt more active when they were in the upright standing position.

Some participants observed modifications in body position, such as a less slouched posture whilst in the standing position. Interestingly, the participants believed this position helped to reduce the chronic neck pain associated with long-duration typing activity in a forward head posture whilst in the sitting position at work.

Obstacles/barriers

Despite having the adjustable sit-stand desk arranged using individualised ergonomic procedures, some participants argued that the design restricted modification and believed that their own personal computers were not considered in the development of the unit.

Others explained, with emphasis, that although the height-adjustable sit-stand desks improved work focus, the units failed to accommodate their usual connected devices, such as printers that needed to be connected by cable.

Physical discomfort

For many participants, static standing for extended periods resulted in discomfort in the feet. Some participants saw that a change from standing to sitting relieved this discomfort.

One participant commented that the positional foot pain was managed by changing the standing position by shifting body weight from one foot to the other.

Use of sit-stand workstation sitting vs. standing

Features/novelties

For many of the participants, the notion of swapping between standing and sitting positions helped them to complete errands. For instance, participants perceived that they could complete errands such as answering the telephone, responding to emails and conducting administrative duties in the sitting and standing positions. One participant felt that online meetings could be conducted in the standing position, while some participants believed the sitting posture was best for answering the phone to respond to student queries.

Comfort

Although some participants described sitting to speak to staff and students on the telephone for 5 to minutes at a time, most of the participants reported being able to stand intermittently for 15 to 30 minutes. Some participants were able to extend the time spent standing from 60 to approximately 90 minutes at a time, while others indicated that the mornings were better for reducing sitting time because they were more attentive and enthusiastic.

Readiness to continue using height-adjustable sit-stand desks.

All participants in the study indicated that they would like to continue using the height-adjustable sit-stand desks if they were made available to staff. Participants reported perceived improvements in work productivity and job satisfaction as the main reasons for supporting an initiative to reduce sedentary behaviour during work hours. Some participants reported that affordability was a limiting factor for not purchasing their own workstations.

4.4 Discussion

The present study aimed to describe how office workers in a South African university setting viewed the feasibility of environmental modifications and, in this study, sit-stand desks for reducing sitting time in the context of the work environment. Self-reported sitting time in the workplace was high yet aligned with previous data. Seven themes were developed, including, overall impressions of the height adjustable sit-stand desks; motivation to experience the adjustable sit-stand desks; enablers of standing work using an adjustable sit-stand desk; use of sit-stand workstation, sitting versus standing; obstacles to using the adjustable sit-stand desk in the standing position; readiness to continue using sit-stand desks; and perceived behaviour modification. These themes focus on healthy workplace behaviours and enhancements to occupational responsibilities, and they present an understanding of how office workers perceive the promotion of interrupted sedentary time as essential.

In agreement with existing evidence (46) data in our study showed a general acceptance of height-adjustable sit-stand desks to interrupt sedentary time without disrupting usual work responsibilities such as email communication and meeting attendance. Other studies reported a different method to interrupt occupational sitting time, with participants using activities, such as walking between meetings, using the toilet, using a printer, or getting coffee to break prolonged sitting (154). Consistent with our findings, a study that investigated the lived experiences of office employees with prior use of sit-stand workstations (193) illustrated that the substitution of a traditional work model (task completion in the seated position) with a sit-stand desk in the workplace could reduce vocational sitting time and improve productivity. Additionally, previous research has reported participant’s variation in the usage of the sit-stand desk stands, with four studies stating the use of the workstation had no influence whilst three indicated that it enhanced productivity (194). Therefore, modifying the workspace by alternating between sitting and standing might be useful to reduce the monotonous feeling of fatigue and boredom.

Consistent with previous literature, our results indicated that individual's willingness to adopt the height-adjustable sit-stand desks in their work environments were mostly precipitated by personal and organisational motives (195). In addition, our findings highlighted personal and organisational influences for participation in this study were driven by curiosity to experiment with the compatibility of the workstation and other anticipated health benefits. Participants with existing musculoskeletal conditions were motivated to participate in the study in order to attain perceived health benefits through alternation between sitting and standing transitions. As noted in previous studies, our results show that participants spend most of their time at work seated, which makes them prone to adverse musculoskeletal events (17). Alternating between sitting and standing positions can be perceived as less comfortable for work activity by some participants (18); however, the study showed that working in the standing position was associated with chronic lumbar pain reduction in employees (194). The acceptance of sit-stands desks in the work environment should nevertheless be investigated further as there might be resistance to change despite demonstrable improvement in physical health.

Consistent with previous research (46, 196), participants in our study were also motivated to use the sit-stand desk because of the perceived benefits to musculoskeletal health, such as reduced chronic lower back pain due to the extended sitting time in the various domains of sedentary behaviour. The occupation-related sitting contributed the most to overall daily sitting, a finding that has been observed in a number of systematic reviews investigating the sedentary behaviours of office workers (197). Participants were also encouraged to use the workstations because of the incidental ergonomic intervention provided by the researchers during the initial setup of the workstations and continued engagement throughout the study. Other studies have shown acute and chronic improvements with the correction of working postures (193, 198), but this needs to be explored further in our study population.

From the perspective of employee health, the findings of our study demonstrate that many occupation-related benefits may be achieved through workplace interventions. Specifically, some of the advantages described by participants included improvements in work productivity and mental concentration. Indeed, one study showed improvements in task engagement in the erect position despite reporting discomfort (18). Evidence is inconsistent regarding productivity, one demonstrating that job performance was not hindered by standing work (199). The present study findings observed that participants viewed the standing position as better for overall job performance compared to the seated position. These data illustrate that in the office environment, tasks conducted in the standing position could also have varying influence on deliverables, depending on the task characteristics, duration allocated for task completion, and expectations of line management. Participants in the present study described improvements in attentiveness in the standing position compared to sitting for the completion of tasks, a finding which is in agreement with contemporary evidence (200).

4.5 Limitations

This study has limitations worth noting, including the small sample size and the lack of information explaining why people declined to volunteer to participate in the study. Participants in this study were university office staff, primarily women, with only one male who participated in the study and may, therefore, not be representative of other office workers. In addition, breaks in sitting time were self-reported, and no objective measures of free-living data were collected. The transport domain is important, and travel to and from work could affect postural choice during the participants' work hours; however, understanding the nature of this domain is outside the scope of this feasibility study and should be examined in future research. This study was conducted during the stricter COVID-19 lockdown measures in South Africa, which limited face-to-face social interaction with the participants. However, the researchers continued engagement with participants using online and telephonic communication. This sample consisted of participants who presumably earn a monthly salary that is higher than other South Africans and may, therefore, not apply to low-income workers in LMICs. Finally, study participants provided information about musculoskeletal injuries that should be considered in future research studies.

4.6 Conclusion

The participants in this study described their experiences using the height-adjustable sit-stand desk. The overall sentiment was that the workstation would be accepted in the workplace, given the potential for sitting less, perceived productivity improvements, and enhanced physical and mental health. The findings of this study suggest that there is a need for a modification of the occupational environment to reduce sitting time.

Chapter 5 Study Three: Sedentary behaviour, physical activity patterns, and cardiometabolic risk factors in South African office-based workers.

The numbering has been amended from the published article. The declaration and co-author agreement to allow the student to include the manuscript (study three) in the Thesis has also been included (See Appendix 11).

5.1 Introduction

Obesity and related cardiometabolic diseases continue to rise and are projected to double in prevalence by 2030, with low-and-middle-income countries having the highest rates of obesity (201). In 2022, the World Health Organisation reported that these diseases were the leading cause of premature death globally and that of all non-communicable chronic disease-related deaths, approximately 77% occur in low- and middle-income countries such as South Africa (201).

Physical activity is the leading modifiable risk factor for cardiometabolic diseases and all-cause mortality (137, 202). Moreover, in the last two decades, research has highlighted that sedentary behaviour is an independent risk factor for poor health outcomes, regardless of meeting the recommended weekly minimum requirements for structured physical activity (47, 89). Specifically, excessive sitting has adverse associations with obesity and related diseases, resulting in increased mortality rates (9, 89). The Sedentary Behavior Research Network defines sedentary behavior as any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalents while sitting, reclining, or lying (5). In contrast, emerging evidence suggests that interruption of sitting time with light physical activity or even standing results in improvements in cardiometabolic biomarkers (203).

The working adult population typically spends the majority of their time in sedentary positions while at work, commuting to work, and during recreation (10,11). In particular, an average employee spends 75% to 85% of their workday sitting behind their desk in high-income countries. Similarly, Gradidge and collegues in their recent qualitative study, found that South African office workers spend 6-8 hours in sedentary positions (31). According to a recent systematic review and meta-analysis comparing device-measured movement across occupations (9), office-based workers reported low physical activity levels and the highest sedentary time compared to their colleagues in other occupations. This is particularly concerning considering that developing countries such as South Africa are also experiencing a transition toward more sedentary occupations and its accompanying association with potential adverse health effects (32).

Existing evidence has predominantly employed self-reported questionnaires to measure physical activity and sedentary behaviours, which are prone to social recall, overestimation, and bias (33, 204). However, there has been an increase in the number of studies reporting on accelerometery and other device-based measures of physical activity and sedentary behaviour, although such data are more expensive to collect and time-consuming to analyse (205).

Previous systematic reviews examining strategies to decrease sedentary behaviour and improve cardiometabolic risk factors among individuals working in office settings have yielded modest improvements or demonstrated the potential for ameliorating various cardiometabolic risk factors such as elevated blood pressure, excess central fat, reduced high-density lipoprotein (HDL) cholesterol, and elevated blood glucose levels (17, 18). However, due to the lack of evidence on the relationships between objectively measured physical activity and sedentary behaviours with cardiometabolic risk factors amongst South African workers, further investigation is necessary to address this research gap, particularly as it relates to office-based workers. This study aimed to quantify sedentary behaviour and overall physical activity using self-reported questionnaires and accelerometers. It also sought to determine the associations between these activity patterns and select cardiometabolic risk factors among South African office-based workers.

5.2 Methods

5.2.1 Study design and participants.

The cross-sectional study of 122 workers was conducted at the University of the Witwatersrand, Johannesburg, and at a credit bureau company in Johannesburg, South Africa. Office-based workers from the University of the Witwatersrand were invited by email to participate in this study, while credit bureau employees were recruited through email invitations from the human resources department. Ethics approval was obtained from the Human Research Ethics Committee (Medical), University of the Witwatersrand (ethics certificate number M190224). All participants provided written consent. The inclusion criteria included adults aged 18 years and older who worked in an office for at least three days a week with access to a desk or workstation within an office, the ability to communicate in English, and the ability to walk and/or stand for at least 10 minutes.

5.2.2 Data collection

The self-administered online questionnaire was set up in the Research Electronic Data Capture (REDCap) web application with the assistance and support of the University of the Witwatersrand Biomedical Informatics team. A link generated from Redcap was then subsequently shared with our Human Resources contact person, who then circulated it to all employees. Interested employees participated by completing the questionnaire through the provided link, after which the researcher (MP) assigned them a code and scheduled appointments for additional measures. To enhance the efficiency of data collection, the researchers (MP) and (PJG) conducted training sessions for BHSc in biokinetics honours students and interns to assist with data collection.

5.2.3 Questionnaires

A demographic was used to obtain information on age and sex. Monthly income was self-reported in South African Rands (ZAR) and then converted to United States Dollars (USD). The five categories used were: prefer not to answer, <1100 USD, 1100-1375 USD, 1376-1650 USD, and >1650 USD. Self-reported sedentary behaviour for the previous seven days was quantified using the Last 7 Days Sedentary Time Questionnaire (SIT-Q-7d). The SIT-Q-7d is acceptable for epidemiological studies, with criterion validity for domain-specific variables ranging from 0.22 to 0.76 (55).

5.2.4 Anthropometry

Body weight was measured using a digital weighing scale to the nearest 0.1 kg (Omron HN288, Japan). Height was measured to the nearest 0.1 cm using a stadiometer (Seca 123, USA) and converted to meters (m). Obesity was defined as a BMI of ≥30.0 kg/m^2 for both males and females (206). Waist circumference was measured using a cloth inelastic measuring tape (Gulick, USA) at the narrowest part of the torso between the lowest ribs and the iliac crest, with feet together and arms hanging by the side. Central obesity was defined by a WC greater than 102 cm for males and 88 cm for females (75). All measurements were administered with participants in minimal clothing by the principal investigator and trained research assistants.

The Omron M7 automated blood pressure (BP) monitor (Omron M7 Intelli IT (HEM-7322T-E), Omron, Kyoto, Japan) was used to measure brachial BP. In accordance with the American College of Sports Medicine'sMedicine's standardised procedures (20), three measurements were obtained after the participant had rested for at least five minutes in a seated position with the back supported and with an appropriately-sized cuff around the right upper arm, supported at the level of the heart (207). The average of the last two BP measurements was recorded. Hypertension was defined as systolic BP (SBP) ≥ 140 mm Hg and/or diastolic BP (DBP) ≥ 90 mm Hg or a history of hypertension or use of antihypertensive medication(s) (207).

5.2.5 Point of care blood samples.

A finger was pricked to draw non-fasting capillary blood samples. The HemoCue Glucose 201RT system (Ängelholm, Sweden) was used to measure random glucose. Glycated haemoglobin (HbA1c) was measured using the HemoCue HbAlc 501 system (Ängelholm, Sweden) (208). The HemoCue HbA1c 501 system correlates with laboratory HbA1c tests (rho = 0.995- p < 0.001) (209, 210). A diagnosis of diabetes was defined as random glucose ≥ 11.1 mmol/L, HbA1c ≥ 6.5%, use of antidiabetic medication(s), or history of diabetes. Total cholesterol, HDL cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides were measured using the CardioChek Plus analyser (Polymer Technology Systems, Inc.). The CardioCheck Plus analyser demonstrates good clinical agreement with a reference analyser, ranging from 95% to 98% (211). Abnormal total cholesterol was defined as ≥ 5.2 mmol/L or the use of medication(s) for the management of hypercholesterolemia. Participants previously undiagnosed for abnormal BP and/or blood values were advised to seek medical attention.

5.2.6 Accelerometer.

Wrist-worn Axivity accelerometers (AX3; Newcastle-upon-Tyne, United Kingdom) were used to objectively measure sleep, sedentary behaviour, light physical activity (LPA), and moderate-to-vigorous physical activity (MVPA). The AX3 monitor has been validated for total energy expenditure and used in large-scale surveillance studies such as the UK Biobank study (212). Participants were instructed to wear the accelerometer for a minimum of 14 hours a day for seven consecutive days, except during water-related activities (e.g., bathing and swimming). Raw continuous wave accelerometer data was processed using GGIR (version 2.8-2) and an R-package (version 4.2.3). At least four days and ≥16 hours of wear time during the seven days was considered acceptable for data analysis.

5.2.7 Statistical analysis.

Statistica 13.1 (StatSoft, Tulsa, USA) was used for all analyses. Descriptive statistics were presented as mean ± standard deviation, median (interquartile range) for continuous data, and frequencies and percentages for categorical data. A multiple linear regression model was used to estimate the association between cardiometabolic risk factors and objectively measured physical activity and sedentary behaviour, reporting the regression coefficients (β) and their respective adjusted R^2 values. In the models, all independent variables were considered, while the dependent variables encompassed BMI, WC, SBP, DBP, Hb1AC, HDL cholesterol, triglycerides, sedentary behaviour, LPA, and MVPA. The following independent variables were initially included in the regression models: gender, age, current smoking, WC, DBP, hours of sleep, sedentary behaviour, LPA, and MVPA. Prior to multiple linear regression, simple univariate regressions were performed to identify the independent variables associated with the dependent variables, which were later included in the regression models. Backwards, stepwise removal of non-significant variables was performed until the final model remained with significant variables. Significance was set at $p < 0.05$.

5.3 Results

5.3.1 Descriptives

Participant demographics, cardiometabolic measures, self-reported sedentary behaviour, and accelerometry data are shown in Table 1. Of the 160 participants, 38 (23.8%) were excluded due to relocation, lost monitors, or inadequate use. A total sample of 122 (76.0%) participants with valid accelerometer and cardiometabolic data were included, mostly female (83 or 68.0%), with an average age of 40.2 ± 9.3 years. Of the participants, 41 (33.6%) had postgraduate qualifications, and 30 (24.6%) reported receiving a monthly salary of >1650 USD, while 49 (40.2%) did not disclose their salary. Table 1 shows a high mean BMI (29.2 ± 6.5 kg/m2) and WC (88.6 ± 14.1 cm). Mean HbA1c was elevated (6.1 ± 1.4 %), while mean glucose, BP, total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides were within normal ranges.

As seen in Table 5.1, the self-reported daily sedentary time for this cohort, accumulated in different sitting activities, was 595.5 min/day (Interquartile ranges (IQR): –13.5 - 863.4 min/day). Furthermore, our participants reported sleeping for an average of 462.9 min/day (IQR: –17.9 - 522.9 min/day). Accelerometry data showed an average sleep duration of 365.5 minutes per night and sleep efficiency of 87.0%. When using the accelerometers, participants were sedentary for a mean of 180.0 min/day (IQR: –33.0 - 223.3 min/day), participated in LPA for 116.6 min/day (IQR:–92.8 - 140.2 min/day), and actively engaged in MVPA for 47.1 min/day (IQR:–24.2 - 83.6min/day).

Table 5.1 Demographics, cardiometabolic measures, self-reported sedentary behaviour, and accelerometery data.

Variables	**N**	**Mean ± SD or Median (IQR) or (%)**
Female	83	68.0
Age (years)	108	40.2 ± 9.3
Current smoker	12	9.84
Educational status		
Completed matric/high school	15	12.3
College diploma	24	19.7
University degree	22	18.0
Post-graduate qualification	41	33.6
Salary categories		
Prefer not to answer	49	40.2
<1100 USD	6	4.9
1100-1375 USD	6	4.9
1375-1650 USD	14	11.5
>1650 USD	30	24.6
Cardiometabolic biomarkers		
Body Mass Index (kg/m^2)	122	29.2 ± 6.5
Waist Circumference (cm)	122	88.6 ± 14.1
Waist-to-height ratio	122	59.3 ± 14.0
Systolic blood pressure (mmHg)	122	123.8 ± 19.2
Diastolic blood pressure (mmHg)	122	82.6 ± 10.0
Random plasma glucose (mmol/L)	122	6.3 ± 2.3

Glycated hemoglobin (%)	121	6.1 ± 1.4
Total cholesterol (mmol/L)	122	4.0 ± 1.1
High density lipoprotein cholesterol (mmol/L)	122	1.2 ± 0.4
Low density lipoprotein cholesterol (mmol/L)	122	1.8 ± 1.1
Triglycerides (mmol/L)	122	1.5 ± 0.7
Sedentary behavior questionnaire		
Sleep time (min/day)	103	462.9 (417.9 - 522.9)
Sleep and napping time (min/day)	103	475.7 (420.1 - 529.3)
Sitting for meal-time (min/day)	108	78.6 (61.3 – 100.1)
Sitting for occupation (min/day)	45	235.7 (84.9 - 287.1)
Sitting for transportation (min/day)	107	83.6 (42.9 - 217.5)
Sitting for screen time (min/day)	104	100.2 (44.5 - 218.0)
Sitting for other activities (min/day)	96	200.9 (115.7 - 360.1)
Total sedentary time (min/day)	98	595.5 (413.5.- 863.4)
Accelerometry data		
Hours of Sleep (min/day)	122	365.5 (288.5 - 406)
Sleep efficiency (%)	122	87.0 (80.0 – 91.0)
Sedentary time (min/day)	122	180.0 (133.0 - 223.3)
Light physical activity (min/day)	122	116.6 (92.8- 140.2)
Moderate-to-vigorous physical activity (min/day)	122	47.1 (24.2 - 83.6)
Meeting the recommended moderate-to-vigorous physical activity goal	85	76.3

BMI: body mass index; WC: waist circumference; WHtR: waist to height ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure.

5.3.2 Associations between sedentary behaviour and physical activity with cardiometabolic risk factors.

Table 5.2 presents the final multivariate linear regression models and exhibits several significant relationships between objectively measured sedentary behaviour/physical activity and cardiometabolic risk factors ($p < 0.05$). Both SBP (β: -0.234, p = 0.037) and DBP (β: -0.250, p <0.001) demonstrated significant negative associations with LPA. Sedentary behaviour showed a positive association with LPA (β: 0.984, p <0.0001) and an inverse association with MVPA (β: -0.081, p=0.032). There was no association between sedentary behaviour and cardiometabolic risk factors after the regression analysis. MVPA was positively correlated with smoking (β: 0.373, p=0.003).

Table 5.2 Multiple linear regression models for objectively measured sedentary time and physical activity with cardiometabolic risk factors.

Dependent variable	**Independent variables**	**Beta coefficient (p-value)**	**Adjusted R^2 (p-value)**
Body mass index	Gender	-0.286 (0.015)	0.236 (<0.000)
	Age	0.305 (0.009)	
	Diastolic blood pressure	0.314 (0.009)	
Waist circumference	Age	0.397 (<0.000)	0.326 (<0.000)
	Diastolic blood pressure	0.379 (<0.00)	
Systolic blood pressure	Gender	0.302 (0.008)	0.269 (<0.000)
	Waist circumference	0.370 (<0.00)	

	Light physical activity	-0.234 (0.037)	
Diastolic blood pressure	Waist circumference	0.430 (<0.000)	0.231 (<0.000)
	Light physical activity	-0.250 (<0.000)	
Glycated hemoglobin	Age	0.294 (0.020)	0.071 (0.020)
High-density lipoprotein cholesterol	Waist circumference	0.331 (0.009)	0.095(<0.009)
Triglycerides	Waist circumference	0.421 (<0.000)	0.164 (<0.000)
Sedentary time	Light physical activity	0.984 (<0.000)	0.925 (<0.000)
	Moderate-to-vigorous physical activity	-0.081 (0.032)	
Moderate-to-vigorous physical activity	Current smoker	0.373 (0.003)	0.284 (0.003)

BMI: body mass index; MVPA: moderate-vigorous physical activity

5.4 Discussion

The current study aimed to measure sedentary behaviour and physical activity using self-reported questionnaires and accelerometers and examine their associations with specific cardiometabolic risk factors in a cohort of office-based workers in South Africa. Our self-reported questionnaire data indicate that South African office-based workers spend most of their wake time in sedentary positions with minimal energy expenditure. This observation is important because existing evidence has shown that physical activity outside the workplace does not offset the increased risks of mortality and morbidity resulting from time in sedentary positions (160, 205).

Our study participants spent an average of about 235.7 min/day sitting at work and another 83.6 min/day sitting for transportation. Thus, it appears that there is an urgent need for public health interventions to promote both breaking prolonged sitting time at work by interspersed bouts of standing/physical activity and actively commuting to and from work, where feasible, to mitigate the future burden of cardiometabolic diseases among working South African adults (31, 127).

In agreement with extensive research attesting to the overestimation of subjectively reported sedentary behaviour (213), our study shows higher self-reported sedentary behaviour compared to objectively derived measures. Notably, our accelerometry results revealed significant negative (i.e., favourable) associations between both SBP and DBP and LPA, a finding that is consistent with previous research demonstrating that lower-intensity exercise training may lower BP as much or more than moderate- or higher-intensity exercise training (202, 214, 215). However, no association was observed between accelerometer-measured sedentary behaviour and cardiometabolic biomarkers. This finding is similar to those of Silva and colleagues investigated different sedentary behaviour patterns in Brazilian adults, their interrelationships, and associated factors (138) but inconsistent with those of other studies demonstrating a detrimental association between sedentary time and cardiometabolic biomarkers (29, 188). The lack of a significant relationship between sedentary behaviour and cardiometabolic biomarkers in our study could potentially be explained by the relatively high levels of physical activity in this cohort of South African office workers. Regarding the latter, many of our participants met the recommended guidelines for participation in MVPA (namely, at least 150 min/week) despite being employed in a sedentary occupation (216).

The major strength of our study is the inclusion of self-reported and objective measures for assessing physical activity and sedentary behaviours. The major limitation of our study is the relatively small sample size, which was further compounded by the fact that almost 40% of the study participants did not comply with the seven-day minimum requirement of wearing the AX3 accelerometer monitors. Non-compliance was attributed to factors such as allergies to the silicone in the strapping material, forgetfulness, and discomfort with wearing the band. Another limitation of the study is the exclusion of approximately 23.8% of participants. While previous research has discussed non-compliance, the notably high exclusion rate observed in this cross-sectional study may be linked to the influence of the COVID-19 pandemic, which occurred during the data collection period. Additionally, the fact that our study was conducted in only two employer organisations may limit the generalizability of the findings beyond university office-based workers and credit bureau employees. Clearly, future research should include a larger sample size to establish a possible independent association between sedentary behaviours/physical activity and cardiometabolic risk factors in clusters of South African office-based workers from multiple diverse employer organisations.

5.5 Conclusions

In our study, South African office-based workers spent considerable time sitting while at work and commuting to and from work. When active, workers spent more time engaged in LPA than MVPA. Although no association was observed between accelerometry-measured sedentary behaviour and cardiometabolic biomarkers, there was a favourable association between SBP, DBP, and LPA. Although additional research is warranted, our findings support the need for public health workplace intervention programs to mitigate the health risks associated with sedentary behaviour and insufficient physical activity. In particular, our observations show that workplace interventions to address sedentary behaviour and cardiometabolic risk factors in South African populations should focus on breaking sitting time by standing and moving more and, where feasible, promoting physically active modes of transportation to and from work.

Chapter 6 Study Four: Ukumela Impilo Randomised Trial: Preliminary Findings of Height-Adjustable sit-to-stand Workstations on Health Outcomes of South African Office Workers.

The numbering has been amended from the published article. The declaration and co-author agreement to allow the student to include the manuscript (study four) in the Thesis has also been included (See Appendix 11).

6.1 Introduction

Sedentary behaviour is defined as prolonged sitting, lying down, or low-energy activities of less than 1.5 metabolic equivalents (5) and is an important public health issue (217). Sitting for more than 6 hours per day, defined as prolonged sitting by WHO, increases the risk of premature death, even for individuals who maintain a regular exercise routine (218). The modern-day workforce is predominantly office-based and spends ≥ 8 hours in uninterrupted sitting despite its concerning implications (143). A recent investigation has demonstrated that the South African workforce experiences prolonged sitting to a similar extent as observed in other settings (31). This is particularly concerning given that low and middle-income countries (LMICs) like South Africa have the highest rates of obesity and NCDs (191). In a systematic review investigating the effects of sedentary behaviour reduction on cardiometabolic risk markers among office-based workers, nine were deemed extremely promising, while ten were categorised as non-promising (30). This systematic review suggests that interrupting prolonged sitting time with a small amount of energy expenditure may improve overall health in office-based workers.

A recent three-arm randomised controlled trial investigating the effectiveness of multifaceted strategies of behavioural change with and without a height-adjustable desk found notable mean change improvements in daily sitting time (-21.2±116.7; -11.4 ± 106.9) mg, body mass index (-0.02 ±1.1); 0.1 ±1.6) kg.m^2, and systolic blood pressure (-2.1 ±11.3; -2.1 ± 11.8) mmHg in both short (≤12 months) and long term

(≥12 months) follow up (29). Therefore, to mitigate the negative health effects associated with prolonged sitting in the workplace, it is recommended to introduce strategies to interrupt sitting time (143). Similarly, multi-component interventions to reduce sedentary behaviour and cardiometabolic health in the workplace have shown to be effective, particularly those involving height-adjustable workstations (49, 219). Although existing evidence suggests that environmental strategies such as height-adjustable sit-to-stand interventions have the potential to reduce occupational sitting time and improve overall health in high-income countries (HICs) (46, 143), it is difficult to generalise these findings to LMICs. Furthermore, there is currently no evidence of the implementation of environmental strategies such as height-adjustable sit-to-stand interventions in South African and African workplaces, including university settings (31). The purpose of this randomised controlled study was to evaluate the effectiveness of a 12-week height-adjustable sit-to-stand intervention on sedentary behaviour and cardiometabolic health outcomes among office-based workers in South Africa

6.2 Main Text

6.2.1 Methods

6.2.1.1 Study design and participants

This randomised controlled trial was conducted at the University of the Witwatersrand, Johannesburg, and a credit bureau in Johannesburg, South Africa. All participants provided written consent, and the criteria for inclusion in the study has been previously reported (1). Ethical clearance was granted by the Human Research Ethics Medical Committee from the University of the Witwatersrand (ethics certificate number M190224).

6.2.1.2 Intervention

A single-blinded randomised controlled trial (RCT) was conducted with a total of 122 participants who were randomly assigned to either the intervention or control group. The group allocation was conducted by a qualified biostatistician independent from the core research team to randomly assign participants into control and intervention. The intervention group consisted of (n=62, 51%) participants, while the control group had (n=60, 49%) participants. Participants in the intervention group were provided with a height-adjustable sit-to-stand workstation (JUMBO DeskStand™, DeskStand, South Africa) as previously described in the protocol (34) and pilot study (31). The researchers modified participants existing workstations by installing a height-adjustable sit-to-stand workstation on top of their desks, which was individually configured for proper ergonomics. Participants were provided with information sheets and trained on how to effectively use the workstation when in the sitting and standing positions. Based on existing evidence, we initially recommended short intermittent bouts of standing activity lasting at least 10 minutes and were encouraged to progress to longer bouts of at least 30 minutes every hour for the duration of the intervention (220). Participants were encouraged to interrupt their sitting time by accumulating bouts of standing activity with an emphasis on reducing sitting time. During the study, the researchers and research assistants visited the participants weekly to assess the effectiveness of the height-adjustable sit-to-stand workstation and encourage them to interrupt prolonged sitting. Additionally, the participants received regular communication regarding the benefits of interrupting their sitting time (weekly) (See appendix).

The control group participants continued to use their traditional desks and were informed verbally about the negative health effects of prolonged sitting. The researcher did not interact with the control group participants during the intervention period except to collect baseline and follow-up data at 12 weeks.

6.2.1.3 Measurements

Measurements were taken at baseline and the 12-week follow-up for all participants. Participants self-reported their age, gender, level of education, and smoking status. Body weight was measured using a digital scale (Omron HN288, Japan) (4), height was measured using a stadiometer (Seca 123, USA), and obesity was defined as a BMI of ≥30 $kg.m^2$ (4). Waist circumference was measured using a measuring tape (Gulick, USA), and central obesity was defined as a waist circumference greater than 94cm for males and 80cm for females (75). Blood pressure was measured using a monitor (Omron M7 Intelli IT (HEM-7322T-E), Omron, Kyoto, Japan), and hypertension was defined as systolic blood pressure ≥ 140 mm Hg and diastolic blood pressure ≥ 90 mmHg, or a history of hypertension or use of hypertension medication (207). Blood samples were taken to measure random glucose, glycated haemoglobin (HbA1c), total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides as previously described in the protocol (1). A diagnosis of diabetes was defined as random glucose ≥ 11.1 mmol/L, HbA1c ≥ 6.5%, use of antidiabetic medication(s), or history of diabetes. The AX3 accelerometer (Newcastle-upon-Tyne, United Kingdom) was used to evaluate sleep, sedentary behaviour, light physical activity (LPA), and moderate-to-vigorous physical activity (MVPA) (58).

6.2.1.4 Statistical analysis

Statistica version 13 (StataSoft Inc., Tulsa, OK, USA) was used for analysis. The normality of the data was determined using the Shapiro-Wilk test and histograms. Data that was normally distributed was presented as mean ± standard deviation or frequency (percentage), while skewed data was presented as median (interquartile range). The differences between baseline and 12-week are presented as effect sizes using Cohen's d. The differences between study groups were determined using dependent t-tests. Independent t-tests and analysis of covariance (ANCOVA) were used to determine the differences in absolute changes in outcomes of interest between the control group and intervention groups. The dependent t-test was performed to determine mean changes between the intervention and controls. The effect sizes were interpreted as large (≥0.8), moderate (0.4 to 0.8), small (0.2 to 0.4), and trivial (<0.2). Significance was set at $p<0.05$.

6.2.2 Results

Figure 6.1 shows the flow of participants involved in the study. One hundred and sixty participants provided written consent to participate in this study, however, 38 participants were excluded from the study due to non-compliance, incomplete measures, and withdrawal from the study. One hundred twenty-two participants were randomised into the intervention group (n=62) and control group (n=60). We observed a significant drop out of the study for the following reasons: provided no reasons (n=29), loss of interest (n=6), unreachable (n=13), retrenched (n=9) and relocated or moved provinces (n=3, %). The final sample of 62 were randomised into the intervention n=4 (71%) and control n=18 (29%) groups, respectively.

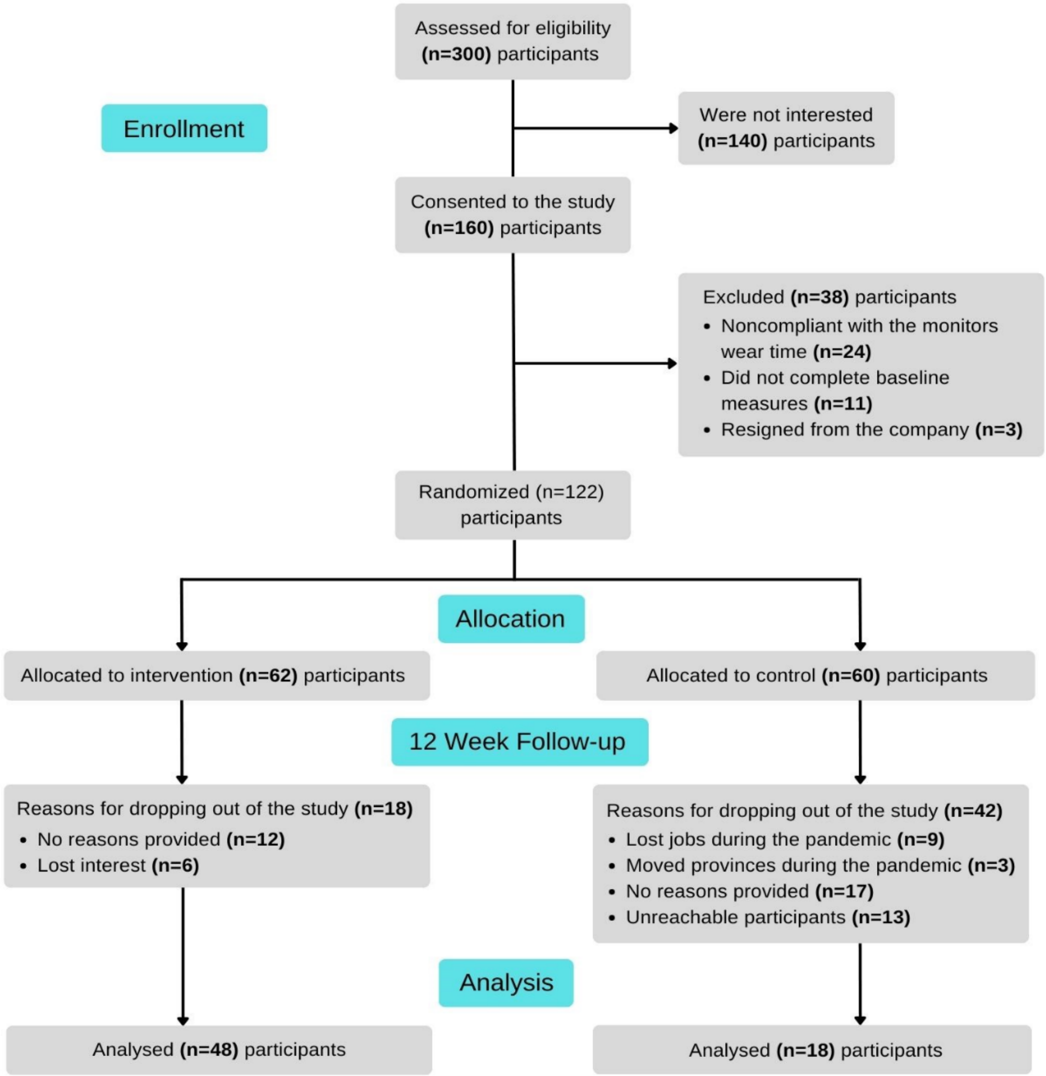

Figure 6.1 Flow diagram of participants through randomised controlled trial

6.2.2.1 Subject characteristics at baseline

Table 6.1 presents the mean age of the participants in the study was 40.32 ± 10.12 years, and they were mostly female (n=49, 79 %). High mean values for BMI were observed in both the intervention group (31.32 ± 7.03 kg.m^2) and the control group (28.13 ± 4.21; kg.m^2), p <0.001 at baseline. The percentages for overweight and obesity were (n=21, 33.87%; n=29, 46.77%), respectively. The systolic and diastolic BP of the intervention (112.55 ± 14.05 and 119.81 ± 14.88; <0.001 mmHg) and the control group were (81.78 ± 8.75 and 81.56 ± 9.42 mmHg), p <0.001. Hypertension and and type 2 diabetes were (n=38, 61.29%; n=25, 40.32%) in this cohort of office-based workers. Sedentary behaviour was [97.52 (80.51- 109.74 mins/day) in the intervention group and 79.65 (53.58 -90.67 mins/day)] in the control group, p <0.001 at baseline. Median MVPA values were 24.64 (11.68- 39.01 mins/day) in the intervention group and 25.30 (9.10-51.08 mins/day) in the control group, p <0.00001.

Table 6.1 Demographic and baseline characteristics of study participants

	Combined sample (n=62)	Intervention group (n=44)	Control group (n=18)	p-value for model
Age (years)	40.32 ± 10.12	41.88 ± 9.37	36.31 ± 11.15	0.247
Female (%)	49 (79.03)	38 (77.55)	11 (22.45)	0.027
Current smokers (%)	12 (100)	7 (58.33)	5 (41.67)	0.134
Education Level				
Completed high school (%)	11 (18.33)	67 (63.64)	4 (36.36)	<0.001
College diploma (%)	15 (25.00)	8 (53.33)	7 (46.67)	<0.001
University degree (%)	14 (23.33)	10 (71.43)	4 (28.57)	<0.001
Postgraduate qualification (%)	20 (33.33)	17 (85.00)	3 (15.00)	<0.001
Cardiometabolic Outcomes				
BMI (kg/m^2)	30.39 ± 6.47	31.32 ± 7.03	28.13 ± 4.21	<0.001
WC (cm)	88.56 ± 12.23	89.93 ± 11.87	85.22± 12.80	<0.001

Overweight (%)	21 (33.87)	15 (24.19)	6 (9.68)	<0.001
Obesity (%)	29 (46.77)	21 (33.87)	8 (12.90)	<0.001
SBP (mmHg)	114.65 ± 14.56	112.55 ± 14.05	119.81 ± 14.88	<0.001
DBP (mmHg)	81.72 ± 8.87	81.78 ± 8.75	81.56 ± 9.42	<0.001
Hypertension (%)	38 (61.29)	27 (43.44)	11 (17.74)	<0.001
RBG (mmol/L^{-1})	6.70 ± 2.71	6.81 ± 3.11	6.43 ± 1.36	<0.001
HbA1c (%)	6.11 ± 1.15	6.16 ± 1.29	5.98 ± 0.67	<0.001
Diabetes (%)	25 (40.32)	16 (25.81)	9 (14.51)	<0.001
Triglycerides (mmol/L^{-1})	1.52 ± 0.66	1.53 ± 0.66	1.49 ± 0.66	<0.001
HDL (mmol/L^{-1})	1.33 ± 0.34	1.37 ± 0.36	1.22 ± 0.26	0.082
LDL (mmol/L^{-1})	1.70 ± 1.25	1.63 ± 1.33	1.88 ± 1.01	<0.001
Total Cholesterol (mmol/L^{-1})	4.09 ± 1.23	4.25 ± 1.20	3.69 ± 1.25	<0.001
Accelerometry data (median IQR)				
Sleeping time (mins/day)	352.19 (2–3.51 - 392.23)	364.89 (2–3.24 - 393.51)	319.05 (1–9.67 - 389.95)	<0.001
Sedentary time (mins/day)	89.12 (73.24 – 107.51)	97.52 (80.51-109.74)	79.65 (53.58 – 90.67)	<0.001
LPA (mins/day)	111.49 (84.96 – 130.08)	111.49 (–6.22 - 133.76)	103.72 (67.72 – 129.24)	<0.001
MVPA (mins/day)	24.64 (10.27 – 39.23)	24.64 (11.68-39.01)	24.18 (9.15 – 65.43)	<0.001

Body Mass Index (BMI); Diastolic blood pressure (DBP); Systolic blood pressure (SBP); Waist Circumference (WC); Random blood glucose (RBG); Glycated haemoglobin (HbA1c); high-density lipoprotein cholesterol (HDL); low-density lipoprotein cholesterol (LDL); Light physical activity (LPA); moderate to vigorous physical activity (MVPA).

6.2.2.2 Effectiveness of a height-adjustable sit-to-stand intervention

Table 6.2 presents changes between baseline and follow-up for cardiometabolic health outcomes with free-living sedentary behaviour and physical activity data. Sedentary behaviour was reduced in the intervention group (-9.3 ± 37.13 mins/day) while showing an increase in the control group (7.66 ± 36.44 mins/day). Light physical increased in the intervention group (4.14 ± 51.04 mins/day) and decreased in the control group (-14.71 ± 52.03 mins/day) from baseline to follow-up. Moderate to vigorous physical activity increased in both the intervention (3.35 ± 20.86 mins/day) and the control groups (6.36 ± 25.32 mins/day), respectively. When considering BMI and total cholesterol measures, we observed trivial effects of (d= -0.11 kg.m^2) and (d=-0.11 mmol/L-1). Similar trivial effects were observed in most cardiometabolic outcomes. The intervention only observed small effects with diastolic blood pressure (d=0.26 mmHg) and light physical activity (d=0.26 mins/day).

Table 6.2 Changes in cardiometabolic health outcomes with free-living sedentary behaviour and physical activity data

	Intervention (n=44)	Control (n=18)	Intervention vs Control		
	Mean change (standard deviation)	Mean change (standard deviation)	Mean change (standard deviation)	Effect size (*d*)	P-value
BMI (kg/m^2)	-0.52 ± 2.72	0.55 ± 2.98	1.08 ± 2.80	-0.11	0.005
WC (cm)	0.07 ± 7.42	-0.06 ± 7.41	-1.32 ± 7.36	0.11	0.162
SBP (mmHg)	2.70 ± 13.33	-4.64 ± 10.55	-1.86 ± 12.83	0.06	0.258
DBP (mmHg)	-0.24 ± 9.51	0.86 ± 9.56	-1.37 ± 9.50	-0.26	0.260
RBG (mmol/L-1)	-0.40 ± 1.62	-0.72 ± 1.45	-0.80 ± 1.60	0.13	<0.001
HbA1c (%)	0.25 ± 1.46	0.10 ± 1.03	-1.58 ± 1.51	0.08	<0.001
TC (mmol/L^{-1})	-0.02 ±1.02	0.15 ± 1.76	-1.32 ± 1.37	-0.11	<0.001

Triglycerides (mmol/L^{-1})	0.10 ± 0.83	0.21 ± 1.33	-1.43 ± 1.11	0.01	<0.001
HDL (mmol/L^{-1})	0.02 ± 0.32	0.04±0.36	-1.32 ± 0.57	0.08	<0.001
LDL (mmol/L^{-1})	0.36 ± 1.20	0.02±1.45	-1.42 ± 1.59	0.11	<0.001
Sleeping time (mins/day)	-8.89 ± 136.32	-51.39 ± 94.31	-22.52 ± 126.39	0.11	0.166
Sedentary time (mins/day)	-9.3 ± 37.13	7.66 ± 36.44	-3.08 ± 37.54	0.06	0.520
LPA (mins/day)	4.14 ± 51.04	-14.71 ± 52.3	2.62 ± 51.78	-0.26	0.691
MVPA (mins/day)	3.35 ± 20.86	6.36 ± 25.3	5.52 ± 22.10	0.13	0.054

Body Mass Index (BMI); Diastolic blood pressure (DBP); Systolic blood pressure (SBP); Waist Circumference (WC); Random blood glucose (RBG); Glycated haemoglobin (HbA1c); high-density lipoprotein cholesterol (HDL); low-density lipoprotein cholesterol (LDL); Light physical activity (LPA); Moderate or vigorous physical activity (MVPA).

6.3 Discussion

This study evaluated preliminary findings of a longitudinal randomised controlled trial (RCT) to address sedentary behaviour and cardiometabolic risk markers in a cohort of South African office-based workers. It is worth noting that this intervention focussed solely on improving cardiometabolic health by using a height-adjustable desk to reduce sitting time during work hours. This current study demonstrates that height-adjustable sit-to-stand workstations effectively reduce sedentary behaviour and improve cardiometabolic outcomes in a cohort of South African office workers over a 3-month follow-up period. These data are important for informing further longitudinal studies of this environmental modification in the workplace.

Our findings show that sedentary behavior decreased in the intervention (-9.3mins/day) and increased in the control group (7.66 mins/day) when measured with accelerometry devices respectively. These results are consistent with those of a previous intervention study that demonstrated significant reductions in sedentary behavior in the workplace in HICs (219). The findings of the current study are similar to those of a recent RCT (29), which found that sedentary behavior deceased in both the behavioral change with (-13.00 (-29.5 to 3.6 min) and without a height adjustable desk (-74.3 (-90.8 to -57.7 min) interventions when compared to the control group in 3 months follow up. Light physical activity and MVPA were improved in the group using the height-adjustable desk. However, bouts of standing were not quantified in the present study in comparison to previous studies that have demonstrated that interrupting sitting time by standing increases overall physical activity (49, 219). Therefore, substituting prolonged sitting time with comparable amounts of light or moderate activity may improve health (47).

An encouraging finding of this study is that small and trivial improvements were observed in most cardiometabolic risk markers, which is in agreement with a recent systematic review and meta-analysis (30). For instance, in the current study, we observed small effects on health outcomes such as BMI (d=-0.11) $kg.m^2$, blood pressure (d=-0.26) mmHg, and cholesterol levels (d=0.11) $mmol/L^{-1}$ in 3 months. It is important to note that the changes observed in this study were relatively small and may not be statistically significant due to a relatively small sample size (30, 46). Despite the paucity of data in LMICs, our study supports using height-adjustable sit-to-stand interventions to reduce sedentary behaviour and improve cardiometabolic outcomes among South African office-based workers (31). However, modifying the existing workplace environment by introducing a height-adjustable sit-stand workstation is not enough to significantly reduce sedentary behavior and improve health outcomes.

Systematic reviews investigated the effectiveness of sedentary behavior reduction workplace interventions on cardiometabolic risk markers, suggesting that short-term and long-term interventions effectively reduce prolonged sitting (30, 46, 143). It is not clear which cardiometabolic risk markers improve with sedentary behavior interventions. Interestingly, previous multi-component long term interventions reduced daily sitting time significantly. Healy and collegues (49) reported a 44 min drop in 231 office workers, Edwardson and collegues (162) found similar reductions of 41 min in a sample of 143 office workers, Pereira and collegues (221) found a decrease of 60 min in a sample of 630 office workers, and Edwardson and collegues (29) found a reduction of 22-62 min in a sample of 547 office workers. This suggests that a combination of environmental strategies such as height-adjustable sit-to-stand workstations and additional strategies such as education, motivation and coaching might be more effective in reducing sedentary behaviour and improving overall health. Further research is needed to identify and implement effective long-term sedentary behaviour strategies aimed at achieving sustained behaviour change in the workplace, particularly in LMICs such as South Africa. The strengths of this study include the robust nature of the methods used and the positive findings that can be used to inform further studies on office workers

6.4 Conclusion

This investigation confirms that short-term height-adjustable sit-stand interventions are effective in reducing workplace sitting time and selected health outcomes. While the effect sizes were small, the results are encouraging, and they suggest that even short-term interventions can positively affect health. Further research is warranted to validate these findings and to explore the long-term impact of a sit-to-stand workstation on reducing sedentary behaviour and enhancing the health outcomes of office workers in South Africa.

6.5 Limitations

There are important implications to these preliminary findings that should be recognised. More than 60% of the participants dropped out of the current study, which reduced the study sample size and may limit the generalizability of the findings. The authors hypothesised that this high drop-out could be attributed to the COVID-19 pandemic implications experienced during the 12-week trial as limited movement and companies moving to full remote (working from home) at the time of the study. Another limitation of the study was that it was conducted during the COVID-19 pandemic when movement restrictions, a shift to full remote work and the closing of companies were imposed on South African workplaces, which may have influenced the large dropout rate.

Chapter 7 Study Five: A qualitative investigation of office workers' experiences and early withdrawal from a height-adjustable, sit-to-stand desk intervention.

7.1 Introduction

Prolonged sedentary behaviour is of particular concern for office-based workers who spend at least 8 hours in seated activities with minimal movement (222). The technological advancements in office-based workspaces have contributed to the rise in sedentary behaviour and the burden of non-communicable diseases in the workplace (138). Several interventions have been implemented to mitigate the risks associated with extended sitting, including height-adjustable sit-to-stand sedentary behaviour interventions (14, 153, 223). Two types of height-adjustable sit-to-stand workstations are frequently used: a full desk unit that can be adjusted manually or electronically, or a modular desktop unit that is fixed to an existing desk and typically adjusted manually. Previous qualitative studies found that workers were more inclined to implement the height-adjustable sit-to-stand desks due to perceived health benefits and work improvements associated with their use (196, 222, 224, 225). Suggesting that using sit-stand desks during vocational hours whilst at work, may be considered a more feasible alternative for office workers compared with physical activity workplace interventions that may require engaging in out-of-office physical activities. However, the provision of a sit-stand desk doesn't necessarily imply that it is being used to break sitting time, nor does it guarantee long-term adherence. It is also important to note that the office work environment presents opportunities and challenges for promoting behaviour change (226).

Systematic reviews have suggested that sedentary behaviour intervention studies were effective in reducing occupational sitting time in office workers, it should be noted that the results across studies are inconsistent (30, 46, 143, 227). Therefore,whether these interventions would be successfully implemented in the workplace is unknown. Similarly, a recent 12-month RCT exploring the effectiveness of a height-adjustable desk intervention on physical behaviours, health outcomes, and performance, on the other hand, revealed a dropout rate of 12.3% of participants at three months (n=93) and 22.2% (n=168) after 12 months (29). Despite the high drop-out rates observed in sedentary behaviour interventions aimed at reducing extended occupational sitting time in office-based workers, there is a paucity of evidence examining the reasons for participant drop-out in these interventions (14, 143, 228). There is thus a need to research and understand the reasons for the drop-out particularly with the interest in developing sustainable workplace interventions.

This work is part of an onging larger study that seeks to understand the effectiveness of height-adjustable sit-to-stand workstations intervention on addressing sedentary behaviour and cardiometabolic outcomes in South African office-based workers with several publications (34). The initial study served as the protocol for the larger study that was concepualised before the Covid 19 pandemic (34). Study two was a qualitative feasibility study conducted on a subset of office-based workers, that did not form part of the intervetion (222). The third study comprised a cross-sectional investigation, providing baseline measures for the intervention, with participants described study one and introduced another study setting in response to the challenges posed by the COVID-19 pandemic (35). The forth study was a three months randomised control follow up on participants from the two study settings (36). Therefore, the present qualitative study aims to determine the dropout rate from the three-month height-adjustable sit-to-stand workstation intervention.Consequently, this study aimed to explore the perceptions and experiences of a group of participants that withdrew early from a height-adjustable sit-to-stand desk workplace intervention.

7.2 Methods

7.2.1 Study design

This qualitative exploratory study used semi-structured interviews to gain insights into why participants withdrew early from the ongoing height-adjustable sit-to-stand desk randomized control trial from the University of the Witwatersrand and a credit bureau company, in Johannesburg, South Africa. This study adheres to the guidelines for transparent reporting of COnsolidated criteria for REporting Qualitative research (COREQ). Please refer to the COREQ statement checklist that is attached as Appendix 13.

7.2.2 Participants and recruitment

The participants in the present study withdrew prematurely from the ongoing height-adjustable sit-to-stand desk randomized control trial from the University of the Witwatersrand and a credit bureau company, in Johannesburg, South Africa (34). The flow of participants through the quantitative and qualitative studies is shown in Figure 1. Of the 160 participants who initially consented to participate in the study, only 122 were randomized into the intervention due to exclusions (35). Sixty participants dropped out from the control (44) and the intervention group (18) groups respectively (36).

During the process of recruitment, the investigator (MP) used the contact information obtained at baseline to initiate communication with 18 prospective participants who voluntarily terminated their involvement in the intervention group between weeks 4 and 10.They were informed of the study's purpose via telephone, email, whatsapp, or SMS depending on the established prefered mode of communication. A final sample of 12 office-based workers was included in this study to share insight into the reasons for drop-out from the height-adjustable sit-to-stand desk intervention. Participants who dropped out of the control group were not included in the current study given that they did not use the height-adjustable sit-to-stand desk.

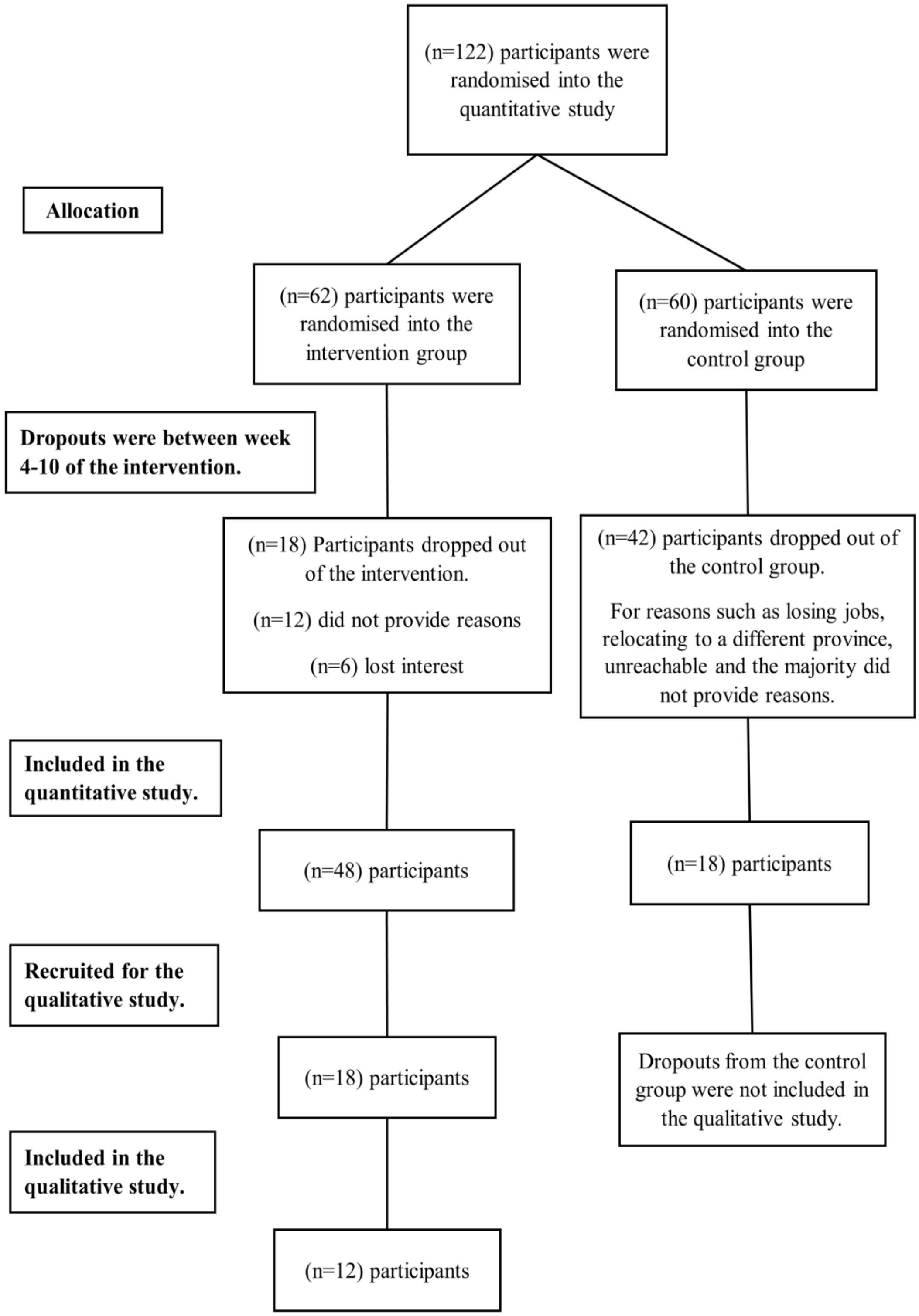

Figure 7.1 Flow of participants through the quantitative and qualitative studies

7.2.3 Data collection

Data was collected English from January to March 2023. Semi-structured interviews lasting on average 20 min (range: 10–41 min) were used. Based on observation and literature, (MP) and (PJG) formulated the interview guide, incorporating demographic information including age, gender, and highest level of education. (See Appendix 14). This study's supervisor (PJG) has expertise in the area of sedentary behaviour and has reviwed all the questions in the interview guide. All interviews were conducted by MP online using Microsoft Teams (version 11, Microsoft Way, United States) or in person at the participants' workplace. Interview discussions were recorded using Microsoft Teams and Phillips (DVT4010 Voice Tracer, Vienna, Austria). During the in-depth interviews, participants were encouraged to think about facilitators and barriers to participating in the height-adjustable sit-to-stand desk intervention in their place of employment. Interviews were conducted until the saturation level of the information was reached. Audio recordings were transcribed, and all transcripts were checked against the recordings to verify accuracy and credibility.

7.2.4 Reflexivity

MP maintained comprehensive documentation throughout the research process, reflecting on her potential biases after each participant interaction. This included writing down her initial thoughts and observations and a dedicated reflection after her first reading of each interview transcript. In these reflections, she documented what she perceived as key themes emerging from the data and noted any features of her own interview style or participant behavior that might influence the results. While PJG and the external expert (SOO) did not directly engage with the participants, they played a crucial role in assisting MP with interrogating the data.

Their guidance, particularly concerning MP's familiarity with the participants and potential impact on the collected data, proved invaluable. With their support, MP continuously challenged her assumptions and biases, ensuring the content analysis remained a true reflection of the participants' experiences, not colored by her pre-existing relationships or subconscious influences.

7.2.5 Data Analysis

Transcripts were analysed using thematic analysis. The two researchers read and re-read all transcripts independently and generated codes and themes arising from the data were further discussed until a consensus was reached. An external expert in qualitative data analysis (SOO) verified and validated the analysis. The deductive approach was based on pre-identified themes centered around the research question, whereas the inductive approach was applied to all themes derived from the transcripts and field notes. Atlas.ti 23 Scientific Software Development GmbH (Berlin, Germany) was used to manage and analyse data. Descriptive statistics were used to analyze the demographic data of the participants.

7.2.6 Ethical considerations

Ethical clearance was granted by the Human Research Ethics Committee at the University of the Witwatersrand (ethics certificate number M190224). Written institutional approval from the University of the Witwatersrand and the credit bureau company was also obtained. Prior to the commencement of data collection, each participant signed the informed consent and granted the researcher permission to audio-record the interviews. Participants were asked to actively engage with the researcher and were promised that their responses would be anonymized in the dissemination of results

7.3 Results

A total of twelve office-based workers participated in this study. Most of these participants were female (n = 10, 83.3%) with a mean age of 46.0 ± 6.5 years. All participants completed high school while 41.7% have post-graduate degrees as shown in Table 7.1.

Table 7.1 Description of study participants.

Variables	Mean ± SD or N (%)
Age (years)	46.0 ± 6.5

Female	10 (83.3)
Male	2 (16.7)
Educational status	
Completed matric	2 (16.7)
College diploma	2 (16.7)
University Degree	2 (16.7)
Post-graduate qualification	6 (50)
Salary categories	
Prefer not to answer	5 (41.7)
1100-1374 USD	1 (8.3)
1375-1649 USD	1 (8.3)
>1650 USD	5 (41.7)

* United States dollar (USD), Mean and Standard Deviation (±), Number (N), percentage (%) and greater than (>).

7.3.1 Themes emerging from the current study

Through an in-depth exploration of the participants' personal experiences, our analysis has identified two major themes (perceived health benefits and perceived barriers) and eight sub themes which are “motivations”, and “height-adjustable sit-to-stand desk experience (perceived health benefits) presented in Table 7.2. Others were "discomforts and dislikes", "applicability and practicality", "people’s perception i.e. that is, what people will say" and "transition to electronic sit-to-stand desks" (perceived barriers) presented in Table 7.3.

7.3.1.1 Perceived health benefits

Perspectives on using a standing desk

Most participants expressed that they were initially sceptical about using the height adjustable sit to stand workstation before joining the study. Whilst some participants indicated that they were initially excited to break up periods of prolonged seating at work by using the height adjustable sit to stand workstation. Others cited an interest in the research and a desire to live an active lifestyle. Despite varying perspectives before participating, all participants shared a common motivation to participate in the study.

Perceived benefits of using a standing desk

Participants highlighted that standing was a better alternative to sitting and is a form of accumulating light physical activity. This improved circulation, strengthened muscles, increased physical fitness, and decreased illness risks. The majority of participants reported that incorporating height-adjustable sit-to-stand standing desks into their working environments improved their ergonomics and posture, resulting in less back, neck, and shoulder discomfort.

Experience's of using a standing desk

All participants in the study found standing and working to be a positive experience. Our discussions revolved around the impact of using height-adjustable sit-stand workstations on overall health since it was the main reason for enrolling in the study. Despite standing and working being a novel experience for most participants, they found that standing enabled them to concentrate deeper and improved their work productivity. In addition, our participants said that working while standing made their tasks more fascinating and less repetitive.

Table 7.2 Sub themes for participant engagement and experiences with illustrative quotes

Sub themes	**Definition of themes**	**Illustrative quotes**
Perspectives on using a standing desk	This sub theme involves examining the various factors driving individuals to take part in the current research. These reasons can encompass personal motivations, such as seeking knowledge or wanting to contribute to others,	"Yes I was skeptical, I wasn't sure how it was going to work because part of it is that the desk has got two levels, so there was the normal level at which I was working at but you could put the computer up on the middle level and it would allow you to continue sitting or you could put it right up at the top where you would stand, so that in itself was an encouraging way to you know, accept there's a reminder because now it's in your face and yeah, accept that it's a reminder and also even the way that I

	alongside external influences like incentives or social pressures.	had to set up my office, it had to change because there was a standard desk now, so I made sure that for me to be able to maximize on the benefits of the standing desk, I had to set up my computer higher, I had to put up my phone higher so that I would be forced even to stretch and to actually work whilst standing. So, with time I stopped being skeptical and embraced the benefits of the standing desk which was quite nice." (Participant 5, female, aged 43 years)
Perceived benefits of using a standing desk	The sub theme highlights the anticipated range from physical health improvements to increased productivity and mental well-being	"I liked that it reminded me that I needed to stand and work which I thought that it is beneficial, you know, long term, and also it kind of relieves body pain and things, I think very similar to my other answers." (Participant 4, female, aged 42 years)
Experience's of using a standing desk	The sub theme " encompasses the user perspectives concerning overall impressions using such desks.	"Interesting. Yeah, no I think it was a good experience, you know, it was nothing wrong with that. I think it's just, you just have to, when you set up, you just have to find what's the comfortable height. So, sometimes you know in the beginning it wasn't at a comfortable height. So, you just had to find that comfortable height where it was on so that you can actually work quite good on it." (Participant 3, male, aged 49 years)

7.3.1.2 Perceived barriers and challenges of using the standing desk

Withdrawal reasons

The most significant reason and a key reason key for most participants to discontinue the study was the size of the height-adjustable sit-to-stand desk which was considered cumbersome and unattractive. Some participants had more than one screen, which made it challenging for them to manually switch between sitting and standing throughout the day; they found it exhausting and mechanistic. In addition, they could not perform certain activities while standing, including taking notes while reading, typing, and using an Excel spreadsheet. Two participants commented favourably on the standing desk's features, particularly its wooden construction. Despite their happiness with the standing workstation, they were both laid off, resulting in their withdrawal from the intervention.

Discomforts of using the workstation

Participants experienced several challenges due to the rigidity of the workstation which led to an unpleasant experience. These issues included discomfort with standing working, slouching, shoulder pain, and exhaustion. The discussion highlighted that prolonged standing was uncomfortable and intermittent smaller bouts of standing were a better alternate. One of the participants mentioned that although standing and working might present some challenges, she chose to wear comfortable shoes to motivate her to stand more and longer.

Usability and practicality of the workstation

While most participants thought that the workplace is an appropriate context to introduce modalities to promote breaking sitting time, some thought it wasn’t an appropriate context but could become a habit if there is awareness. Participants preferred to alternate between standing and sitting positions throughout the day while some stood more in the morning or after lunch. While some participants thought it was impractical to stand and work, others found it productive to complete certain tasks such as working on Excel spreadsheets, data capturing, typing, answering calls, and attending meetings.

People’s perception i.e. what others would say

Participants expressed gratitude for bringing attention to the significance of reducing sedentary behaviours and cultivating health practices in the workplace. The conversations highlighted the outstanding support received from family members, managers, and coworkers for using the height-adjustable sit-to-stand desk. They were also skeptical about what people will say about them working while standing. However, one participant stated that her manager was not supportive in this aspect.

Adoption of electronic sit-to-stand desks

Participants indicated a desire to continue interrupting prolonged occupational sitting time if given an aesthetically designed tiny electronic height-adjustable workstation instead of a manual height-adjustable sit-to-stand desk employed in the current study. In addition, three participants stated that they enjoyed reducing sitting time and planned to purchase electronic height-adjustable desks within their budgets.

Table 7.3 Sub themes for barriers and challenges with illustrative quotes

Sub themes	**Definition of themes**	**Illustrative quotes**
Withdrawal reasons	The sub theme encompasses the diverse obstacles and reasons leading individuals to discontinue participation in a research project.	"If, so in the beginning what I was trying to adjust between standing and sitting, it is a little bit cumbersome trying to go from being back in a sitting position going up to standing. So, it’s just, it’s just a little bit like finicky getting it back into those positions." (Participant 2, female, aged 52 years)
Discomforts of using the workstation	The sub theme involves identifying and exploring the specific physical or psychological discomforts and	“By the end of the experiment, so it was like a mistake on my part but still, I wasn’t really comfortable using it, not the word comfortable but I like tried to comply with like standing up and working but I was happy when I thought it was over because I didn’t think it would have been something for me,

	negative aspects that individuals experienced during the intervention.	so that's where I was at with that stand." (Participant 4, female, aged 42 years)
Usability and practicality of the workstation	The sub theme pertains to assessing the suitability and feasibility of height-adjustable sit-to-stand workstations in practical settings.	"I tend not to put it in the standing position often. I think it's more just because a lot of my work I tend to use the keyboard even during meetings. Even though I talk quite a lot during meetings, I am typing and taking a lot more notes if that makes sense. So, sitting during meetings is a lot more prevalent, so having that eye level raise from my laptop has definitely helped. I don't have a lot more; I have a lot less up and neck and shoulder discomfort. So that's definitely helped. But as I say, I tend to not use the standing position at all." (Participant 6, female, aged 45 years) "So, so I think that you can adjust the levels. I mean it took me a little while to get, to get the levels to be right for my height. Actually interesting – I got wedge heels today, so I must actually see if it makes a difference – but I think that this one is height adjustable and that I can fit extra screens on it. I just think from a negative perspective – if the top shelf was maybe slightly thinner, because having the laptop moved to the second, the lower shelf, it, the gap is too narrow to work properly, to have both screens for standing. So, then the tilt of the laptop screen is a problem, but I've got the smaller laptop here today, so I'm going to see if that, if it fits

		better on the lower level, to be able to fit underneath the, the upper screen." (Participant 1, Female, aged 51 years)
People's perception i.e. what others would say	The sub theme centers around the reactions and responses of participants' colleagues, families, friends, and researchers to their usage of the workstation.	"They would actually see me as a weird person, they used to laugh, why don't you sit down, I'm like no, this is a very nice experience because they've never experienced it." (Participant 7, Female, aged 32 years)
Adoption of electronic sit-to-stand desks	The sub theme involves participants expressing their willingness to join future studies if there's a shift from manually adjusted height-adjustable desks to electronic ones, despite dropping out of the current study.	"Ja. No, so, I mean I think the automated desk definitely. And then I think finding the right balance to have the multiple screens is, would also make it easier – that I'm not having to plug something in and unplug something – that it's all plugged in and works." (Participant 1, Female, aged 51 years)

7.4 Discussion

This study sheds light on the challenges associated with the implementation of height-adjustable sit-to-stand desk interventions in the South African workplace while suggesting potential solutions to promote and enhance adherence. Given the limitations of our research, our study is novel concerning the perceptions and experiences of a group of participants who withdrew early from a height-adjustable sit-to-stand desk workplace intervention. Our analysis revealed two primary themes: perceived health benefits and experiences and barriers and challenges associated with using the standing desk along with their respective sub themes, offer a comprehensive understanding of the study's findings. The study findings reveal that there was general acceptance of the workstation. Consistent with a systematic review of 22 qualitative studies exploring barriers and facilitators to reducing workplace sitting time (229). However there were divergent opinions on the size of the height-adjustable sit-to-stand desk, with a majority of participants perceiving it as large, while some thought it was an ideal size. Which may indicate that the size of the height-adjustable sit-to-stand desk may not be appropriate for everyone and in every organisation.

In agreement with previous studies our participants found that although working while standing was a new experience, it was feasible in this cohort and led to improvements in their work productivity and were able to immerse themselves in their tasks (230). This suggest a need to develop effective strategies to interupting prolonged sitting time in office based workers. Similarly to previous studies office based workers motive to participate in strategies to interrupting occupational sitting time is based on perceived health benefits such as reducing musculoskeletal pain, improving ergonomic posture, and incorporating bouts of light physical activity to improve overall health (195, 229, 231). Despite the existing relationship observed in the motivate to participate and increased use and compliance in workplace strategies to address sedentary behaviour in workers(46). Interestingly, although participants in this cohort were motivate to participate in the height-adjustable sit-to-stand desk intervention they all withdrew early from the intervention. suggesting the importance of involving participants in selecting a functionally appropriate workplace intervention for sustained usage and long-term adherence.

The novel finding of this study is that the motivation to continue with the intervention was hindered by the large and poor design of the height-adjustable sit-to-stand workstation. This included concerns about the desk's bulkiness, rigidity, ability to occupy excessive space on the supporting desk, and difficulty configuring multiple screens when alternating between sitting and standing positions. A previous study showed that participants stopped using a height-adjustable sit-to-stand desk due to a perceived lack of functionality, and there is a paucity of data on the links between size, aesthetics and usability of workstations (193). Similarly, participants expressed their willingness to continue with the intervention or a similar strategy if provided with an electronic height-adjustable desk (13). These findings suggest that an electronically height-adjustable desk with a smaller footprint that naturally blends with the workspace arrangement is more likely to increase compliance and effective utilization and potentially contribute to successful implementation. However, there is a need to assess the long-term usage, compliance, and retention of height-adjustable sit-to-stand workstations before investing in expensive electronic units. Consistent with earlier research, participants in this study reported that standing while working was tiresome and uncomfortable (232). This finding suggested that employees avoid using the height-adjustable sit-to-stand desk to prevent discomfort and musculoskeletal aches associated with its use. Our study also highlights varying perspectives regarding the suitability of the workplace as a context for standing and working on whether the workplace is an appropriate context for standing and working; interestingly, few participants deemed it inappropriate to stand and work. Previous studies support the complexity of the standing and working concept and are influenced by several factors, such as cultural, societal, and workplace norms (193, 229). Therefore, it is important to consider individuals' existing workstations and preferences, potential discomfort, fatigue, job requirements, and productivity when implementing height-adjustable sit-to-stand workstation interventions in the workplace.

7.5 Limitations

This study has several limitations. First, the study comprised of a small sample size of 12 participants, and it was only carried out in two organizations. Second, majority of the participants were female with only one male. Third, most of the interviews were conducted online, which hindered the observation of nonverbal cues such as facial expressions and body language. Due to the highlighted limitations, the findings of this study should be cautiously interpreted and not be generalised.

7.6 Conclusion

The findings of this study revealed that the majority of the participants dropped out due to the perceived barriers which included “withdrawal reasons”, “discomfort associated with using the workstation”, “usability and practicality of the workstation”, support and people’s perceptions, i.e., what others would say” and “adoption of electronic sit-to-stand desks”. The findings of this study could help formulate a policy indicating that there is a need to address potential barriers to a height-adjustable sit-to-stand workstation workplace. Future studies should consider individual preferences, design, functionality, knowledge, and motivation to ensure effective implementation, utilization, and compliance with height-adjustable sit-to-stand workstations.

Chapter 8 Conclusion and Recommendations

8.1 Thesis Findings

Notably, sit-to-stand desk interventions for reducing workplace sitting time have not been implemented in South African office employees. Therefore, the main aim of this thesis was to determine the effectiveness of an adjustable sit-to-stand intervention on the selected cardiometabolic markers in office-based workers and to significantly contribute to the body of knowledge around addressing sedentary behaviour and cardiovascular diseases in the workplace, particularly in the LMICs.

Table 8.1 Summary Table of Objectives and Findings

Objective	Objective and Chapter	Methods used	Key findings related to objectives
To conduct a pilot study to assess the feasibility and efficacy of the sedentary behaviour randomized controlled trial among South African office workers.	1: 4	This study employed qualitative methods. Data was collected through semi-structured interviews.	• The study showed the acceptability of height-adjustable sit-stand desks. • Participants reported increased work productivity and mental concentration. • Perceived health benefits precipitated participation.
To determine sedentary behaviour and overall physical activity using self-reported questionnaires and accelerometers	2: 5	This study employed quantitative methods. Data was collected through questionnaires, accelerometers, blood samples and anthropometry measures.	• Both accelerometry and self-reported questionnaires showed that participants spent a considerable amount of time being sedentary 180.0 [(IQR: – 33.0 - 223.3 min/day); 595.5

		The data collected was used as baseline measures for the RCT.	min/day (IQR: 413.5-863.4) min/ • day) respectively] • They actively engaged in light physical activity 116.6 (IQR:–92.8 - 140.2 min/day) and moderate to vigorous physical activity 47.1 (IQR:–24.2 - 83.6 min/day).
To determine the associations between these activity patterns and select cardiometabolic risk factors among South African office-based workers.	2: 5	This study employed quantitative methods. Data was collected through questionnaires, accelerometers, blood samples and anthropometry measures. The data collected was used as baseline measures for the RCT.	• Sedentary behaviour has a positive association with light physical activity. • Sedentary behaviour showed no association with cardiometabolic outcomes • Systolic and diastolic blood pressure showed an inverse association with light physical activity.

To compare and evaluate to evaluate the effectiveness of a 12-week height-adjustable sit-to-stand intervention on sedentary behaviour and cardiometabolic health outcomes among office-based workers in South Africa	3: 6	This study employed quantitative methods. Data was collected through questionnaires, accelerometers, blood samples and anthropometry measures. Data collected was measured for the RCT.	• Higher BMI was found in both the control and the intervention groups. • The intervention group had higher MVPA values than the control group. • Total cholesterol showed significant trivial effect sizes, while most cardiometabolic outcomes showed non-significant effect sizes.
To investigate the perceptions and experiences of participants who dropped out of sedentary behaviour intervention.	4: 7	This study employed qualitative methods. Data was collected through semi-structured interviews.	• Most participants dropped out of the intervention early because of the bulkiness and poor design of the sit-to-stand height adjustable workstation. • Some participants dropped out of the intervention because it was impractical and

			uncomfortable for them to work while standing

8.2 Emerging themes from the thesis:

8.2.1 Acceptability and feasibility of the sit-to-stand workplace intervention.

This thesis concluded that the height-adjustable sit-stand workstations were generally accepted due to their potential to incorporate light activities to break up prolonged sitting, increase productivity, and improve the overall health of South African office workers. In agreement, Chau and colleagues found that the overall sentiment in a group of desk workers was that the sit-to-stand workstation was acceptable and feasible (195). Previous research has shown that office workers are more likely to adopt sit-to-stand workstations if they perceive benefits (142), ease of use (194), social norms, and support (46). Despite a lack of prior knowledge or experience, our qualitative data indicate that participants were willing to adopt and implement the adjustable height-adjustable sit-to-stand desks in their workplaces. We hypothesize that this may have been influenced by the health implications of prolonged occupational sitting and discovering alternative working methods that are not detrimental to their well-being and overall health.

Contrary to previous studies, our participants in the first qualitative paper reported that alternating between sitting and standing helped alleviate chronic musculoskeletal discomforts and reduced boredom and fatigue (46, 194). Demonstrating a keen interest, these participants expressed their willingness to continue using the workstations if they were freely provided to them. Participants in the first qualitative study accepted the modification of their working environment through height-adjustable sit-to-stand desks, acknowledging that it prompted them to sit less and stand more, enhancing both their concentration and work productivity. Despite the positive feedback from the first qualitative study, the high withdrawal rates observed in the RCT suggest that the universal feasibility of using height-adjustable sit-to-stand desks for alternating between sitting and standing may not apply to all South African office workers. The last qualitative paper suggests that automating small, aesthetically pleasing height-adjustable sit-to-stand desks may be a potential solution to promote increased utilization of these workstations.

8.2.2 Association between sedentary behaviour, physical activity and cardiometabolic outcomes in office workers

Sedentary behaviour was prevalent in our cohort of office workers, with an average of over 10 hours of sedentary time per day, most of which accumulated in the workplace. Similarly, sedentary behaviour patterns observed in this cohort have been documented over the last decade and are associated with mortality and morbidity rates(46, 137). Interestingly, participants in this cohort were significantly participating in light physical activity, and the treatment group in baseline was meeting the minimum recommended moderate to vigorous physical activity. Similarly, previous studies have shown that relocating occupational sedentary behavior with light activities increases energy expenditure and can potentially improve health benefits in a cohort of Japanese employees (1). In the present study, the treatment and control groups in baseline had increased BMI with a mean average for obesity and overweight, respectively. Of concern, the increased prevalence of overweight and obesity in South African adults has been on the rise and is projected to double by 2030 (201).

It should be noted that the relationship between sedentary behaviour and cardiometabolic outcomes was not observed in this cohort, which contrasts with emerging evidence. We hypothesise that these differences could be explained by the smaller sample size used in this study instead of trends observed in the existing literature. In agreement with previous studies, our findings found an association between light physical activity and sedentary behaviour (233, 234). Suggesting that prolonged sitting time is more likely interrupted by bouts of light-intensity daily activities such as attending meetings, printing, lunch, and toilet breaks. Also, this study demonstrates an inverse association between blood pressure and light physical activity (49, 219). Therefore, bouts of light physical activity could be enough to reduce or reverse the burden of NCDs on office workers. Consistent with previous literature, the inverse association between sedentary behaviour and total moderate to vigorous physical activity highlights the significance of increasing higher levels of physical activity, particularly MVPA, while minimizing sedentary behaviour for the best possible health outcomes (137, 235).

8.2.3 Effectiveness of sit-to-stand workplace intervention.

In the qualitative aspects of the thesis, participants find that they were productive in the standing position compared to the seated position, emphasising being able to concentrate and focus intensely on specific work tasks while standing. In support of this notion, studies have demonstrated that introducing a sit-to-stand workstation to the office setting boosts employees' performance and productivity because they feel energised and actively involved in their jobs. Some participants expressed that the sit-to-stand intervention improved their overall health, posture, and ergonomics, alleviating musculoskeletal discomfort. Similarly, a study found that breaking prolonged sitting by incorporating sit-to-stand workstations in the workplace can lower the risks associated with chronic diseases such as obesity and cardiovascular diseases (69). A Cochrane systematic review highlighted the importance of incorporating light activities into the workday to reduce musculoskeletal-related pain(143).

The 12-week sedentary behaviour intervention found small improvements in diastolic blood pressure and light physical activity in a cohort of office workers. Consistent findings were found by similar short-term interventions investigating the effectiveness of a sit-to-stand workstation on sedentary behaviour and cardiometabolic outcomes (14, 28, 192). Although a study hypothesised that long-term sedentary behaviour intervention might significantly affect cardiometabolic outcomes (188), it does not seem to be the case with evidence from a recent randomised control trial (29). Therefore, interrupting prolonged sitting time alone as a behaviour change modification may not significantly improve health outcomes. This study observed trivial effects with most cardiometabolic risk markers. These findings are consistent with several reviews investigating the effectiveness of sedentary behaviour reduction workplace interventions on cardiometabolic risk marker (30, 46, 143). The observed changes in this study should be interpreted with caution because they were not clinically significant and relatively small. An explanation for these small changes could be the smaller sample size used in the study, which may have resulted in insufficient statistical power to identify more significant effects.

8.2.4 Barriers to implementing successful strategies to mitigate prolonged sitting.

Our study shows that over half of our participants thought introducing the sit-to-stand workstation in the workplace was appropriate, while a significant portion faced difficulties and discontinued the intervention earlier. We observed mixed feedback from participants regarding the sit-to-stand workstations, suggesting that the "one size fits all" approach may not be the best way to combat sedentary behaviour in the South African workplace. While some participants were satisfied with the workstation, some found the size of the desk to be cumbersome and had difficulties manually configuring multiple screens when alternating between sitting and standing positions. Previous research has emphasized the need to take height-adjustable sit-to-stand workstation design and functioning into account when implementing these workstations, and there is limited advice addressing the size and aesthetics of these workstations (193, 195). However, it is crucial to recognize that elements like workstation size and aesthetic appeal can impact user satisfaction and usability. Although not extensively explored in the literature, design and functionality should be considered when choosing sit-to-stand workstations that may improve user experience and satisfaction in implementing a successful intervention. Alternatively, workplaces could invest in sit-to-stand desks rather than height-adjustable workstations as they are compact, easy to alternate between sitting and standing postures and look appealing.

Our participants also reported that breaking up prolonged sedentary behaviour by standing for extended periods was considered uncomfortable and strenuous. Consistent with our findings, a study found that a group of Swedish workers had no motivation to stand and work and that standing is tiring and uncomfortable (153). Previous studies have suggested that alternating between sitting and standing improves health benefits and relieves musculoskeletal discomfort, taking two breaks every 20 minutes (30) or 30 minutes throughout a workday (11). Therefore, we suggest standardising sedentary behaviour guidelines regarding the duration and frequency of interrupting prolonged sitting time to address long-standing cycles. Our findings revealed that specific tasks, such as typing, were not feasible to perform while standing instead of sitting. Consequently, participants reported a perceived decrease in productivity and efficiency and opted to use their workstations while seated.

8.3 Strengths and Limitations.

While the specific results chapter delves into strengths and limitations, additional points worth attention for future research are listed below.

8.3.1 Below are some of the Strengths of this study.

- This study has several strengths and limitations worth noting. This PhD thesis was acceptable and effective in interrupting prolonged sitting with bouts of light activities and improving cardiometabolic health outcomes with a height-adjustable sit-to-stand workstation. This study adds to the existing body of knowledge and attempts to close research gaps in workplace interventions to address sedentary behaviour and cardiovascular diseases in South African workers.
- This study's significant strength is using qualitative and quantitative approaches to investigate sedentary behaviour in a cohort of office workers. Qualitative studies used in-depth semi-structured interviews to understand the acceptability, feasibility, and practicality of the height-adjustable sit-to-stand workstation intervention on South African office-based workers. Meanwhile, quantitative studies used objective measures to collect cardiometabolic risk markers, sedentary behaviour, and physical activity.

8.3.2 Below are some of the limitations encountered in this study.

- The results of this study might not be generalised beyond university administrative staff and credit bureau employees because of the study's small sample size and a high proportion of female participants.

- The study also used a convenient sampling for qualitative and quantitative studies, which may have produced a healthier sample and yielded positive outcomes. Therefore, the results may not be generalizable to other populations of interest.
- Data collection for this study commenced before the onset of the COVID-19 pandemic, which significantly impacted participation rates. Additionally, participants had to adjust to the new reality of working from home, frequently without adequate workstations, resulting in many dropouts. Most participants reported job loss, voluntary resignation, or migration as a direct result of the epidemic.
- The accelerometery used in this study presented difficulties distinguishing between standing postures and bouts of light activities during the day, limiting the ability to define light physical activity accurately.
- The duration of the study was short; as a result, we could not observe significant long-term improvements in sedentary behaviour and cardiometabolic outcomes.

8.4 Recommendations for future research.

This thesis project has identified the following areas that warrant consideration for future research:

- Longitudinal studies using objective measures and accelerometery are needed to quantify the relationship between sedentary behaviour, physical activity, and cardiovascular diseases of office-based employees. Longitudinal data will help us better understand how sedentary behaviour and insufficient physical activity impact the occurrence of cardiometabolic risk factors in the African population.
- Future studies should consider the inclusion of multiple clusters in a trial to diversify the population, ensure a large sample size and reduce contamination. This will ensure the validity and generalisation of the results to a broader population of office workers.

- There is a need to develop long-term randomised control trials (> 12 months) to reduce sedentary behaviour and improve cardiometabolic markers in office-based workers. Given the increased prevalence of obesity and related cardiometabolic diseases in our setting, there is a need to understand the effects of occupational sedentary behaviour on workers' health, given the paucity of data in South Africa.
- For future interventions in the workplace, we recommend including various stakeholders such as managers, policymakers, HR personnel and workplace champions in the design and implementation process. This collaborative approach will enable the development of tailored interventions and can affect policy change in the respective setting. In addition, incorporating peer motivation by a colleague with a workload might aid in the effectiveness of the sedentary behaviour intervention in reducing occupational sitting and cardiometabolic risk markers.

Specific recommendations on results were discussed in each chapter.

8.5 Conclusion

This study supports the growing body of knowledge on the strategies to address the link between sedentary behaviour and cardiovascular diseases in office workers. Qualitative aspects of the thesis provide evidence that a stand workstation is practical and feasible for interrupting occupational sitting and improving work productivity and overall health. This study confirmed a high prevalence of sedentary behaviour and cardiometabolic risk factors in South African office workers, particularly obesity. This is of concern, considering the increased burden of obesity in South Africa. Most participants met the minimum recommendation of 30 minutes of moderate to vigorous physical activity daily.

Further research is warranted to investigate which domain these physical activity patterns were accumulated. The finding of this thesis is that the sedentary behaviour intervention had minor improvements and promised to improve cardiometabolic outcomes, suggesting that long-term interventions yield significant clinical changes in cardiometabolic risk factors of office-based workers. Despite the high dropout observed in this study, participants expressed that they were willing to continue with the intervention if provided with a sit-to-stand desk instead of the height-adjustable-sit-to-stand workstation, as they are easy to use and aesthetically appealing.

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Appendices

Appendix 1 Ethical Clearance Certificate

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R14/49 Dr Philippe Gradidge

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M190224

NAME: **(Principal Investigator)**	Dr Philippe Gradidge
DEPARTMENT:	Centre for Exercise Science and Sports Medicine TransUnion Africa
PROJECT TITLE:	Ukumela impilo: A randomised controlled trial targeting sendentary behaviour to address cardiovascular disease risk factors in office workers
DATE CONSIDERED:	22/02/2019
DECISION:	Approved unconditionally
CONDITIONS:	Phase 1 only
SUPERVISOR:	
APPROVED BY:	Dr CB Penny, ~~Chairperson,~~ HREC (Medical)
DATE OF APPROVAL:	12/04/2019

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized
to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **February** and will therefore be due in the month of **February** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature   Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 2 Permission to conduct the study (Study setting 1)

TransUnion

Prof. P. Cleaton-Jones
Chair
Human Research Ethics Committee (Medical)
University of the Witwatersrand

04 February 2019

PERMISSION TO CONDUCT RESEARCH

Dear Sir,

We hereby confirm that TransUnion gives Dr Philippe Gradidge, principal investigator of the TransUnion Africa study, permission to conduct the research entitled "*Ukumela impilo: A randomised controlled trial targeting sedentary behaviors associated with cardiovascular disease amongst office workers*" at TransUnion Africa.

Sincerely,

Ndivhu Nepfumbada
Senior Director, HR | TransUnion Africa

TransUnion Africa: Wanderers Office Park, 52 Corlett Drive, Illovo, 2196. P: +27 011 214 6000 (Johannesburg)
TransUnion Africa (Pty) Ltd. Reg. No. 1992/007124/07
Director: Y. Naik, D. Neenan (USA), H. Karrim, T. Cello (USA), H. Russell (USA), G. Friedlander - (alternative director) (USA)

transunion.co.za

Appendix 3 Permission to conduct the study (Study setting 2)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

2021/12/06

Professor P Gradidge
School of Therapeutic Sciences
Centre for Exercise and Sports Medicine
Medical School
University

Sent by e-mail to: Philippe.Gradidge@wits.ac.za

Dear Professor Gradidge

Re: **Protocol Ref No:** M190224
Protocol Title: *Ukumela impilo: A randomised controlled trial targeting sendentary behaviour to address cardiovascular disease risk factors in office workers*
Principal Investigators: Professor P Gradidge

I refer to your e-mail of 2021/10/26 and our subsequent discussions.

We have no problem in principle with you extending Phase 1 of your study to members of the Wits administrative and secretarial staff, subject to you getting the necessary management permissions.

Thank you for keeping us informed.

Yours Sincerely

I. Burns
....
Mr I Burns
For the Human Research Ethics Committee (Medical)

CB Penny
....
Dr CB Penny, Chairperson, Human Research Ethics Committee (Medical)

Appendix 4 Information Sheet

Good Day. My name is Ms Merling Phaswana and I am a registered PhD student at the Centre for Exercise Science and Sports Medicine, University of the Witwatersrand, Johannesburg

I would like to invite you to consider participating in our research study, entitled "Sedentary behaviour in a sample of south african office-based workers."

The study will be conducted at TransUnion Africa and the University of the Witwatersrand, Johannesburg South Africa.

Your personal information will remain confidential, and participation is completely voluntary. There are no risks involved, and withdrawal from the study will not result in any penalties, loss of benefits, or prejudice. Your participation in this study is essential, and there are no right or wrong answers.

The research will consist of three phases: baseline, 3 months and 6 months follow up interventions, participants will complete of a questionnaire on demographics, sedentary behaviour, mental health, absenteeism, diet, smoking and alcohol consumption. In addition to measuring your height, weight, waist and hip circumference, blood pressure, blood glucose, total cholesterol, HDL, LDL, triglycerides and Hb1Ac.

Thank you for considering participating, if you have any questions, or wish to obtain a copy of the results of this survey, please contact the following people:

Mrs Phaswana Merling (Student)

(Tel) (011) 717 3372 (email) merling.phaswana@wits.ac.za

Kind regards

Merling Phaswana

Appendix 5 Consent Form

Title of the research study: Sedentary behaviour in a sample of south african office-based workers

Name of participant: ____

Participant’s involvement: You are requested to take part in this survey, which will determine the effects of a 12 weeks sit-stand desk workstation in comparison with health messages on anthropometry, blood pressure and cardiometabolic risk factors associated with sedentary behaviour in office workers
Nature of the research: This is a randomized controlled trial involving 12 weeks ’ workstation and healthy messages to address sedentary behaviour associated with cardiovascular diseases at the workplace.
What’s involved? This study involves 12 weeks ’ workstation and healthy messages intervention, baseline, 6 months follow up measurements of height, weight, waist, hip, circumference, blood pressure, cholesterol, glucose and Hb1Ac; also, I will be asking questions around socioeconomic status, smoking, physical activity level, diet and sleep behaviour.
Risks: There are no risks or side effects involved in this study. The intervention is expected to be a positive, informative & exciting experience.
Benefits: Your Participation will benefit you in terms of health-wise, you will know your physical activity level and benefits of engaging in physical activity which will help you make better future decisions concerning your health. However, there are no direct benefits to participating in this research project.

- I hereby confirm that I have been informed by the researchers, Ms Phaswana Merling about the nature, conduct, benefits and risks of the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- Given the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.

- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

Participant signature___________________________

Witness signature_____________________________

Researcher signature________________________

Appendix 6 Consent form for audio recording of study participation for qualitative studies.

Title of the research study: Sedentary behaviour in a sample of South African office-based workers

I hereby consent to an audio recording of the interview of the focus group discussion.

I understand that:

The recording will be stored in a secure location (a locked cupboard or password-protected computer) with restricted access to the researcher and the research supervisor.
The recording will be transcribed and any information that could identify me will be removed,
The recordings will be erased within either (a) two (2) years of the publication of the research findings, or (b) six (6) years if no publications arise from this research.
Anyone wishing to access this information in the future will first have to obtain the approval of the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg.
Direct quotes from my interview, without any information that could identify me, may be cited in the research report or other write-ups of research.

Name of Participant: ____
Date: ____
Place: ____
Signature ____

Witnessed by:
Name of Witness: ____
Signature: ____
Date: ____

Appendix 7 Questionnaire

Title of the research study: Sedentary behavior in a sample of south african office-based workers

Participant code:

Dear Participant

Please complete the following questions. The researcher will do the measurements.

Section 1: Demographics and socioeconomic status

1.1. What is your Age?

1.2. What is your gender? Please tick the appropriate box

Male	Female

1.3. What is your highest level of school education? Please tick the appropriate box.

No school	Primary school (Grade 1 to 7)	Incomplete high school (Grade 8 to Grade 11, and did not complete grade 12)	Matric (Completed grade 12/ standard 10)	Diploma/ College certificate	Degree University	Postgraduate degree

1.4. What is your occupation type? Please tick the appropriate box

1.5. What is your net salary per month? Place an ‘X’ over the appropriate answer.

Prefer not to answer	<R15000	R20000-R25000	R25000-R30000	≥R30000

Section 2: Absenteeism

1. About how many hours altogether did you work in the past 7 days? (If more than 97, enter

97.)

Number of hours (00-97)

2. How many hours does your employer expect you to work in a typical 7-day week? (If it varies, estimates the average. If more than 97, enter 97.)

Number of hours (00-97)

3. Now please think of your work experiences over the past 4 weeks (28 days). In the spaces provided below, write the number of days you spent in each of the following work situations.

In the past 4 weeks (28 days), how many days did you... Number of days (00-28)

3.1. Miss an entire workday because of problems with your physical or mental health? (Please include only days missed for your own health, not someone else’s health.)

3.2. Miss an entire workday for any other reason (including vacation)?

3.3. Miss part of a workday because of problems with your physical or mental health? (Please include only days missed for your own health, not someone else's health.)

3.4. Miss part of a workday for any other reason (including vacation)?

3.5. Come in early, go home late, or work on your day off?

4. About how many hours altogether did you work in the past 4 weeks (28 days)? (See examples below.)

Number of hours in the past 4 weeks (28 days)

Examples for Calculating Hours Worked in the Past 4 Weeks
• 40 hours per week for 4 weeks = 160 hours • 35 hours per week for 4 weeks = 140 hours • 40 hours per week for 4 weeks with 2 8-hour days missed = 144 hours • 40 hours per week for 4 weeks with 3 4-hour partial days missed = 148 hours • 35 hours per week for 4 weeks with 2 8-hour days missed and 3 4-hour partial days missed = 112 hours

5. On a scale from 0 to 10 where 0 is the worst job performance anyone could have at your job and 10 is the performance of a top worker, how would you rate the usual performance of <u>most</u> workers in a job similar to yours?

0	1	2	3	4	5	6	7	8	9	10

Worst performance Top performance

6. Using the same 0-to-10 scale, how would you rate your usual job performance over the past year or two?

0	1	2	3	4	5	6	7	8	9	10

Worst performance Top performance

7. Using the same 0-to-10 scale, how would you rate your overall job performance on the days you worked during the past 4 weeks (28 days)?

0	1	2	3	4	5	6	7	8	9	10

Worst performance Top performance

3. Medical History

3.1. Family history: Do you have a family history (parents or siblings) of any of the following medical conditions? (Tick yes for each disease and indicate if they had a disease before or at the age of 50).

Heart disease	Yes	Before or at the age of 50
Insulin-dependent diabetes	Yes	Before or at the age of 50
Non-insulin dependent diabetes	Yes	Before or at the age of 50
Peripheral vascular disease	Yes	Before or at the age of 50
High cholesterol	Yes	Before or at the age of 50
High blood pressure	Yes	Before or at the age of 50
Stroke	Yes	Before or at the age of 50
Cancer	Yes	Before or at the age of 50

3.2. Personal medical history: Have you suffered or do you suffer from any of these medical conditions? (Tick yes for each disease and indicate if they had a disease before or at the age of 50).

Heart disease	Yes	Before or at the age of 50
Insulin-dependent diabetes	Yes	Before or at the age of 50
Non-insulin dependent diabetes	Yes	Before or at the age of 50
Peripheral vascular disease	Yes	Before or at the age of 50
High cholesterol	Yes	Before or at the age of 50
High blood pressure	Yes	Before or at the age of 50
Stroke	Yes	Before or at the age of 50
Cancer	Yes	Before or at the age of 50
Peripheral vascular disease	Yes	Before or at the age of 50
Exercise-induced asthma	Yes	Before or at the age of 50

Asthma	Yes	Before or at the age of 50

Diagnosed by?	Cardiologist	Specialist physician	Medical practitioner	Blood test
Diagnosed when?	In the past year	1-5 years ago	> 5 years ago	
Specific intervention?	Healthy dietary habits	Medication	Regular activity	

3.3. Medication: Are you currently on medication for heart disease, peripheral vascular disease, cholesterol and/or blood pressure?

Yes	No

If yes, please write your medical condition, name of medication and dosages, below:

Condition: e.g. Cholesterol	Medication: e.g. Lipitor	Dosage: e.g. 10mg 1/day

Pregnancy

Are you currently pregnant? □ Yes □ No

If yes, how many months pregnant are you? (e.g. 5) ____________ Months

Section 3: Behaviours

Smoking status: Please tick the appropriate box relating to your smoking

Never smoked ☐

How long have you been an ex-smoker?

☐ less than 3 months	☐ 1-5 years	☐ 11-15 years	☐ less than 1 year	☐ 6-10 years	☐ more than 15 years

Current smoker ☐

☐ <10 per day	☐ 10-20 per day	☐ 21-30 per day	☐ > 30 per day
☐ Cigar	☐ Pipe	☐ Cigarettes	☐ Chewing Tobacco/Snuff

.

Regularly use E-cigarettes/vaping? ☐

☐ Less than weekly but at least once/month			☐ less than daily	☐ usually every day	
What strength(s) of nicotine do you currently vape with?					
☐ No nicotine	☐ 1-6 mg nicotine/mL	☐ 7-12 mg nicotine/mL	☐ 13-18 mg nicotine/mL	☐ over 18mg nicotine/mL	☐ I don't know

For smokers only: Please tick only one of the options that best describe your current smoking

- I have no intention of becoming tobacco-free in the next 6 months.
- I intend to become tobacco-free in the next 6 months.

- I am trying to become tobacco-free, but I am not always successful
- Although I am currently using tobacco again, in the past I have been tobacco-free for more than 3 months

4.2. Alcohol use: Please make the appropriate selection relating to your weekly alcohol consumption.

- I don’t have any alcoholic drinks
- Nevermore than 1-2 drinks per occasion or per day
- 3 or more drinks in a day, more than once a week and/or more than 4 drinks at a time
- 3-4 drinks in a day, only 2-3 per month
- 3-4 drinks in a day, 4 times per month

Stress management:

Are you coping with your daily stress?

☐ No, and I have no intention to implement coping strategies in the next 6 months.

☐ No, but I intend to learn how to cope with my daily stress in the next 6 months.

☐ I am trying to cope but I do not always cope successfully

☐ Yes, I have been coping with my daily stress, but for LESS than 6 months.

☐ Yes, I have been coping with my daily stress for MORE than 6 months.

☐ Although I am not coping with my daily stress, in the past I have coped well for more than 3 months.

Mental health (CES-D-R 10)

Below is a list of some of the ways you may have felt or behaved.

Please indicate how often you have felt this way during the past week by checking the appropriate box for each question.

	Rarely or none of the time (less than 1 day)	Some or a little of the time (1-2 days)	Occasionally or a moderate amount of time (3-4 days)	All of the time (5-7 days)
1. I was bothered by things that usually don't bother me.				
2. I had trouble keeping my mind on what I was doing.				
3. I felt depressed.				
4. I felt that everything I did was an effort.				
5. I felt hopeful about the future.				
6. I felt fearful.				
7. My sleep was restless				
8. I was happy.				
9. I felt lonely.				
10. I could not "get going."				

Dietary assessment

Think about your eating habits over the past year or so. Approximately how often do you eat of the following foods? Tick one box for each food.

Meat/Snack	Never/Once or less than once per month	2-3 times per month	1-2 times per week	3-4 times per week	5+ times per week

Hamburgers or cheeseburgers					
Red meat, e.g. beef and mutton					
Fried chicken (with skin)					
Hot dogs, frankfurters, salami, Russians, sausages					
Cold meats, e.g. colony, cheese/olive loaf, beef (+ fat), etc.					
Salad dressing, mayonnaise					
Margarine or butter					
Eggs					
Bacon or pork sausage					
Cheese or cheese spread					
Full-cream milk					
Potato chips (“slap chips”)					
Potato crisps, corn chips, popcorn, etc.					
Ice cream Doughnuts, cake, cookies, puddings, etc.					

Think about your eating habits over the past year or so. Approximately how often do you eat of the following foods? Tick one box for each food.

Fruit/vegetables/fibre	Never/Once or less than once per month	2-3 times per month	1-2 times per week	3-4 times per week	5+ times per week
Brown rice/whole-wheat pasta					
Fruit (not counting juice)					
Green salad					
Potatoes with skin					
Dried beans, e.g. baked beans, kidney beans, legumes					
Other vegetables					
High-fibre/bran cereal or high-fibre bread or oat porridge					
Whole-wheat, brown or high-fibre bread (e.g. rye)					

Do you currently feel that you are following a healthy diet?

- No, and I have no intention of following a healthy diet in the next 6 months.
- No, but I intend to follow a healthy diet in the next 6 months.
- I am trying to follow a healthy diet, but I am not always successful.
- Yes, I have been following a healthy diet, but for LESS than 6 months.

- Yes, I have been following a healthy diet for MORE than 6 months.
- Although I am currently following a healthy diet, in the past I have followed a healthy diet for more than 3 months.

Beverage intake questionnaire

Instructions:

In the past month, please indicate your response for each beverage type by marking an "X" in the bubble for "how often" and "how much each time".

1. Indicate how often you drank the following beverages, for example, if you drank 5 glasses of water per week, mark 4-6 times per week.
2. Indicate the approximate amount of beverage you drank each time, for example, if you drank 1 cup of water each time, mark 1 cup under "how much each time".

NOT in the milk categories.

3. Do not count beverages used in cooking or other preparations, such as milk in cereal.
4. Count milk added to tea and coffee in the tea/coffee with cream beverage category

	HOW OFTEN (MARK ONE)							HOW MUCH EACH TIME (MARK ONE)				
Type of Beverage	Never or less than 1 time per week (go to next	1 time per week	2-3 times per week	4-6 times per week	1 time per day	2+ times per day	3+ times per day	Less than 6 fl oz (3/4	8 fl oz (1 cup)	12 fl oz (1 1/2 cups)	16 fl oz (2 cups)	More than 20 fl oz (2 1/2

	bevera ge)							cu p)				cup s)
Water												
100% Fruit Juice												
Sweetened Juice Beverage/ Drink (fruitage, lemonade, punch, Sunny Delight)												
Whole Milk												
Reduced Fat Milk (2%)												
Low Fat/Fat-Free Milk (Skim, 1%, Buttermilk, Soymilk)												
Soft Drinks, Regular												
Diet Soft Drinks/Artificially Sweetened Drinks (Crystal Light)												

Sweetened Tea												
Tea or Coffee, with cream and/or sugar (includes non-dairy creamer)												
Tea or Coffee, black, with/ without artificial sweetener (no cream or sugar)												
Beer, Ales, Wine Coolers, Non-alcoholic or Light Beer												
Hard Liquor (shots, rum, tequila, etc.)												
Wine (red or white)												
Energy & Sports Drinks (Red Bull,												

Rockstar, Gatorade, Powerade, etc.)												
Other (list):												

SIT-Q-7days: Questionnaire

These questions are about the amount of time that you spent sitting or lying down in the last 7 days. This questionnaire is organised into five sections, each asking about sitting or lying down in different settings.

Please first answer the question below and read the instructions underneath, which will help you to complete this questionnaire.

Please tick (□) one box only

Compare your amount of <u>sitting time</u> over the last 7 days with a typical week for you. In the last 7 days, my amount of sitting was …				
Much less than normal	A little less than normal	About the same	A little more than normal	A lot more than normal

Instructions:

1. Please complete the following sections by thinking about the last 7 days.
2. Each period of sitting down should only be entered once on this questionnaire. For example, if you spent one hour sitting on the sofa reading a book while you were listening to music, count this time as one hour reading if this was your main focus. Do not also count this as one hour listening to music.
3. If there is a big difference between different weekdays or between different weekend days for some answers, then tick the box which is nearest to the average for those weekdays or weekend days in the last 7 days.

4. The focus of this questionnaire is sitting and lying while doing the activities specified below. If some of these activities also involved standing or walking around, please try to only include the time spent sitting and lying during these activities.
5. If you tick the wrong box, please put a large cross through it and then tick the correct box.

Please try to answer every question as accurately and honestly as possible. Your answers will be treated as strictly confidential.

SECTION 1 – SLEEPING AND NAPPING

Sleeping

Think about what time you went to sleep and got up in the last 7 days. If you had variable sleeping patterns (e.g. you did shift work), please record the average time you went to bed and got up on weekdays and on weekend days.

DO NOT INCLUDE:

Reading or watching TV before falling asleep or after waking. This is part of section 5.

	1. In the last 7 days,	
	at what time did You get up?	at what time did you get up?
Weekday	_____(pm ☐ / am ☐)	_____(pm ☐ / am ☐)
Weekend day	_____(pm ☐ / am ☐)	_____(pm ☐ / am ☐)

Napping

A nap is a brief period of sleep, often during the day. A nap can be taken on a sofa as well as in a bed.

Please tick (□) one box only per line.

	2. In the last 7 days, on average, how long did you nap per day?					
	No daily napping	1-15 min	15-30 min	30-45 min	45 min- 1 hour	More than 1 hour
Weekday						
Weekend day						

SECTION 2 – MEALS

Please think about the amount of time you spent sitting for breakfast, lunch and dinner, on average in the last 7 days.

➔ DO NOT INCLUDE:

- Time spent eating while watching TV. This is part of section 5.

➔ DO INCLUDE:

time spent sitting for breakfast, lunch and dinner (at home, work,…), also when you were reading, chatting to other people or listening to the radio. For example, if you spent 30 minutes sitting for breakfast while reading the newspaper, or for lunch while working, then include this in this section.

Please tick (□) one box only per line.

	3. In the last 7 days, on average, how long did you sit for each of these meals per day?

	None	1-10 min	10-20 min	20-30 min	30-45 min	45 min-1 hour	More than 1 hour a day
Weekday							
Breakfast							
Lunch							
Dinner							
Weekend day							
Breakfast							
Lunch							
Dinner							

SECTION 3 – TRANSPORTATION

This section refers to the time you spent sitting during transportation (travelling in a car, bus, train, on a motorbike, etc.) in the last 7 days. The questions are about travelling to and from your occupation, travelling as part of your occupation, and getting about apart from your occupation.

"Occupation" refers to three different types of activities: work, study and volunteering. "Work" refers to all tasks done to earn money. "Study" refers to educational activities. "Volunteering" refers to work that you do for no pay, such as helping in a sports club. Please think about all three of these categories for the following questions.

➔ DO NOT INCLUDE:

- cycling on a pedal bicycle

9.	4. Have you been working, studying or volunteering (referred to as "occupation") in the last 7 days?	Yes □ No □

➔ If you did not have an occupation in the last 7 days, please skip to the "Getting about – apart from your occupation" section below.

➔ If you did have an occupation, please answer the questions below. There is space for two different occupations ("Occupation 1" and "Occupation 2").

Travelling to and from your occupation

5. In the last 7 days, how many days a week did you sit while travelling to and from your occupation? (in a car, bus, train, on a motorbike, etc.; do not include cycling on a pedal bicycle)

Occupation : _____________ days

Please tick (□) one box only per line.

	6. In the last 7 days, on average, how long did you sit while travelling to and from your occupation on such a day? (in a car, bus, train, on a motorbike, etc.; do not include cycling on a pedal bicycle)												
	None	1-15 min	15-30 min	30-45 min	45 min1 hour	1-1.5 hours	1.5-2 hours	2-2.5 hours	2.5-3 hours	3-4 hours	4-5 hours	5-6 hours	6-7 hours	More than 7 hours
Occupation													

Travelling as part of your occupation

Now think about the time you sit while travelling as part of your occupation, for example driving from one customer to another, driving a taxi, etc.

7. In the last 7 days, how many days a week did you sit while travelling as part of your occupation? (in a car, bus, train, on a motorbike, etc.; do not include cycling on a pedal bicycle)	Occupation: ___________days

Please tick (□) one box only per line.

	8. In the last 7 days, on average, how long did you sit while travelling as part of your occupation on such a day? (in a car, bus, train, on a motorbike, etc.; do not include cycling on a pedal bicycle)												
	None	1-15 min	15-30 min	30-45 min	45 min-1 hour	1-1.5 hours	1.5-2 hours	2-2.5 hours	2.5-3 hours	3-4 hours	4-5 hours	5-6 hours	6-7 hours	More than 7 hours
Occupation													

Getting about – apart from your occupation

Now think about the time you sit while getting about apart from your occupation, for example when going to the supermarket, going to visit friends, etc. Please include time spent sitting to and from your destination.

Please tick (□) one box only per line.

	9. In the last 7 days, on average, how long did you <u>sit</u> for getting about <u>apart from your occupation</u> per <u>day</u>? (in a car, bus, train, on a motorbike, etc.; <u>do not</u> include cycling on a pedal bicycle)													
	None	1-15 min	15-30 min	30-45 min	45 min-1 hour	1-1.5 hours	1.5-2 hours	2-2.5 hours	2.5-3 hours	3-4 hours	4-5 hours	5-6 hours	6-7 hours	More than 7 hours
Weekend														
Weekend day														

SECTION 4 – WORK, STUDY AND VOLUNTEERING

This section is about the time you spent <u>sitting</u> during your occupation, which refers to work, study and volunteering. Please think about <u>all three</u> of these categories for the following questions.

10. Did you have an “occupation” in the last 7 days?	Yes □ No □

- ➔ If you did not have an occupation in the last 7 days, please skip to section 5.
- ➔ If you did have an occupation, please complete this section. There is space for two different occupations (“Occupation 1” and “Occupation 2”).

11b. Type of occupation

Work □

Study □

Volunteering

□

12b. Name of occupation (e.g. receptionist) ____________________

13b. How many days did you do occupation in the last 7 days?______________________ days

14b. In the last 7 days, on average, how much time per day did you spend sitting while doing occupation?

□ DO NOT INCLUDE:

- Time spent sitting for transportation (in a car, bus, train, on a motorbike, etc.) either for travelling to and from this occupation, or as part of this occupation. This was part of section 3.
- Breakfast, lunch or dinner. This was part of section 2.

Please tick (□) one box only

None	1-15 min	15-30 min	30 min-1 hour	1-2 hours	2-3 hours	3-4 hours	4-5 hours	5-6 hours	6-7 hours	7-8 hours	More than 8 hours

15b. In the last 7 days, on average, how many times per day did you interrupt your sitting time while doing the occupation, for example by standing up, walking somewhere, or getting a coffee________ times?

16. Did you have a second occupation in the last 7 days?

Yes □

No
□

➔ If you did not have a second occupation in the last 7 days, please skip to section 5.

➔ If you did have a second occupation in the last 7 days, please answer the questions below.

SECTION 5 – SCREEN TIME AND OTHER ACTIVITIES

This last section refers to the time you spent sitting or lying down during other activities in the last 7 days. Remember, each period of sitting down should only be entered once. For example, if you spent one hour sitting on the sofa reading a book while you were listening to music, count this time as one hour reading if this was your main focus. Do not also count this as one hour listening to music.

Screen time

Please tick (□) one box only per line.

	17. In the last 7 days, on average, how long did you spend sitting or lying down in the following activities per day?											
		None	1-15 min	15-30 min	30 min-1 hour	1-2 hours	2-3 hours	3-4 hours	4-5 hours	5-6 hours	6-7 hours	More than 7 hours

Watching TV, DVDs/videos DO include meals while sitting and watching TV	Weekday											
	Weekend day											
Using computer apart from work (internet, e-mail, chat, networking (Facebook))	Weekday											
	Weekend day											
Playing computer games (Playstation, Xbox). DO NOT include non-sitting games	Weekday											
	Weekend day											

Watching TV, DVDs/videos DO include meals while sitting and watching TV	Weekday											
	Weekend day											
Using computer apart from work (internet, e-mail, chat, networking (Facebook))	Weekday											
	Weekend day											
Playing computer games (Playstation, Xbox). DO NOT include not sitting games	Weekday											
	Weekend day											
Watching TV,	Weekday											

DVDs/videos DO include meals while sitting and watching TV	Weekend day												

Now think about the total time you spent watching TV in the last 7 days.

☐ If you did not watch TV in the last 7 days, please skip to the "Other activities" section below.

☐ If you did watch TV in the last 7 days, please answer the questions below.

18. In the last 7 days, on average, how many times per day did you interrupt your sitting time while watching TV for example, by standing up, walking somewhere, or getting a drink_______________ times

Snacking while watching TV

This is about how often you had snacks or drinks while watching TV in the last 7 days in addition to your usual meals. Only think of snacks which are not part of your breakfast, lunch or dinner.

Please tick (☐) one box only per line.

	19. In the last 7 days, on average, how often did you have the following snacks or drinks while watching TV in addition to your breakfast, lunch or dinner?

	None	1-15 min	15-30 min	30 min-1 hour	1-2 hours	2-3 hours	3-4 hours	4-5 hours	5-6 hours	6-7 hours	More than 7 hours
Savoury snacks (e.g. crisps, salted nuts)											
Sweets, chocolate(s) (bars), cakes, biscuits											
Ice cream, chocolate mousse											
Yoghurt, rice pudding											
Soda (e.g. coke)											
Fruit juice											
Squash											
Milk, milkshake, hot chocolate											
Tea or coffee											
Alcoholic drinks (e.g. beer, wine, spirits)											
Other:_____________											

Other activities

Please remember that each period of sitting down should only be entered once.

Please tick (□) one box only per line.

	20. In the last 7 days on average, how long did you spend sitting or lying down in the following activities per day?										
		None	1-15 min	15-30 min	30 min-1 hour	1-2 hours	2-3 hours	3-4 hours	4-5 hours	5-6 hours	6-7 hours	More than 7 hours
Sitting while reading (book, magazine, newspaper,…)	Week day											
	Week end day											
Sitting while doing household tasks (cooking, ironing,…)	Week day											
	Week end day											
Sitting while caring for children,	Week day											
	Week end day											

grandchildren, elderly or disabled relatives												
Sitting for hobbies (Playing piano, cards, doing crosswords,)	Week day											
	Week end day											
Sitting for socializing (visiting friends, pub, cinema, sporting event…)	Week day											
	Week end day											
Sitting while listening to music (radio, CD, MP3, iPod)	Week day											
	Week end day											
Sitting for other activities(write below):	Week day											
	Week end day											

Anthropometric measures

Height (cm)	
Weight (kg)	
Waist circumference (cm)	
Hip circumference (cm)	

Blood Pressure and pulse rate

Reading	1	2	3
Systolic blood pressure (mm Hg)			
Diastolic blood pressure (mm Hg)			
Pulse (bpm)			

Blood samples

	Reading
Random blood glucose (mmol/L)	
Hb1Ac (%)	
Triglycerides (mg. dl^{-1})	
Total Cholesterol (mg. dl^{-1})	
High-density lipoprotein cholesterol (mg. dl^{-1})	
Low-density lipoprotein cholesterol (mg. dl^{-1})	

Queens College Step Test (3-minute step test)

The step test uses a 41.3 cm step with a stepping rate of 24 steps/minute for men and 22 steps/minute for women for a period of 3 minutes. Within 5 seconds of the participant sitting, a research assistant will measure the post-exercise heart rate (HR). Maximal oxygen uptake (VO_{2max}) will be calculated for men (VO_{2max}= 111.33 – (0.42 x HR) and women (VO_{2max}= 65.81 – (0.1847 x HR).

Bench height 41.25 cm	Post exercise heart rate (standing)	VO_{2max} (ml/kg/min)
Male (24 steps/min^{-1})		= 111.33 - (0.42 x heart rate (bpm))
Female (22 steps/min^{-1})		= 65.81 - (0.1847 x heart rate (bpm)

Appendix 8 Co-author agreement for study one: standing up against office sitting – a study protocol.

Declaration: Student's contribution to article(s) and agreement of co-author(s)

I, [Merling Phaswana], student number [1406668], declare that this Thesis is my own work and that I contributed adequately towards research findings published in the article(s) stated below which are included in my Thesis.

Signature of Student **Date** 04/04/2023

Name of Primary Supervisor Associate Professor Philippe Jean-Luc Gradidge

Signature of Primary Supervisor ....**Date** 04/04/2023

Agreement by co-authors: By signing this declaration, the co-authors listed below agree to the use of the article(s) by the student as part of his/her Thesis/Dissertation/Research Report. In cases where the student is not the 1st author of a published article, the primary supervisor must explain (under comments) why the student is entitled to use the paper for his/her degree purposes.

Article 1: Title: Standing up against office sitting: A study protocol
Journal name, year, volume and page numbers: *South African Journal of Physiotherapy, 2020, 76: 1-6*

Authors	Name	Signature	Date
1st author	Philippe Jean-Luc Gradidge		04/04/2023
2nd author	Merling Phaswana		04/04/2023
3rd author	Katrien Wijndaele		04/04/2023
4th author	Nigel Crowther		04/04/2023
5th author	Catherine Draper		04/04/202
6th author			

Comments by primary supervisor:

The candidate is housed within the PI's (supervisor) larger research project. This PhD thesis provides formative data for this project.

Appendix 9 Co-author agreement Study Two: "If money was no object": a qualitative study of South African university office workers' perceptions of using height-adjustable sit-stand desks

Declaration: Student's contribution to article(s) and agreement of co-author(s)

I, [Merling Phaswana], student number [1406668], declare that this Thesis is my own work and that I contributed adequately towards research findings published in the article(s) stated below which are included in my Thesis.

Signature of Student Date 04/04/2023

Name of Primary Supervisor Associate Professor Philippe Jean-Luc Gradidge

Signature of Primary Supervisor ....**Date** 04/04/2023.

Agreement by co-authors: By signing this declaration, the co-authors listed below agree to the use of the article(s) by the student as part of her Thesis. In cases where the student is not the 1st author of a published article, the primary supervisor must explain (under comments) why the student is entitled to use the paper for his/her degree purposes.

Article 2: Title: If money was no object": A qualitative study of South African university office workers' perceptions of using height-adjustable sit-stand desks

Journal name, year, volume and page numbers: *South African Journal of Sports Medicine 2022, 34:1-6.*

Authors	Name	Signature	Date
1st author	Philippe Jean-Luc Gradidge		04/04/2023
2nd author	Merling Phaswana		04/04/2023
3rd author	Josephine Yuk-Yin Chau		11/04/2023
4th author			
5th author			
6th author			

Comments by primary supervisor:

The candidate has contributed significantly to the articles. The data presented in these articles add evidence to support the interpretation of the findings of this PhD thesis.

Appendix 10 Interview guide for study two

What motivated you to participate in the trial of the sit-stand workstation?

What were your general impressions of using the sit-stand workstation?

Prompts

How much did you use the sit-stand workstation?

Was there anything about using the sit-stand workstation that you particularly liked?

Was there anything that you particularly disliked?

Any comments about the work surface attached to the workstation?

What types of tasks did you generally do standing up?

Prompts

Where there times of the day when you stood more?

What made you change from standing to sitting?

Were there any reasons for those decisions?

What types of tasks did you generally do sitting down?

Prompts

Where there times of the day when you sat down more?

What made you change from sitting to standing?

Were there any reasons for those decisions?

Did anything encourage you to stand up more to complete your work?

Prompts

Were other people around you using a workstation?

Did certain types of footwear make it easier?

Were you able to stand for long periods over time?

How long did you tend to stand up for each time?

Was there anything that stopped you from standing more than you did?

Prompts

Did being in an open plan office make any difference?

Were there any tasks that were not practical while standing?

Was it comfortable to stand and work?

Did you have any injuries or other personal factors?

What types of physical changes did you notice from using the workstation?

Prompts

Any changes in posture?

Any musculoskeletal changes?

Any changes in tiredness or energy levels?

Were these related to using the workstation?

What types of changes in your work performance did you notice from using the sit-stand workstation?

Prompts

Any effect on productivity?

Any effect on the ability to concentrate?

Would you continue to use the sit-stand workstation if you could?

Prompt: why/why not?

In closing, is there anything else you'd like to say about your experience of using the workstation or about your experience of wearing the activity monitors?

Appendix 11 Co-author agreement Study three: Sedentary behavior , physical activity patterns, and cardiometabolic risk factors in South African office-based workers.

Declaration: Student's contribution to article(s) and agreement of co-author(s)

I, [Merling Phaswana], student number [1406668], declare that this Thesis is my own work and that I contributed adequately towards research findings published in the article(s) stated below which are included in my Thesis.

Signature of Student **Date** 30/11/2023

Name of Primary Supervisor Associate Professor Philippe Jean-Luc Gradidge

Signature of Primary Supervisor ....**Date** 30/11/2023

Agreement by co-authors: By signing this declaration, the co-authors listed below agree to the use of the article(s) by the student as part of her Thesis. In cases where the student is not the 1st author of a published article, the primary supervisor must explain (under comments) why the student is entitled to use the paper for his/her degree purposes.

Article 3: Title: Sedentary behavior, physical activity patterns, and cardiometabolic risk factors in South African office-based workers

Journal name, year, volume and page numbers: *American Journal of Lifestyle Medicine 2023;0(0).doi:10.1177/15598276231210479.*

Authors	Name	Signature	Date
1st author	Merling Phaswana		30/11/2023
2nd author	Neil F. Gordon		11/12/2023
3rd author	Philippe Jean-Luc Gradidge		30/11/2023
4th author			
5th author			
6th author			

Comments by primary supervisor:

The data showcase early evidence of a larger trial and are essential to this PhD thesis

Appendix 12 Co-author agreement Study four: Ukumela Impilo Trial: Preliminary Findings of Height-Adjustable Sit-to-Stand Workstations on Health Outcomes of South African Office Workers

Declaration: Student's contribution to article(s) and agreement of co-author(s)

I, [Merling Phaswana], student number [1406668], declare that this Thesis is my own work and that I contributed adequately towards research findings published in the article(s) stated below which are included in my Thesis.

Signature of Student **Date** 11/12/2023

Name of Primary Supervisor Associate Professor Philippe Jean-Luc Gradidge

Signature of Primary Supervisor ... .**Date** 11/12/2023

Agreement by co-authors: By signing this declaration, the co-authors listed below agree to the use of the article(s) by the student as part of her Thesis. In cases where the student is not the 1st author of a published article, the primary supervisor must explain (under comments) why the student is entitled to use the paper for his/her degree purposes.

Article 4: Title: Ukumela impilo randomised trial: preliminary findings of height-adjustable sit-to-stand workstations on health outcomes of South African office workers.

Journal name, year, volume and page numbers: *BMC Research Notes, 2023, 16, 361 https://doi.org/10.1186/s13104-023-06642-2*

Authors	Name	Signature	Date
1st author	Merling Phaswana		11/12/2023
2nd author	Philippe Jean-Luc Gradidge		11/12/2023
3rd author			
4th author			
5th author			
6th author			

Comments by primary supervisor:

The data showcase early evidence of a larger trial and are essential to this PhD thesis.

Appendix 13 COREQ (Consolidated criteria for Reporting Qualitative research) Checklist

Topic	**Item number**	**Guide questions/description**	**Reported on**
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	Methods, paragraph describing data collection)
Credentials	2	What were the researcher's credentials?	Methods, paragraph describing data collection
Occupation	3	What was their occupation at the time of the study?	Methods, paragraph describing data collection
Gender	4	Was the researcher male or female?	Methods, paragraph describing data collection
Experience and training	5	What experience or training did the researcher have?	Methods, paragraph describing data collection
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	Methods, paragraph describing data collection

Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	Methods, paragraph describing data collection
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	Methods, paragraph describing data collection
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Thematic content analysis (Methods, paragraph describing data analysis)
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience,	Participants were recruited purposively (Methods, paragraph describing

		consecutive, snowball	setting and sample)
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	Participants were recruited by telephone or email or WhatsApp or SMS
Sample size	12	How many participants were in the study?	12
Non-participation	13	How many people refused to participate or dropped out? Reasons?	Six participants refused to participate
Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	Participants houses and their workplace (Methods, paragraph describing setting)
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	No.
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	Age, gender, educational status and salary (Results section, Table 1)
Data collection			

Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	See Appendix 2
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	N/A
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	Data were audio recorded using a Microsoft Teams and digital recorder (Methods, data analysis section)
Field notes	20	Were field notes made during and/or after the interview or focus group?	No
Duration	21	What was the duration of the inter views or focus group?	10–41 minutes
Data saturation	22	Was data saturation discussed?	Yes
Transcripts returned	23	Were transcripts returned to participants for comment and/or correction?	No
Domain 3: analysis and findings			
Data analysis			

Number of data coders	24	How many data coders coded the data?	3
Description of the coding tree	25	Did authors provide a description of the coding tree?	No, however the coding were informed by the interview guide initially and coding was continuously developed.
Derivation of themes	26	Were themes identified in advance or derived from the data?	Themes were identified from the data.
Software	27	What software, if applicable, was used to manage the data?	Atlas.ti was used to manage the data.
Participant checking	28	Did participants provide feedback on the findings?	No.
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	Yes. (see Table 2)
Data and findings consistent	30	Was there consistency between the data presented and the findings?	Yes (see results section).
Clarity of major themes	31	Were major themes clearly presented in the findings?	Yes (see results section).

Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	Yes (see discussion section where major and minor themes are interpreted).

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Appendix 14 Interview guide for study five

Participant code: _________

Dear Participant

Please complete the following questions. The researcher will do the measurements.

Section 1: Demographics and socioeconomic status

1.1. What is your Age?

1.2. What is your gender? Please tick the appropriate box

Male	Female

1.3. What is your highest level of school education? Please tick the appropriate box.

No school	Primary school (Grade 1 to 7)	Incomplete high school (Grade 8 to Grade 11, and did not complete grade 12)	Matric (Completed grade 12/ standard 10)	Diploma/ College certificate	Degree University	Postgraduate degree

1.4. What is your occupation type? Please tick the appropriate box

1.5. What is your net salary per month? Place an 'X' over the appropriate answer.

Prefer not to answer	<R15000	R20000-R25000	R25000-R30000	≥R30000

Qualitative questions

1. Motivation to participate.
    a. Why did you want to take part in this study?

2. Motivation to use the sit-to-stand desk.

a. Before we began this study, did you want to stand or were you sceptical about standing at work?
b. Why were you interested in standing at work initially?
c. What do you now understand the benefits of standing at work to be?

3. Expectations about standing.
   a. What were your expectations about standing at work before you started?
   b. Have your expectations about standing at work changed since your started?

4. Experience of standing
   a. How long were you in the intervention?
   b. Describe your standing experience over the intervention period.
   c. When / in what situations did you stand at work during this period?
   d. Did you discover any other methods or tools for reducing your sitting time at work?
   e. What did you like the most about using the sit-to-stand workstation?
   f. What did you not like about using the sit-to-stand workstation?

5. Capability / Opportunity to stand.
   a. Did anything restrict you from standing?
   b. Did anything facilitate your standing?
   c. Would anything make it easier for you to stand, or make you more willing to stand?
   d. Have you found any particular tasks more conducive to sitting versus standing?
   e. Have you found any particular times of days more conducive to sitting versus standing?

6. Workplace context for standing norms and habits in meetings
   a. Did it seem ‘normal’ to stand at work or was it a new experience for you?
   b. How did others in your office (if applicable) react to you standing?
   c. Did you stand in any other aspects of your job?

d. Do you think the workplace is an appropriate context to stand?
e. Was your manager supportive of your standing at work?

7. Reasons for drop-out
    a. When did you stop using the workstation?
    b. When did you decide to leave the study?
    c. What are some of the things that influenced you to use the sit-to-stand workstation? This can either be barriers or motivating factors.
    d. Is there anything that could be changed about the sit-to-stand intervention to encourage you to continue using the workstation?

Appendix 15 Turnitin Report

Turnitin

ORIGINALITY REPORT

4%	5%	6%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	uobrep.aws.openrepository.com Internet Source	1%
2	researchmgt.monash.edu Internet Source	1%
3	ir.lib.uwo.ca Internet Source	1%
4	doaj.org Internet Source	1%
5	discovery.researcher.life Internet Source	1%

Exclude quotes	On	Exclude matches	< 1%
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