A randomised controlled trial of physical activity and health messages on anthropometric and cardiometabolic outcomes amongst South African university professional staff

David Vusumuzi Khumalo

Student number: 1510679

A dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of MSc (Med) in Sport and Exercise Science by dissertation

Supervisors: Associate Professor Philippe Gradidge,
Adjunct Professor Demitri Constantinou, and
Ms. Merling Phaswana

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Declaration

I, David Vusumuzi Khumalo, declare that this dissertation is my own, unaided work. It is being submitted for the Degree of MSc (Med) in Sport and Exercise Science (dissertation) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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(Signature of candidate)

____________day of____________________20__________________in______________

Dedication

I wish to dedicate this dissertation to:

My wife Pascaline Khumalo and my sons Thabiso and Mduduzi

My parents, Ernest Vuyo and Beauty Khumalo

My sister Duduzile and her husband Bornface and their daughters Talia and Dineo

My brother Vuyani and his wife Sharon

My brother Daniel and his wife and their children Dan-junior, Mbali, and Nosimilo-Abigail

Abstract

Background: Physical inactivity among the adult population is increasing. The workplace is identified as an appropriate setting to promote physical activity. Emerging research suggests high-intensity interval training (HIIT) is time-efficient compared to the traditional moderate-intensity continuous training (MICT). Health messages intervention grounded on behaviour change techniques may improve healthy lifestyle choices. South Africa is experiencing an increasing prevalence of overweight and obesity, physical inactivity, and cardiovascular diseases. There is limited research on the effect of HIIT, MICT, and health messages intervention in improving body composition and cardiometabolic outcomes among adults employed in a South African setting.

Aim: To investigate the effects of high-intensity interval training (HIIT), moderate-intensity continuous training (MICT), and health messages interventions on body composition and selected cardiometabolic outcomes amongst university professional staff employed at the University of the Witwatersrand.

Setting: University of the Witwatersrand.

Methods: The study used a mixed methods approach that used a parallel randomised controlled (RCT) design and focus group discussions (FGDs). A total of 54 professional staff were randomly assigned to 12-week high-intensity interval training (HIIT), moderate-intensity continuous training (MICT), or the control group. The HIIT exercise protocol included 18 to 31 minutes of cycling for 3 days per week at three near-maximal (80-90% HRmax) intervals of up to 30 seconds interspersed with a recovery (65%-75% HRmax). The MICT exercise protocol included cycling for 30 to 55 minutes, 3 days per week at 55-70% HRmax. There was no intervention in the control group. HIIT and MICT training sessions were supervised at 1:1 at the workplace gym. Both MICT and HIIT groups received the health messages intervention that included receiving text health messages through SMS messaging to motivate them to improve their lifestyle behaviour. Messages were sent 5 times per week over the 12-week intervention at random times. Employee perceptions of the intervention were explored in post-intervention focus group discussions (FGDs). Anthropometric variables and selected cardiometabolic outcomes were measured at baseline and follow-up.

Results: Eleven participants (20.37%) were lost upon follow-up. Most of those lost to follow-up were in the control (35.29%) followed by the MICT (21.05%) and the HIIT (5.56%). The analysis was done for participants who had both baseline and follow-up data (n=43). A within-group comparison showed a decrease in anthropometry variables (body weight, waist circumference (WC), and body mass index (BMI), and selected cardiometabolic outcomes; systolic blood pressure (SBP), pulse pressure (PP), random blood glucose (RBG), and estimated VO_{2max}) in both the HIIT and MICT health messages group and these observed changes were statistically significant ($p<0.05$). There was an increase in anthropometric variables (body weight, WC, and BMI), cardiometabolic outcomes (SBP, RBG), and a decrease in estimated VO_{2max} ($p<0.05$) in the control group.

The between-group comparison shows that there was no significant difference in change in anthropometry (WC, BMI), cardiometabolic outcomes (SBP, DBP, RBG), RHR, PP, MAP, and VO_{2max}) between the HIIT group and the MICT group. Furthermore, there was a significant difference change in WC, BMI, MAP, RBG, and VO2max between the HIIT and MICT groups compared to the control group.

No injuries were reported as a result of the intervention in both the HIIT and MICT groups.

Participants expressed the view that time constraints, lack of interest/motivation, high workload, and fatigue/burnout were barriers to participation. While guidance through health messages, instructor-led exercise sessions, and a conveniently accessible location in the workplace facilitated their participation.

Conclusion: The 12-week supervised HIIT and health messages in the workplace setting was more time-and volume-efficient in significantly improving anthropometric and selected cardiometabolic outcomes compared to MICT. The supervised HIIT and health messages may be an effective protocol for promoting physical activity, improving anthropometric and cardiometabolic outcomes among professional staff.

Addressing potential barriers and promoting facilitators in the workplace physical intervention may promote increased participation in employee wellness programmes.

Keywords: Anthropometric; Cardiometabolic outcomes; Health messages; Physical activity; Randomised controlled trial; South Africa

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Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

- ACSM: American College of Sports Medicine
- BEVQ-15: Beverage intake questionnaire
- BMI: Body mass index
- BP: Blood pressure
- cm: Centimetre (s)
- CVD: Cardiovascular disease
- DBP: Diastolic blood pressure
- GPAQ: Global physical activity questionnaire
- HC: Hip circumference
- kcal: Kilocalories
- kg: Kilogram (s)
- Kj: Kilojoules
- LMICs: Low- and middle-income countries
- NCD: Non-communicable diseases
- m^2: Metre (s) squared
- METS: Metabolic equivalents
- Min/week: Minute (s) per week
- MVPA: moderate-to-vigorous physical activity
- PA: Physical activity
- SBP: Systolic blood pressure
- SES: Socioeconomic status
- SSA: Sub-Saharan Africa
- SSB: Sugar-sweetened beverages
- WC: Waist circumference
- WHO: World Health Organization
- WHR: Waist to hip ratio
- WHtR: Waist to height ratio

Definition of terms

Physical activity

Physical activity is defined as "any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure, (1) among adults including recreational or leisure-time physical activity, active transport (walking or cycling), work-related activity, household chores, play, games, sports, or planned exercise (2).

Physical exercise

Physical exercise is defined as a subcategory of physical activity that is "planned, structured, repetitive and improves or maintains one or more components of physical fitness" (3).

Physical inactivity

Physical inactivity represents the non-achievement of physical activity guidelines (4).

Sedentary behaviour

Sedentary behaviour describes any waking behaviour characterised by an energy expenditure <1.5 METs, while in a sitting, reclining, or lying posture (4).

High-intensity interval training (HIIT)

High-intensity interval training (HIIT) describes intense intermittent training, which may elicit ≥ 80% maximal heart rate (HR_{max}) (5).

Moderate-intensity continuous training (MICT)

Moderate-intensity continuous training is a term used to describe continuous training at 65%-75% maximal heart rate (HR_{max}) (5).

Obesity

Obesity is defined as a body mass index (BMI) greater than or equal to 30 kg/m^2 (1).

Cardiorespiratory fitness

Cardiorespiratory fitness describes the ability to perform large muscle, dynamic, moderate-to-vigorous intensity exercise for prolonged periods (1).

Preface

Epidemiological and clinical evidence has established a dose-response relationship between regular physical activity (PA) and the improvement of various health outcomes (1,6). However, regardless of this knowledge globally, approximately one in four adults (27.5%) is physically inactive (7). Besides morbidity and premature mortality, physical activity is increasing direct healthcare costs, productivity losses, and disability-adjusted life-years (DALYs) (8).

Interestingly, the workplace is identified as an important setting for promoting PA participation among working adults (9–11) given that ~33% of the time is spent at work. I have worked for more than a decade in the corporate wellness sector, and I have observed the impact of physical inactivity on both employees and organisations. Thus, I have generated an interest in conducting research in designing and implementing evidence-based interventions to promote PA in the workplace.

In the past decade, there has been an increased interest in HIIT research (12). However, these studies have predominantly been restricted to the laboratory setting, thus there is a lack of intervention studies in the workplace setting.
The results of this study will contribute to the limited evidence on the effects of real-world HIIT on anthropometry and selected cardiometabolic outcomes among working adults in the workplace. Furthermore, the findings are important in designing feasible and effective PA in the workplace setting as a population strategy to reduce the rapidly increasing prevalence of cardiometabolic diseases.

Furthermore, gaining an in-depth understanding of the views and perceptions of the participants' experiences, perceived barriers, and facilitators of the PA intervention will improve the delivery and sustainability of PA interventions in the workplace.

Chapter 1 Introduction and background

1.1 Introduction

This chapter presents the background of the study, the problem statement, the aim, and the objectives of the study. Furthermore, the significance of the study and research gaps will be highlighted. Lastly, the chapter will provide an outline of the dissertation.

1.2 Background

Physical inactivity (i.e., not doing at least 150 min to 300 minutes of moderate-intensity aerobic PA or 75 min to 150 minutes of vigorous-intensity aerobic physical activity per week, or any equivalent combination of the two throughout the week) is a leading risk factor for non-communicable diseases (13). A recent study (14) demonstrates a high prevalence of physical inactivity in the South African adult population (~30% in men and ~50% in women) and these findings highlight the urgency to develop effective programmes to meet the 2025 global physical activity target of 10% reduction in insufficient physical activity (13).

Evidence demonstrates that physical inactivity is associated with an increased risk of cardiovascular diseases (CVDs) (7,14,15), which is one of the leading causes of global morbidity and mortality, accounting for 31% of global deaths annually (7). This is a concern for the South African population as the burden of CVDs is growing (16), with data showing that 1 in 6 deaths (~17.3%) have a CVD-related origin (7). Approximately 80% of the CVD-related deaths in adults might be prevented by behaviour modification such as a shift from sedentary to becoming physically active (16,17).

The importance of physical activity in reducing the prevalence of obesity is highlighted in a study that demonstrated lack of physical activity as a common factor attributable to increased risk of obesity among females (7%) and males (9%) (18). These results suggest that lack of physical activity alone accounts for 15% of obesity in South African adults. The prevalence of obesity is shown to be increasing from 2008 to 2012 (by 3.7%), with a significant prevalence observed in females (37.9%) compared to males (13.3%) (18).

Workplaces have been identified as an appropriate setting to implement intervention to reduce obesity and cardiometabolic disease risk factors (9). An employee wellness study conducted in 2015, demonstrates a growing burden of CVD in employed South Africans (19). Additionally, the study suggests an increased cost to the company for healthcare and productivity losses. It is therefore important for employers to invest in employee health and wellness programmes to address the growing risk of CVD. This study highlights the concerns around CVD risk amongst higher-earning employees; however, data are limited on understanding and addressing disease in employees in the lower-earning strata such as professional staff. The professional staff includes cleaners, landscapers, security officers, amongst others.

Workplace individual-based interventions have demonstrated a significant effect of physical activity on anthropometric variables such as weight and body mass index but an inconclusive effect on cardiometabolic variables such as blood pressure (9). This finding suggests the need for further investigation on developing cost-effective workplace interventions targeting obesity and related cardiometabolic factors (9,19).

Literature suggests that short message service (SMS) text messaging is an effective, low-cost intervention strategy for improving physical activity levels and reducing sedentary behaviour (20). A recent study (21) demonstrated the feasibility of messaging intervention with a statistically significant decrease (2.4%) in body weight, and waist circumference (4.8%) in the intervention group, compared to the control group.

The effectiveness of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) in reducing obesity and cardiometabolic variables is inconclusive (22). A recent study (23), demonstrated that overweight and obese adults were more likely to choose unsupervised HIIT (5-25 minutes per day for 3 days per week) compared to unsupervised MICT (30 minutes per day for 5 or more days of the week). This suggests that the shorter protocols (≤10 min) are cost-effective and feasible, saving ~25% of the time per session (22), as a workplace intervention for professional workers in a time time-constrained environment.

Adherence to 2 or more sessions per week of unsupervised HIIT declined from 60.8% at baseline to 19.6% by 12 months, which may suggest the importance of supervised protocol to improve adherence and support (23). The findings of these studies may not apply to all employed populations; therefore, there is a need to investigate the comparison of workplace-based HIIT, MICT, and health messages intervention amongst professional staff.

1.3 Problem statement

Epidemiological evidence demonstrates that cardiometabolic diseases presents a serious health and economic burden and are predicted to increase (24) because of nutritional transition (25) increase in urbanisation, and mechanisation (2).

Evidence demonstrates that cardiometabolic diseases are a result of common preventable lifestyle risk factors (tobacco use, physical inactivity, unhealthy diet, and alcohol consumption) (26). Furthermore, these are independent risk factors in the development of cardiometabolic diseases (24).

Of concern is that rapid technological advancements have resulted in a decrease in the volume of both occupational physical activity and active transport (walking and cycling) (13). Physical activity is shown to be effective in improving key risk factors in cardiometabolic diseases (2). Thus, targeting a reduction in sitting time to increase physical activity may improve cardiometabolic health outcomes (27).

Also, emerging evidence demonstrates that health messaging (SMS and WhatsApp) may support the modification of lifestyle risk factors such as physical activity and cardiometabolic outcomes (28).

Adults in urban areas spend approximately 77% of their waking time being inactive at the workplace, leaving little time for physical activity (10). The workplace may be a suitable setting to improve the cardiometabolic outcomes of employees (29). Therefore, a need to design evidence-based interventions to reduce the burden of cardiometabolic diseases in the workplace (24).

Increasing physical activity is a simple, widely applicable, low-cost global strategy that could reduce CVD and deaths (30). However, few studies have investigated the effects of physical activity on cardiometabolic outcomes in the South African adult working population.

The prevalence of cardiometabolic diseases is predicted to increase thus causing serious health and economic burden (24), therefore, a need to design evidence-based interventions to reduce the burden of cardiometabolic diseases in the workplace (24).

1.4 Aim

The aim of the study was to investigate the effects of high-intensity interval training (HIIT), moderate-intensity continuous training (MICT), and health messages interventions on anthropometry and selected cardiometabolic outcomes amongst university professional staff employed at the University of the Witwatersrand.

1.5 Objectives of the study

The objectives of the study were:

1. To determine baseline sociodemographic and behavioural risk factors associated with the anthropometric and cardiometabolic outcomes of interest, i.e., anthropometric variables include body mass index (BMI) and waist circumference; whilst cardiometabolic variables include blood pressure, heart rate, and random blood glucose.
2. To determine the changes in anthropometry and cardiometabolic factors following a 12-week intervention of either; (1) high-intensity interval training (HIIT) and health messages and (2) moderate intensity-intensity continuous training (MICT) and health messages.
3. To compare the changes in outcome measures of; (1) HIIT and health messages, (2) MICT and health messages, with a (3) control group.
4. To explore factors that affected participation in the 12-week physical activity and health messaging intervention.

1.6 Significance of the study

The study findings have the potential to impact future policy such as improved accessibility to fitness facilities, health, and wellness programmes to the professional staff at the University of the Witwatersrand and similar environments. Also, the study findings may assist in determining the scalability and efficacy of physical activity intervention and health messages in promoting health and wellness amongst professional staff employed in a South African university. Lastly, the study findings will contribute to the body of knowledge amongst exercise science specialists in exercise prescription of workplace interventions.

1.7 Research gaps

In the South African context, cross-sectional studies (31–33) indicate a high prevalence of CVD risk factors in tertiary institutions.

The evidence of the effects of HIIT and MICT is drawn from short-duration interventions (<12 weeks) and there is a lack of studies that have investigated augmenting health messaging in HIIT and MICT interventions. Furthermore, limited studies exist on the effects of HIIT, MICT, and health messaging conducted in LMICs including in South Africa.

Therefore, there is a need for investigation of HIIT, MICT, and health messaging among professional employees in South Africa.

1.8 Outline of this dissertation

Figure 1.1 illustrates the outline of this dissertation.

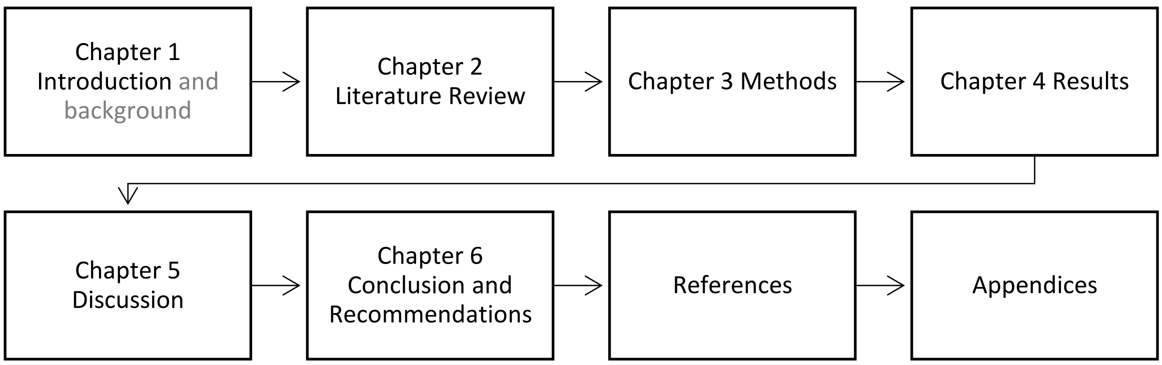


Figure 1.1. Outline of the dissertation

1.9 Summary

Physical inactivity is associated with an increased risk of cardiovascular diseases, which is one of the leading causes of global mortality and morbidity. The workplace is identified as an appropriate setting to implement low-cost physical activity interventions to reduce obesity and cardiometabolic disease risk factors. In South Africa, there is a lack of studies investigating the effects of HIIT, MICT, and health message intervention in reducing obesity and cardiometabolic outcomes in a workplace setting. The study findings have the potential to impact future policy in similar settings.

Chapter 2 Literature review

2.1 Introduction

This chapter aims to highlight the increasing prevalence and the burden of NCDs, and the urgent attention needed to address the challenge. Furthermore, the chapter will highlight the theoretical and conceptual framework of the study. The chapter will also discuss the effects of HIIT and MICT on anthropometric and selected cardiometabolic outcomes. Furthermore, findings from similar studies will be presented.

2.2 Importance of physical activity in the prevention of cardiometabolic disease

Overwhelming evidence has demonstrated a dose-response relationship between physical activity (PA) and health outcomes (1,34). In adults, PA offers numerous benefits including decreased mortality and morbidity, reduction in cardiovascular disease (CVD) risk factors, improved cardiovascular and respiratory function, improved sleep, and health-related quality of life (1).

Evidence demonstrates that physical activity is a cost-effective intervention that provides protective effects against obesity, high cholesterol, elevated blood pressure, and blood glucose levels which increase the risk of the development of cardiometabolic diseases (2).

Evidence from a recent meta-review (35) of 33 systematic reviews (including 25 meta-analyses) suggested that HIIT compared to non-active controls demonstrated multiple physiological and psychological improvements including cardiometabolic risk factors (e.g., BMI, waist circumference (WC), blood pressure, total cholesterol (TC), lipid profiles), inflammatory markers as biomarkers for cardiovascular), cardiorespiratory fitness (CRF) (e.g. $VO2_{max}$, exercise capacity, muscle mass, and muscle structure, cognitive functioning (e.g., attention, memory, problem-solving) and mental health (e.g. depression, anxiety).

Furthermore, these HIIT-induced improvements in cardiometabolic disease risk factors are comparable with those resulting from moderate-intensity continuous training (MICT), and they are more likely to occur among adults at higher risk of CVD and diabetes than in healthy adults (36).

2.3 Conceptual framework

Figure 2.1 illustrates the conceptual framework (37,38) used for this dissertation, furthermore the intervention theory of change (39) is illustrated in Appendix A.

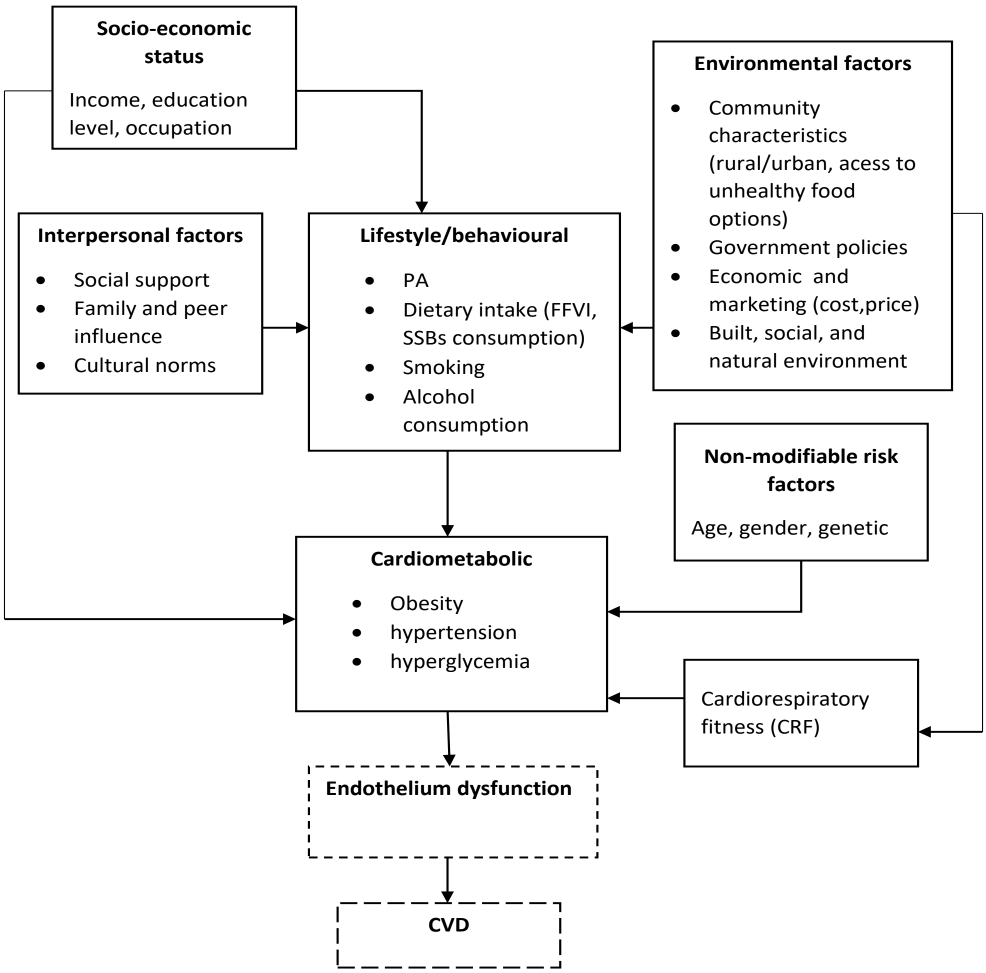
The conceptual framework is adapted from the socio-ecological model (40) which highlights the impact and connections between individuals and their environment. The socio-ecological model posits that behaviour results from different levels including interpersonal factors (e.g. social support, family, and cultural norms), environmental factors (e.g. community characteristics, government policies, economic and marketing, built, social, and natural environment), and socioeconomic status (income, education level, occupation) have been established to have an impact on modifiable lifestyle behaviour (e.g. PA, dietary intake, smoking, and alcohol consumption) (38,41).

In the South African context, physical activity and nutritional transition are suggested to be playing a significant role in the development of CVD. Physical activity is characterised by a shift away from a traditional lifestyle that requires substantial moderate-intensity to a modern western lifestyle that is characterised by substantial low PA (25,42,43). While, nutritional transition describes a shift away from traditional dietary patterns (based on indigenous staple grains, fruit, fibre, and vegetable) to a western diet comprised of more animal-based food products, processed food, fat, and sugar intake (25,42,43).

Much of the population's risk of CVD is attributable to modifiable traditional risk factors, including smoking, history of hypertension and/or diabetes, obesity, unhealthy diet, lack of physical activity, excessive alcohol consumption, elevated blood lipids, psychosocial factors, and other risks factors (44). These behavioural and cardiometabolic risk outcomes coexist, thereby increasing the cumulative risk for an individual (45).

These risk factors are mostly modifiable behavioural risks, which account for more than 60% of CVD deaths globally (46) and continue to be a global public health challenge including low-and middle-income countries, where more than three-quarters of the deaths are attributable to these risk factors (47). This makes prevention, early diagnosis, and management of these risk conditions important because of the increasing burden of CVDs in SSA (48).

In South Africa, approximately 51% of deaths are attributable to NCDs and there is 26% probability of premature mortality (dying between the ages of 30 and 70 years) from NCDs (47). The prevalence of NCDs impacts negatively on economic development through loss of productivity and income (49). These data demonstrates the burden on public health which may be attributed to physical inactivity and urgent development of intervention programmes.



The hypothetical links of the lifestyle behaviours, anthropometry, and cardiometabolic outcomes (37,38).

The solid boxes illustrate the concepts investigated. The solid arrows depict the hypothetical association under investigation. The dashed boxes illustrated the hypothetical association not investigated. CRF: Cardiorespiratory fitness; CVD: Cardiovascular disease; FFVI: Fruit, fibre, and vegetable intake; PA: Physical activity; SSBs: Sugar-sweetened beverages.

Figure 2.1. Conceptual framework of the study

2.4 Contributing factors in the prevalence of cardiometabolic diseases

Epidemiological evidence indicates a different incidence and prevalence of non-communicable diseases (NCDs), particularly cardiometabolic diseases such as cardiovascular disease, stroke, and diabetes, and their major risk factors (obesity, hypertension, diet, tobacco, air pollution, and physical inactivity) between high-income countries (HICs) and low- and middle-income countries (LMICs) (50). Of concern is the increase in cardiovascular disease mortality in low- and middle-income countries (LMICs), particularly Sub-Saharan Africa (SSA) (48), and a decline in high-income countries (HICs) over the last decades with 80% of global non-communicable disease deaths occurring in low-income and middle-income countries (43). A total of 7.2% and 7.6% of all-cause and cardiovascular disease deaths, respectively, are attributable to physical inactivity (43). Although population attributable risks (PARs) are more than double in HICs compared with LICs, evidence demonstrates that 69% of total deaths and 74% of cardiovascular disease deaths associated with physical inactivity are occurring in middle-income countries, given their population size (43).

Evidence suggests the pathway of CVD involves multiple drivers including social determinants (globalisation, urbanisation, aging, income, education, housing) which leads to behavioural risk factors (tobacco use, unhealthy diets, physical inactivity, harmful use of alcohol). Prolonged unhealthy behaviours lead to cardiometabolic diseases such as hypertension, diabetes, dyslipidemia, and obesity which may lead to the CVD epidemic. These behavioural and cardiometabolic risk outcomes coexist thereby increasing the cumulative risk for an individual (45). Furthermore, emerging evidence suggests cardiometabolic risks increase in time spent sitting and sedentary activities (2). Physical inactivity is an established risk of cardiometabolic diseases (2).

2.5 Effect of workplace PA interventions on anthropometry and cardiometabolic outcomes among the working adult population

The workplace is suggested as an appropriate setting to improve physical activity amongst employees (10,51–53). This is because employers may have resources (i.e. financial, policies, programmes) that may be used to successfully improve the workplace environment and implement workplace-based interventions that may promote PA among employees (54).

Evidence suggests that employed adults are physically inactive in their workplace. Approximately 77% spend their waking time in sedentary behaviours (10) thus leaving little time for physical activity. In addition, the workplace is suggested as an appropriate setting to improve physical activity amongst employees (10).

A recent systematic review and meta-analysis (10) of 33 studies (n= 36,188 men and women, age 32 to 55 years) demonstrated that changes in diet and PA in the workplace from different employment settings including university personnel had a significant and positive effect on body weight, BMI, and waist circumference among the working adult population (10).

Results from the meta-analysis (10) showed an overall significant intervention effect for body weight (16 studies, Mean difference: -2.61, 95% CI- -3.89, − 1.33), body mass index (19 studies, Mean difference: -0.42, 95% CI- -0.69, − 0.15) and waist circumference (13 studies, Mean difference: -1.92, 95% CI- -3.25, − 0.60). However, the results need to be interpreted with caution because of considerable heterogeneity among estimates (I^2 = 94, 89, and 92% respectively; $p < 0.0001$) (10).

Systematic review and meta-analyses evidence shows that workplace PA interventions can positively affect anthropometric outcomes and may positively alter the cardiometabolic risk markers such as lipids, blood pressure, and blood glucose. (10,55), work attendance and job stress (56). Thus, workplace PA interventions may provide an effective approach to addressing the burden of CVD (10). However, none of the studies included cohorts from Africa thus making the application of the results in the African setting difficult.

Global levels of physical activity have significantly increased due to improved technological advancement, a high rate of urbanisation, and mechanisation (2). This is suggested as a “preventive paradigm” which is further facilitated by legislation and the adoption of technical ergonomic aids (57). The workplace has to be significantly characterised by a decrease in PA in the workplace in many occupations across different industries including cleaning and other labour-intensive occupations (57).

Epidemiological evidence posits that the aforementioned factors contribute to a decrease in physical activity in different types of settings, including work, travel to and from places, and recreational activities (2). Labour legislation in South Africa provides a framework for addressing employee health and wellness through the provision of the Occupational Health and Safety Act 85 of 1993 (OHSA), the Basic Conditions of Employment Act (no. 75 of 1997), and the Code of Good Practice: Working Time: This Code is of particular significance for employees who perform shift work or regular night work (58). Legislation might be necessary to ensure that the safety, health, and wellness of employees are taken seriously.

Employer benefits of physical activity intervention in the workplace include improved employee productivity, reduced sickness absence, improved employee retention and recruitment, competitive company profile, increased corporate social responsibility, and reduced absenteeism (11,51).

2.6 Literature search strategy

2.6.1 Information sources

A computer-assisted database search for potential research articles was carried out in the main bibliographic databases in the health sciences which included Cochrane, PubMed, PsycINFO, SPORTDiscus, EMBASE, and Scopus search engines. Additional sources were identified using other databases such as Google Scholar or free Internet searches and other secondary databases such as the South African National ETD portal.

2.6.2 Literature search

The following keywords were used "workplace, work setting, intervention, randomised controlled trial, physical activity, exercise, high-intensity interval training, moderate-intensity continuous training, anthropometric outcomes, body composition, 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 of physical activity on anthropometric and cardiometabolic outcomes among employed adults. Table 2.1 illustrates the database search strategy.

Table 2.1 Database search strategy

1. Workplace	11. Anthropometric outcomes
2. Work setting	12. Body composition
3. Intervention	13. Obesity
4. Randomised controlled trial	14. 11 or 12 or 13
5. 1 or 2 or 3 or 4	15. Cardiometabolic outcomes
6. Physical activity	16. Cardiovascular risk factors
7. Exercise	17. Hypertension
8. High-intensity interval training	18. type 2 diabetes mellitus
9. Moderate-intensity continuous training	19. 15 or 16 or 17 or 18
10. 6 or 7 or 8 or 9	20. 5 and 10 and 14 and 19

2.6.3 Data extraction

The literature search was independently conducted by the researcher. The research from the databases was pooled and duplicates removed. Also, the reference lists of appropriate full-text articles were hand-searched for further relevant articles.

Only papers published between 2014 and 2021 in English were considered. The search period lasted from January 2020 to December 2021.

The results were exported to the Zotero bibliographic manager database version 6.0 (Corporation for Digital Scholarship, Virginia, USA).

2.6.4 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, duration, frequency, mode and equipment, training protocol), and the findings. Table 2.2 illustrates characteristics of HIIT and MICT interventions in the workplace setting.

Table 2.2 Characteristics of HIIT and MICT interventions in the workplace setting

Reference in parentheses; Year published	Study design	Setting Place Country	Population M/F (Age, years)	N	Group	Duration (wks)	Freq ($dy \cdot wk^{-1}$)	Mode Equipment	Training protocol	Findings
(59) 2015	RCT	Workplace University of Birmingham UK	Physically inactive 30 M 60 F (42± 11)	90	HIIT (n=46)	10	3	Cycling Cycle ergometer	Supervised Repeated sprints (15-60 seconds, >90% HR_{max}) recovery (≤25 min/session	Adherence 83±14 HIIT improved VO_{2max}, insulin sensitivity, ↓abdominal fat mass, and blood lipids ($p<0.05$).
					MICT (n=44)	10	5	Cycling Cycle ergometer	Supervised MICT continuous cycling (~70% HR_{max}, 30-45 min/session	Adherence 61±15% MICT improved $VO2_{max}$, insulin sensitivity, ↓abdominal fat mass, and blood lipids ($p<0.05$)
(60) 2020	Single-case interventi on study	Workplace. Corporate wellness programme South Africa	Physically inactive. Hypertension, obesity, and depression. 1 M (49)	1	NA	12	NR	NR	Supervised Programme designed on the MyWellness® Technogym® Cloud Platform	Significantly improved CRF and weekly PA levels.

Reference in parentheses; Year published	Study design	Setting Place Country	Population M/F (Age, years)	N	Group	Duration (wks)	Freq ($dy \cdot wk^{-1}$)	Mode Equipment	Training protocol	Findings
(61) 2021	RCT	Workplace University employees South Africa	Participants with ≥2 CVD risks factors and physically inactive 8 M 40 F SIT (37±5) HIIT(39±7) MICT (40±6) CON (38±5)	48	SIT (n=14)	6	3	Indoor cycling	Supervised SIT (90s x 3 times/day) Total time commitment 4 min 30s/day)	Adherence 82% Compared to CON ↓HbA1C % Δ = -1.3%; ↑ LDL/HDL % Δ = 8.2
					HIIT (n=12)	6	3	Indoor cycling	HIIT (90 s followed by 4 min 30s rest x3 reps Total time commitment per day =18 min)	87% ↓ TG Δ = -31.9%
					MICT (n=11)	6	3	Indoor cycling	MICT (55-69% HR_{max})- 30 min per session Total time commitment per day=30 min)	77% Compared to the CON group;MICT ↓DBP (MD = 5.4±3.8, % Δ = -6.8%, d = -0.81, d (95% CI): -1.68, 0.06) ↓ %BF (MD = 0.7±2.1, % Δ = -2.5, d = -0.83, d (95% CI): -1.70, 0.04)
					CON (11)	6	NA	NA	CON-no treatment	Decreased body weight, WC, SBP, DBP

Reference in parentheses; Year published	**Study design**	**Setting** **Place** **Country**	**Population** **M/F** **(Age, years)**	**N**	**Group**	**Duration (wks)**	**Freq (dy·wk^{-1})**	**Mode** **Equipment**	**Training protocol**	**Findings**
(62) 2018	RCT	Workplace University employees University of Venda South Africa	Occupation types; academics and non-academics All females	115	INT (n=49)	12	3	Indoor treadmill walking	Supervised 30 min, Moderate Intensity (5,0-5,5 km/hr, RPE 4 to 8/10)	↓BMI -0.80 ↓WC -1.50 ↓ SBP -4.02 ↓ DBP -2.37 ↑MVPA (min/wk) (+165)
			INT (44,4±11,5) CON (37,4±8,78)		CON (n=66)	12	NA	NA	No treatment	↑ BMI +1.05 ↑WC +1.73 ↑SBP +4.64 ↑DBP +4.94 ↓MVPA (min/wk) (-3,5)

Reference in parentheses; Year published	Study design	Setting Place Country	Population M/F (Age, years)	N	Group	Duration (wks)	Freq (dy·wk^{-1})	Mode Equipment	Training protocol	Findings
(63) 2020	Prospective intervention design	Workplace Corporations in the financial business sector South Africa	Employees in a corporate setting with low to high cardiac risk factors 79 males /172 females Age (median (IQR) 31,0 (10,0)	251	Intervention	12	NR	Multi-modal	Individualised and self-monitored using the MyWellness TG Cloud platform	↓ Body weight (Mean(±SD) -0,3 (5,0) ↓BMI -0.3 (5.4)% ↓WC -2.2%(6.3%) ↓SBP (-1.2 (14.7%) ↑$VO_{2\ peak}$ 14.2%. ↑Upper- and lower-body strength (17.9% and 20%) respectively ↓Productivity loss (1.1%) ↓Absenteeism (0.4%) ↓Presenteeism (0.8%)
(64) 2019	RCT	Workplace University employees USA	Faculty employee population Low to moderate CVD risk and physically inactive.	32	HIIT (n=16)	8 wk	2-4	Cycling Cycle ergometer	Supervised; HIIT 10 min/day 20 s sprint, 3 min recovery, 20 s sprint,	Mean, 89.2% (range, 75%-100%), ↑CRF 12% ↓SBP -5% ↓WC -1.4% ↓Metabolic syndrome (MetS) severity -62%

Reference in parentheses; Year published	Study design	Setting Place Country	Population M/F (Age, years)	N	Group	Duration (wks)	Freq ($dy{\cdot}wk^{-1}$)	Mode Equipment	Training protocol	Findings
			16 males/16 females HIIT (40,8±10,8) MICT (42,2±9,7)		MICT (n=16)	8	5		30 min at 50%-65% HRR)	Mean, 87.8% (range, 77,1%-100%) ↑CRF ,7% ↓SBP MICT-2% ↓WC -0,3%)
(65) 2021	Non-RCT	Workplace Office-based employees Northeast England	Employees with no medical conditions. 20 males/34 females. 46±10.	54	HIIT (n=30)	8		Multi-modal (boxing, stair climbing, stair-stepping)	Supervised; HIIT 4 to 7 60s high-intensity 75-s of rest. Progression↑ 60 s every 2 wks. Exercise session 15 -22 min/wks.	82±15% ↑$VO_{2\ max}$ (mL/kg/min) mean (95%CI), d 3,9 (-0.2 to 8.1) 0.47 ↓Habitual PA (MET min/wk) -310 (-1640 to1019); ↑Glucose(mmol/L) 0,09 (-0.5 to 0.7) 0.12; ↑SBP (mmHg) -1.2 (-4.3 to 6.7) 0,09; ↑DBP (mmHg) 0.1 (-3.9 to 4.1) 0,01; ↓WC (cm) -0.2 (-1.4 to1.0) -0.02; ↓BMI (kg/m^2) -0.029 (-0.5 to 0.4) -0,01; ↓HDL (mmol/L) -0.1 (-0.2 to 0.04) -0.20; ↑TG 0.06 (-0.2 to 0.3) 0.09; ↑TC 0.007 (-0.3 to 0.4) 0.01.
					CON (n=24)	8 wk	NA	NA		The control-adjusted mean increase (95% CI) in predicted VO_{2max} was 3.9 (−0.2 to 8.1) mL·kg−1·min−1, corresponding to a Cohen's D of 0.47

Reference in parentheses; Year published	Study design	Setting Place Country	Population M/F (Age, years)	N	Group	Duration (wks)	Freq (dy·wk^{-1})	Mode Equipment	Training protocol	Findings
(66) 2020	RCT	Workplace. University employees University of Newcastle, New South Wales, Australia	Participants were sedentary 6 males/41 females. 43±10,7	47	HIIT (n=24) Wait-list control (n=23)	8	2-3	Multimodal; aerobic and muscular fitness exercises	Supervised; HIIT (wk1-8; 2-3 sessions/wk for 8 min, a work-to-rest ratio of 30s: 30s, preceded by a 2 min gross warm-up; wk5-8 work-to-rest ratio 40s:20s for the 8 min session)	Adherence 59±22,1% ↑CRF (+2.9 laps, 95%CI (-4.19-10,14; d=0,34) BMI 0.3 (-0.23-0.79) d=0,40 ↑work productivity (+0.26,(-0.10 -0.62) d=0.47)
(67) 2014	RCT	Real-world setting Community park Christchurch, New Zealand	Participants were overweight or obese and physically inactive. 13 males/36 females 35-59	49	MICT (n=17)	12	3	Walking or jogging	Supervised; MICT (33 min at 65-75%HR_{max})	Adherence MICT 75% VO_{2max} -1.03 peak HR(bpm) -1.12 BMI kg/m^2 -0.09 WC (cm) -4.03 Body fat (%) -0.8 SBP -3.90 HOMA(%) 4.33 TC(mg/dL) -13.4 HDL(mg/dL) -1.8
					HIIT (n=16)	12 wk	3	Walking or jogging	HIIT(4 min jogging at 85-95% HR_{max}, 3 min recovery at 65-75%HR_{max})	Adherence 59% VO_{2max} 1.01 peak HR (bpm) -1.24 BMI kg/m^2 0.02 WC (cm) -2.46 Body fat (%) -0.71 SBP -4.64 DBP -5.61 HOMA (%) 3.39 TC (mg/dL) 1.4 HDL (mg/dL) -0.7

Reference in parentheses; Year published	Study design	Setting Place Country	Population M/F (Age, years)	N	Group	Duration (wks)	Freq (dy·wk^{-1})	Mode Equipment	Training protocol	Findings
					SIT (n=16)	12 wk	3	Walking or jogging	30s all out, 4 min low intensity)	Adherence 75% VO_{2max} 0.06 peak HR (bpm) -3.78; WC (cm) -4.27; Body fat (%) -1.27; SBP -5,84 DBP -6,94) HOMA (%) 11.94 TC (mg/dL) 13.2 HDL(mg/dL) -2.9
(68) 2015	Cluster RCT	Workplace Copenhagen Denmark	Employment as a cleaner for >20hr / wk 28 males/88 females 45.6±8.6	116	INT (n=57)	16	2	NR	Supervised Aerobic training >60% VO_{2max}	Adherence 51% hs-CRP (μg/mL) (Δ -0.41±SE 0.19 (95%CI -0.004,-0.78) Fibrinogen (g/L) 0.14±0.09 (−0.04, 0.33) HDL (mmol/L) −0.03±0.02 (−0.08, 0.02) TC (mmol/L) −0.31±0.12 (−0.54, −0.07) TG (mmol/L) 0.37±0.10 (0.18, 0.56) HbA1C (%) 0.11±0.05 (0.02, 0.20)

Reference in parentheses; Year published	Study design	Setting Place Country	Population M/F (Age, years)	N	Group	Duration (wks)	Freq (dy·wk^{-1})	Mode Equipment	Training protocol	Findings
					Reference (n=59)	16		NA	2 lectures for 2 hr for 16 wks on healthy living and not PA	High-sensitive C-reactive protein (μg/mL) 0.17±0.18 (−0.18, 0.53) Fibrinogen (g/L) 0.28 ±0.09 (0.10, 0.45) HDL (mmol/L) −0.04 ±0.02 (−0.09, 0.00) LDL(mmol/L) −0.56 ±0.10 (−0.36, −0.75) TC (mmol/L) −0.03± 0.11 (−0.25, 0.19) TG (mmol/L) 0.20± 0.09 (0.02, 0.38)
(69) 2019	Multi-centre	18 aerobic exercise training interventions from 8 different universities in 5 countries (Belgium, Norway, Australia, Canada, USA)	CAD, T2DM, MetS, physically active and healthy aged	677	high-volume HIIT (n = 299)	3-16	3	NR	Included studies that had participants complete >15 min of high-intensity efforts per session	Adherence >80% Significantly greater ($P < 0.05$) absolute $V0_{2peak}$ increase (0.29 L/min) compared to MICT
					low-volume HIIT/SIT (n = 116	3-16	3	NR	Included studies using < 15 min of high-intensity	Adherence >80% Improved V02peak (0.18 L/min)
			495 males/182 females					NR	efforts per session	

Reference in parentheses; Year published	**Study design**	**Setting** **Place** **Country**	**Population** **M/F** **(Age, years)**	**N**	**Group**	**Duration (wks)**	**Freq (dy·wk^{-1})**	**Mode** **Equipment**	**Training protocol**	**Findings**
			56.3 ± 16.0 yrs		MICT (n = 262)	3-16	3		≤30 min of continuous exercise at 64-76% HR $_{max}$ or equivalent	Adherence >80% Improved $V0_{2peak}$ (0.20 L/min)
(66) 2018	Interventi on	Workplace Kent State University College of Education USA	university employees Self-reported physical inactive BMI 32.7 ±7.1 7 males/43 females 48 ± 10	50	INT (n=50)	12	3	Walking	Supervised group training. Aerobic and resistance PA using existing (group walking, aerobic dancing, yoga, boot camp, and various sports	To achieve ≥10000 steps/day lower BMI scores (pre-post = − 0.59 kg/m^2, $p < 0.001$), lower HDL scores (pre-post = − 2.58 mg/dL, $p < 0.034$), and higher IFG scores (pre-post = 9.48 mg/dL, $p < 0.001$) Participants at risk for CVD had greater reductions than those not at risk for several risk factors, including SBP ($p = 0.020$), DBP ($p = 0.028$), IFG ($p = 0.002$), LDL ($p = 0.006$), and total serum cholesterol ($p = 0.009$).
(71) 2021	RCT	Diamantina (Minas Gerais, Brazil).	BMI ≥25 Primarily involved in sedentary occupations	22	HIIT (n=11) 38±6	8	3	Outdoor running	HIIT training, participants ran at 85% of Vshuttle for weeks 1-2. Velocity increased to 90% for weeks 3–6, 95% for week 7 and 100% for week 8	HIIT improved $VO_{2\,max}$, BMI, body fat, visceral fat, SBP, total cholesterol, fasting glucose, and triglycerides ($p < 0.05$)

Reference in parentheses; Year published	Study design	Setting Place Country	Population M/F (Age, years)	N	Group	Duration (wks)	Freq ($dy \cdot wk^{-1}$)	Mode Equipment	Training protocol	Findings
					MICT (n=11) (39±5)		3		Running at 60% of $V_{shuttle}$ during the 1-2 weeks. The training intensity was increased to 65% for weeks 3–6, 70% for week 7 and 75% for week 8	MICT only improved $VO_{2\,max}$, BMI, and visceral fat (p <0.05)

↑ The up arrow indicates an increase. ↓ The down arrow indicates a decrease. Δ indicates change. % BF: Percentage of body fat; BMI: Body mass index; CI: Confidence interval; CON: Control; CRF: Cardiorespiratory fitness; CVD: Cardiovascular disease: DBP: Diastolic blood pressure: F; Female; HbA1C: Glycated haemoglobin; HDL: High-density lipoprotein; HIIT: High-intensity interval training; HOMA-IR: Homeostasis Model Assessment; HR: Heart rate; HR_{max}: Maximum heart rate; hs-CRP: High Sensitive C-reactive protein; IFG: Impaired fasting glucose; INT: Intervention; LDL: Low-density lipoprotein; M: Male; MD: Mean difference; MetS: Metabolic syndrome; MICT: Moderate-intensity continuous training; MVPA: Moderate-vigorous physical activity; NA: Not applicable; NR: Not reported; PA: Physical activity; RCT: Randomised controlled trial; RPE: Rating of perceived exertion; SBP: Systolic blood pressure; SD: Standard deviation; SIT: Sprint interval training; TC: Total cholesterol; TG: Triglycerides; VO_{2max}: Maximum oxygen consumption; VO_{2peak}: Peak volume of oxygen consumed; WC: Waist circumference.

2.7 Comparing anthropometric, cardiometabolic, and physiological adaptations between HIIT and MICT

Table 2.3 Illustrates anthropometric, cardiometabolic, and physiological adaptations occurring significantly more with HIIT compared with MICT (12,22,36,72–78).

These adaptations are time-dependent and influenced by various factors including individual characteristics (age, sex, and CVD risk), central factors (cardiac output, MAP, sympathetic nervous system, heart rate), and peripheral factors (muscle contractions, vascular conductance function-structure) moderated by type (modality of exercise) and intensity of the exercise (79).

Table 2.3 Comparing anthropometric, cardiometabolic, and physiological adaptations between HIIT and MICT (12,22,36,72–78)**.**

HIIT	Adaptation	MICT
	Cardiovascular	
↑↑	Cardiac output	↑
↑↑	Stroke volume	↑
↑↑	Resting heart rate	↑
↑↑	VO_2 max	↑
↑	Capillary density	↑↑
↑	A-V O_2 diff	↑↑
	Body composition	
--	[a]BMI, TFM, BF%, BW	--
↑↑	[b]BMI, %BF, WC, WHR, BW	↓
Glycolysis pathway	**Predominant energy system**	OXPHOS pathway
Type II	Fibre-type specific adaptation	Type I
↑	Mitochondrial efficiency and respiration	↑↑
	Cardiometabolic outcome	
↑↑	VO_2 peak	↓
↓↓	Systolic and diastolist BP	↓
↑↑	High-density lipoproteins	↑
↓↓	Triglycerides and fasting blood glucose	↓
	HOMA-IR	
↓↓	Oxidative stress and inflammatory markers (CRP, IL-6, BNP, MPO, and TNF-alpha	↓
↓↓	FATP-1 and FAS	↓
↑↑	Adiponectin, insulin sensitivity, and β-cell function	↑
↓	HbA1c	↓↓
	Skeletal muscle	
↑↑	PGC-1α	↑
↑↑	Maximal rate of Ca^{2+}	↑

HIIT	Adaptation	MICT
	Myocardium and vasculature	
↑↑	Endothelium function	↑
↑↑	Availability of nitric oxide	↑
↑↑	Cardiac function	↑
	Psychological	
↑↑	Enjoyment of exercise	↑
↑↑	Quality of life	↑
↑↑	Adherence	↑

Two arrows (↑↑) indicate a greater magnitude of adaptation, and dashes (--) denote no difference. a: short-term HIIT or MICT (<12 weeks); b: long-term HIIT or MICT (≥ 12 weeks); A-V O_2 diff: arteriovenous oxygen difference; %BF: body fat percentage; BMI: Body mass index; BNP: Brain natriuretic peptide; BW: body weight; CRP: C-reactive protein; FAS: fatty acid synthase; FATP-1: Fatty acid transport protein 1; HbA1c: Glycated haemoglobin; HOMA-IR: Homeostasis Model Assessment of Insulin Resistance; IL-6: Interleukin 6; MPO: Myeloperoxidase; OXPHOS: Oxidative Phosphorylation; PGC-1α: Peroxisome proliferator-activated receptor gamma coactivator 1-alpha; TFM: Total fat mass; TNF-alpha: Tumour-necrosis-factor-alpha; WC: Waist circumference; WHR: waist-hip ratio.

2.8 Prevalence of physical inactivity

Physical inactivity is an established risk of cardiometabolic diseases (2). Physical inactivity is responsible for up to 8% of deaths and non-communicable diseases that are attributable to physical inactivity. In Sub-Saharan Africa (SSA) 21.4% of the population are not meeting the PA guidelines and women are less active (24.8%) than men (17.9%) (13). In South Africa, 57.4 (95%CI: 55.9-59) % of the population are not meeting physical activity guidelines, men were likely to be more active than females (80), and urban populations are less active than rural-dwelling South Africans (81).

South Africa continues to experience the burden of NCDs. The prevalence of NCDs impacts negatively on economic development through loss of productivity and income (49). Chronic, non-communicable diseases (NCDs) remain a major burden in South Africa, where 51% of all mortality had an NCD-related origin in 2016 (82).

A recent study (33) among a population of South African university cleaners (n=57; age 41±8.83 years; BMI 29±7.0 kg/m²) demonstrates that cleaners engaged in insufficient PA are at an increased risk of CVD. Cleaners spent most of their working hours performing light OPA and were exposed to limited moderate to vigorous occupational PA, moreover, they spent less time in MVPA (83).

Only 28.0% (n=16) of the cleaners engaged in MVPA at work or outside working hours and were at high risk of CVD. This is one of the few studies in South Africa to be conducted on university cleaners. The study highlights the need for workplace intervention to improve regular PA and reduce the risk of CVD outcomes among the working population.

Increased prevalence and incidence of CVD risk outcomes among cleaners suggest chronic disease might be present. University cleaners should adhere to a supervised elevated-intensity exercise programme, individualised to their physical fitness, to reduce the risk of cardiovascular disease.

2.9 Health messages interventions

Evidence from a systematic review (84) demonstrates an increase in mobile technologies for health (m-Health) in both high and low-and middle-income countries (LMICs) due to the proliferation of information and communications technology (ICT).
Increasing evidence suggests the efficacy of m-Health in supporting non-pharmacological lifestyle modification interventions, such as increasing physical activity, dietary modification, smoking cessation, and reducing alcohol consumption (28).

Systematic review evidence suggests the effectiveness of e-and-mHealth (including text health messaging) interventions in promoting PA and healthy diets in both high-income and low-and middle-income countries (LMIC) due to due to the proliferation of information and communications technology (ICT) (84,85). These interventions may be cost-effective in reaching large numbers of people to address the increasing prevalence of NCDs (85) and PA messaging may play a role in improving PA levels in different populations (86).

The evidence of health messaging is demonstrated in an RCT study by Chow et al who showed that a 6-month automated text-messaging program (TEXT ME, n=710) was associated with increased self-reported PA (345 $MET \cdot min \cdot wk^{-1}$, 95%CI: 195, 495, $p<0.001$) and improvement in other cardiometabolic risk factors including SBP and smoking cessation.
Data shows smartphone subscriptions reaching 53.4 million (91.2%) in 2019, with an increase of 47.7% in 2016. South Africa's 3G mobile network coverage increased from

99.5% in 2018 to 99.7% in 2019 (87). Because m-Health is affected by accessibility and affordability (84), this makes use of m-Health in the South African context applicable because of increasing access to mobile phones and network coverage.
Health messages are an effective low-cost tool in promoting lifestyle behaviours through the application of the behaviour change theories (BCT) (84).

2.10 Epidemiology of hypertension

Globally, hypertension is the leading modifiable risk factor for cardiovascular disease and premature mortality (88). In 2010, estimates suggested a global hypertension prevalence of 31.1% (1.39 billion) among adults (89).
Hypertension remains an issue of global concern especially in low and middle-income countries (LMICs) (89). The prevalence of hypertension is higher in LMICs (31.5%) compared in high-income countries (28.5%) (89) and slightly higher in men (31.9%) than in women (30.1%). Of concern, is the highest prevalence of hypertension among women (36.3%) in Sub-Saharan Africa (SSA) (89).

2.10.1 Risk factors for hypertension

Modifiable risk factors include unhealthy diets (excessive salt consumption, a diet high in saturated fat and trans fats, low intake of fruits and vegetables), physical inactivity, consumption of tobacco and alcohol, and being overweight or obese (90). Other factors include psychological stress, sleep disorders, and noise exposure (26,89)
Non-modifiable risk factors include a family history of hypertension, age over 65 years, and co-existing diseases such as diabetes or kidney disease (26,89).

From 2000 to 2010, the hypertension prevalence in HIC decreased by 2.6%, and awareness, treatment, and control improved substantially while during the same period, LMICs saw a 7.7% prevalence increase and little improvement in awareness, treatment, and control (89). These data document large and widening global disparities in hypertension prevalence and control (89). Suggesting a responsive implementation of innovative, cost-effective, and sustainable programs for hypertension prevention and control should be a public health priority for these countries (88,89).

2.10.2 Epidemiology of hypertension in South Africa

Despite the presence of highly effective and cost-effective blood pressure-lowering interventions, SA is still experiencing high levels of hypertension (91).

In SA hypertension prevalence ranges between 38.4%-48.2% among adults according to South African national surveys SANHANES-1 (2012) (92) and 2016 Demographic and Health Survey (91).

In SA, the prevalence of hypertension has nearly doubled since 1998, from 25% to 46% among women and from 23% to 44% among men (91), with the national mean systolic and diastolic blood pressure levels among women and men have rising by 4-11 mmHg across all ages (91). The prevalence of hypertension rises steadily with increasing age, peaking at 84% among women and men age 65 and older (91).

A comparative analysis (93) of the National 2012 SANHANES and 2016 Demographic and Health Survey in both survey years shows that hypertension was significantly higher among males, the coloured population group, urban participants, and those with self-reported high blood cholesterol. Of concern, is that the odds of hypertension increased non-linearly with age, body mass index (BMI), and waist circumference (93).

2.10.3 The measure of blood pressure

BP measurement is a vital clinical sign that is poorly performed in clinical settings (90). Hypertension and elevated blood pressure may be reduced through recommended lifestyle changes including weight reduction to achieve normal body weight (18.5-24.9kg/m^2), moderation of alcohol consumption (no more than 2 drinks per day), complete cessation of smoking, physical activity (30 min/day most of the days), reduction of sodium intake (<6g/ day), increase of fruit and vegetable intake, and decreasing saturated fat and total fat (90). Table 2.4 illustrates the classification of blood pressure (90).

Table 2.4 Definitions and classification of blood pressure (90).

Stage	Systolic BP, mmHg	Diastolic BP, mmHg
Normal	<120	<80
Optimal	120-129	80-84
High normal	130-139	85-89
Grade 1	140-159	90-99
Grade 2	160-179	100-109
Grade 3	≥180	≥110
Isolated systolic	≥140	<90

BP should be categorised into the highest level of BP whether systolic or diastolic **(90).**

BP: Blood pressure.

2.10.4 The effect of HIIT and MICT on blood pressure

Meta-analysis evidence (94) demonstrates that HIIT (<12 weeks) significantly improved DBP (SMD-0.52,95%CI-0.89 to -01.6; p<0.01) while HIIT (≥12 weeks) improved SBP (SMD −0.35, 95% CI −0.60 to −0.09; p<0.01) and DBP (SMD −0.38, 95% CI −0.65 to −0.10; p<0.01) and resting heart rate (SMD −0.33, 95% CI −0.56 to −0.09; p<0.01).

Table 2.5 illustrates the comparative effects of HIIT and MICT on blood pressure. There is a similar reduction in SBP in HIIT group (Δ (mmHg), -12 to 0; Δ (%) -8.2 to 0) and MICT group (Δ (mmHg), -12 to -2.2; Δ (%) -8.4 to -1.7) while there was a higher reduction in DBP in HIIT group (Δ (mmHg), -10 to -1; Δ (%) -10.4 to -1.3) compared to MICT group (Δ (mmHg), -5.4 to -0.8; Δ (%) -6.8 to -1).

Table 2.6 illustrates the comparative effect of HIIT and MICT on MAP and PP. There is a similar reduction in MAP in HIIT group (Δ (mmHg), -11 to -1; Δ (%) -9.7 to -1.1) and MICT group (Δ (mmHg), -8 to -1.3; Δ (%) -7.4 to -1.3) while there was a higher reduction in PP in MICT group (Δ (mmHg), -8 to 0.4; Δ (%) -15.1 to 1.2) compared to HIIT group (Δ (mmHg), -3 to 1; Δ (%) -6 to 2.1).

Table 2.5 Comparative effects of HIIT and MICT on blood pressure

			SBP, mmHg				DBP, mmHg			
Author, date	**Ref**	**Group**	**Pre (mean ± SD, mmHg)**	**Post (mean ±SD, mmHg)**	**Δ (mmHg)**	**Δ (%)**	**Pre (mean ± SD, mmHg**	**Post (mean ±SD, mmHg)**	**Δ (mmHg)**	**Δ (%)**
Reljic et al (2021)	(95)	HIIT	144±16	133±11***	-11	-7.6	94±11	86±7***	-8	-8.5
		MICT	143±14	131±11**	-12	-8.4	90±7	85±8*	-5	-5.6
		CON	136±15	136±12	0	0	86±11	86±9	0	0
Rugbeer et al (2021)	(61)	HIIT	113±13.1	110.9±13.6	-2.1	-1.9	79.1±5.98	77.3±7.91	-1.8	-2.3
		SIT	111.0±13.6	108.0±8.30	-3	-2.7	78.4±7.33	78.0±6.38	-0.4	-0.5
		MICT	113.0±12.0	108.7±12.3	-4.3	-3.8	80.0±9.48	74.6±9.59	-5.4	-6.8
		CON	110.0±13.0	105.2±10.5	-4.8	-4.4	78.73±6.50	77.36±6.86	-1.4	-1.7
Reljic et al (2020)	(96)	HIIT	147 ± 17	135 ± 15***	-12	-8.2	96 ± 10	86 ± 10***	-10	-10.4
		CON	137 ± 11	136 ± 12	-1	-0.7	90 ± 9	87 ± 10	-3	-3.3
Cuddy et al (2019)	(64)	REHIIT	130.4±8.8	123.8±6.6	-6.6	-5.1	83.2±5.6	82.2±4.9	-1	-1.2
		MICT	128.9±17.4	126.7±14.4	-2.2	-1.7	82.5±9.6	81.7±7.1	-0.8	-1
Shephered et al (2015)	(59)	HIIT	123±11	123±10	0	0	76±10	75±9	-1	-1.3
		MICT	127±14	123±13*	-4	-3.1	78±9	76±9	-2	-2.6

* (p<0.005), ** (p<0.01), *** (p<0.001) significantly different from pre-intervention.

Data are presented as mean ± SD. CON: Control; DBP: Diastolic blood pressure; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; REHIIT: Reduced-exertion high-intensity interval training; SBP: Systolic blood pressure.

Table 2.6 Comparative effect of HIIT and MICT on mean atrial pressure (MAP) and pulse pressure (PP)

	MAP, mmHg	PP, mmHg

Author, date	Ref	Group	Pre (mean ± SD, mmHg)	Post (mean ±SD, mmHg)	Δ (mmHg)	Δ (%)	Pre (mean ± SD, mmHg)	Post (mean ±SD, mmHg)	Δ (mmHg)	Δ (%)
Reljic et al (2021)	(95)	HIIT	110±11	102±7***	-8	-7.3	50 [b]	47 [b]	-3	-6
		MICT	108±8	100±8**	-8	-7.4	53 [b]	45 [b]	-8	-15.1
		CON	103±11	103±9	0	0	50 [b]	50 [b]	0	0
Rugbeer et al (2021)	(61)	HIIT	90.4 [a]	88.5 [a]	-1.9	-2.1	33.9 [b]	33.6 [b]	-0.3	-0.9
		SIT	89.3 [a]	88 [a]	-1.3	-1.5	32.6 [b]	30 [b]	-2.6	-8
		MICT	91 [a]	85.7 [a]	-5.3	-5.8	33 [b]	33.4 [b]	0.4	1.2
		CON	89.2 [a]	86.6 [a]	-2.6	-2.9	31.3 [b]	27.8 [b]	3.5	11.2
Reljic et al (2020)	(96)	HIIT	113 ± 11	102 ± 11***	-11	-9.7	51 [b]	49 [b]	-2	-3.9
		CON	106 ± 9	103 ± 10	-3	-2.8	47 [b]	49 [b]	2	4.3
Cuddy et al (2019)	(64)	REHIIT	98.9 [a]	96.1 [a]	-2.8	-2.8	47.2 [b]	41.6 [b]	-5.6	-11.9
		MICT	98 [a]	96.7 [a]	-1.3	1.3	46.4 [b]	45 [b]	-1.4	-3.0
Shephered et al (2015)	(59)	HIIT	92±9	91±9	-1	-1.1	47 [b]	48 [b]	1	2.1
		MICT	95±10	92±17	-3	-3.2	49 [b]	47 [b]	-2	-4.1

* (p<0.005), ** (p<0.01), *** (p<0.001) significantly different from pre-intervention. [a] derived MAP=DBP+⅓ (SBP-DBP). [b] derived PP=SBP-DBP.

Data are presented as mean ± SD. CON: Control; DBP: Diastolic blood pressure; HIIT: High-intensity interval training; MAP: Mean arterial pressure; MICT: Moderate-intensity continuous training; PP: Pulse pressure; REHIIT: Reduced-exertion high-intensity interval training; SBP: Systolic blood pressure.

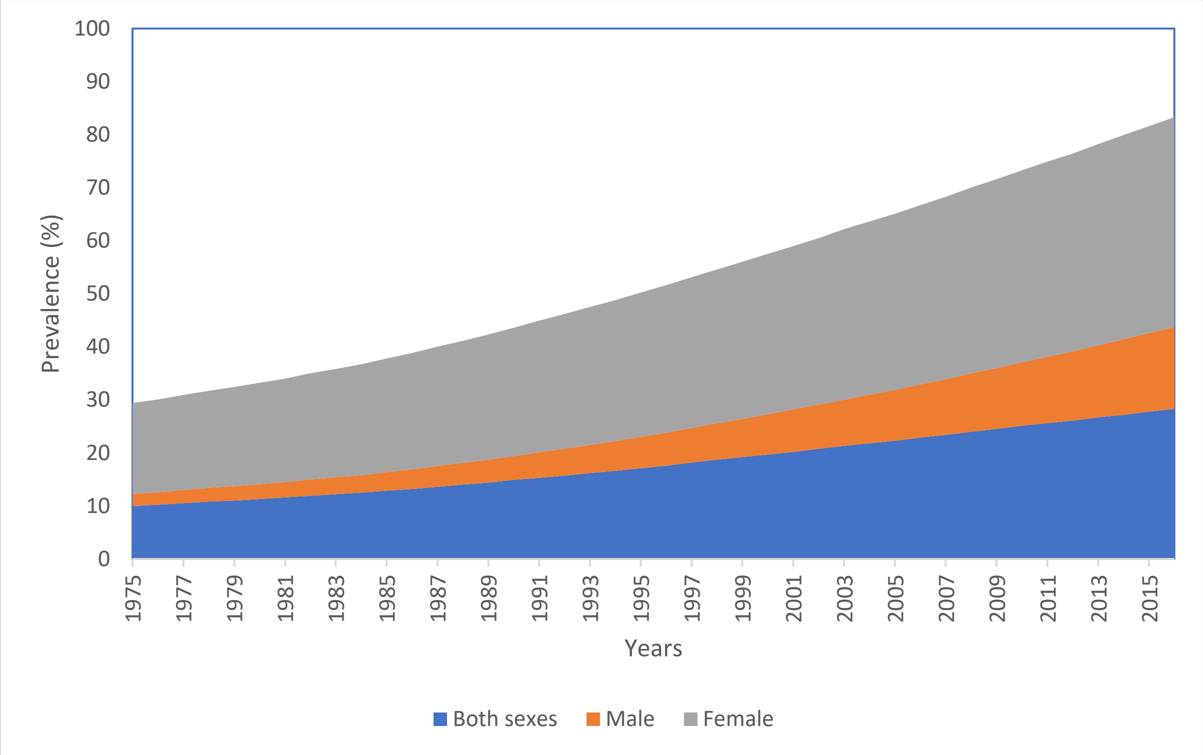
2.11 Epidemiology of overweight and obesity in South Africa

Previous studies have demonstrated a much higher prevalence of obesity in females (41.8%) compared to males (14.1%) in the urban South African setting (91). Results from previous studies suggest that urban African females have a very high prevalence of obesity than African males (91).

The prevalence of obesity in SA is concerning with the recent South Africa Demographic and Health Survey (SADHS) (91) showing that two-thirds (68%) of women aged 15 and older are overweight or obese. In contrast, a third (31%) of men aged 15 and older are overweight or obese. The prevalence of overweight and obesity is highest among women aged (45 to 64 years) (81%-82%) and men aged 65 or older (54%).

In comparison with the SADHS 1998, the prevalence of overweight or obesity among women increased from 56% to 68% (+12%), while the prevalence of overweight and obesity among men was 29% in 1998 and 31% in 2016 (+2%) (91). This further demonstrate by approximately 7% increase of mean BMI among women (from 27.3 kg/m^2 in 2016 to 29.2 kg/m^2 in 2016) and insignificant change approximately 1% among men (23.4 kg/m^2 in 1998 and 23.6 kg/m^2 in 2016) (91).

The prevalence of overweight or obesity is similar among urban and non-urban women (68% and 66%) respectively, the prevalence is modestly higher among men in urban areas than among those in non-urban areas (34% and 26%, respectively) (91).
One in five women (20%) are severely obese while only 3% of men are severely obese. Severe obesity seems to increase with increasing wealth among both men and women (91). Figure 2.2 illustrates trends in age-standardised prevalence of obesity (BMI≥30) in the South African adult population (≥18 years) from 1975 to 2016.



Source of data: Global Health Observatory (GHO) data (97).

Figure 2.2. Trends in age-standardised prevalence of obesity (BMI≥30) in the South African adult population (>18 years) from 1975 to 2016

2.11.1 Classification of disease risk based on BMI and WC

An increased risk of obesity-related diseases, health conditions, and mortality are associated with a BMI ≥30.0 kg·m^{-2} (1). Increased WC is also a marker for increased risk even for increased risk of normal weight (1). Table 2.7 illustrates the classification of risk using BMI and WC according to the World Health Organisation (WHO) guidelines (1).

Table 2.7 Classification of disease risk using BMI and WC (1)

Classification of disease risk based on Body Mass Index (BMI) and Waist Circumference (WC)			
		Disease risk relative to normal weight and waist circumference	
	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

WHR ≥0.90 Male and ≥0.85 Female (risk of metabolic complication substantially increased). Dashes (-) indicate that no additional risk at these levels of BMI was assigned. Body mass index (BMI); Waist circumference (WC).

2.12 Effect of HIIT and MICT on anthropometric variables

A systematic review (94) shows HIIT (≥12 weeks) significantly improved waist circumference (SMD −0.20, 95% CI −0.38 to −0.01; p<0.05), % body fat (SMD −0.40, 95% CI −0.74 to −0.06; p<0.05). Meta-analysis evidence (22) comparing the effect of HIIT and MICT on CVD risk factors among overweight adults showed that both HIIT and MICT resulted in statistically significant reductions in weight (SMD: 0.305 and 0.319 for HIIT and MICT group, respectively), BMI (SMD:0.591 and 0.727 for HIIT and MICT group, respectively), fat% (SMD:0.609 and 0.647 for HIIT and MICT group, respectively).

HIIT is an emerging PA intervention strategy for controlling obesity and other cardiometabolic risk factors. Table 2.8 illustrates the comparative effects of HIIT and MICT on body weight. There is a greater weight decrease in HIIT group (Δ (kg), -5.3 to 0.5; Δ (%) -4.3 to 0.6) compared to MICT group (Δ (kg), -2 to -0.5 ; Δ (%) -2 to -0.6). A weight loss of at least 5% is considered to produce clinically meaningful improvements in other cardiometabolic factors such as blood pressure, blood glucose, or lipids (98).

The superior benefits of HIIT over MICT in reducing weight loss is that the higher exercise intensity plays a central role in the regulation of body composition and local fat consumption where HIIT is superior to MICT in promoting secretion of catecholamines, epinephrine, norepinephrine, and growth hormone which promotes fat decomposition to achieve effective weight loss (22).

Table 2.8 Comparative effect of HIIT and MICT on body weight

Body weight, kg						
Author, date	**Ref**	**Group**	**Pre (mean ± SD, kg)**	**Post (mean ±SD, kg)**	**Δ (kg)**	**Δ (%)**
Reljic et al (2021)	(95)	HIIT	116.7±28.1	112.7±27.6***	-4	-3.4
		MICT	101.1±18.1	99.1±18.7**	-2	-2
		CON	106.4±20.2	103.6±20.9***	-2.8	-2.6
Rugbeer et al (2021)	(61)	HIIT	79.9±12.0	80.2±11.6	0.3	0.4
		SIT	85.1±23.4	85.6±23.8	0.5	0.6
		MICT	83.2±14.7	83.2±14.2	0	0
		CON	84.6±18.0	85.5±18.4	0.9	1.1
Reljic et al (2020)	(96)	HIIT	121.9 ± 28.9	116.6 ± 28.1***	-5.3	-4.3
		CON	109.4 ± 18.3	105.7 ± 19.7***	-3.7	-3.4
Cuddy et al (2019)	(64)	REHIIT	81.9±11.3	82.4±11.3	0.5	0.6
		MICT	79.2±14.4	78.7±13.5	-0.5	-0.6
Shephered et al (2015)	(59)	HIIT	78.8± 18.3	77.8±17.9	-1	-1.3
		MICT	77.5±15.8	76.6±15.8	-0.9	-1.2

* (p<0.005), ** (p<0.01), *** (p<0.001) significantly different from pre-intervention.

Data are presented as mean ± SD. CON: Control; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; REHIIT: Reduced-exertion high-intensity interval training.

Table 2.9 illustrates the comparative effect of HIIT and MICT on waist circumference. There is a greater WC decrease with HIIT (Δ (cm), -7.5 to -2.2; Δ (%) -6.3 to -2.4) compared to MICT (Δ (cm), -3.7 to 0.3; Δ(%) -3.4 to -0.3).

Table 2.9 Comparative effect of HIIT and MICT on waist circumference

Waist circumference, cm						
Author, date	**Ref**	**Group**	**Pre (mean ± SD, cm)**	**Post (mean ±SD, cm)**	**Δ (cm)**	**Δ (%)**
Reljic et al (2021)	(95)	HIIT	117.2±20.0	110.8±17.9***	-6.4	-5.5
		MICT	109.0±12.4	105.3±12.1**	-3.7	-3.4
		CON	110.3±12.3	109.3±13.3	-1	0
Rugbeer et al (2021)	(61)	HIIT	90.6±8.97	88.4±9.39	-2.2	-2.4
		SIT	89.8±19.1	91.3±14.4	1.5	1.7
		MICT	93.7±11.8	91.5±10.4	-2.2	-2.4
		CON	97.1±12.8	95.3±10.9	-1.8	-1.9
Reljic et al (2020)	(96)	HIIT	120.5 ± 18.9	113.0 ± 18.0 **	-7.5	-6.3
		CON	110.7 ± 11.1	109.2 ± 11.8	1.5	-1.4
Cuddy et al (2019)	(64)	REHIIT	86.6±10.5	85.4±9.7*	1.2	-1.4
		MICT	87.6±10.1	87.3±9.1	0.3	0.3

* (p<0.005), ** (p<0.01), *** (p<0.001) significantly different from pre-intervention.

Data are presented as mean ± SD. CON: Control; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; REHIIT: Reduced-exertion high-intensity interval training.

Table 2.10 illustrates the comparative effect of HIIT and MICT on BMI. There is a greater BMI reduction in HIIT (Δ (kg·m^{-2}), -1.8 to 0.3; Δ (%) -4.5 to 1) compared to MICT (Δ (kg·m^{-2}), -0.8 to 0; Δ (%) -2.2 to 0).

Table 2.10 Comparative effect of HIIT and MICT on BMI

BMI, kg·m^{-2}						
Author, date	**Ref**	**Group**	**Pre (mean ± SD, kg·m^{-2})**	**Post (mean ±SD, kg·m^{-2})**	**Δ (kg·m^{-2})**	**Δ (%)**
Reljic et al (2021)	(95)	HIIT	38.5±6.8	37.1±6.8***	-1.4	-3.6
		MICT	35.7±5.0	34.9±4.9**	-0.8	-2.2
		CON	37.5±5.4	36.5±5.8	-1	-2.6
Rugbeer et al (2021)	(61)	HIIT	29.5±4.71	29.8±4.86	0.3	1
		SIT	32.2±9.80	32.2±9.59	0	0
		MICT	31.0±5.44	31.0±5.51	0	0
		CON	31.3±5.09	31.8±5.52	0.5	1.6
Reljic et al (2020)	(96)	HIIT	39.9 ± 7.5	38.1 ± 7.3***	-1.8	-4.5
		CON	37.5 ± 5.9	36.2 ± 6.2***	-1.3	-3.4
Shephered et al (2015)	(59)	HIIT	27.7±5.0	27.4±4.9	-0.3	-1.1
		MICT	27.7±4.6	27.4±4.7	-0.3	-1.1

* (p<0.005), ** (p<0.01), *** (p<0.001) significantly different from pre-intervention.

Data are presented as mean ± SD. BMI: Body mass index; CON: Control; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; REHIIT: Reduced-exertion high-intensity interval training.

2.13 Epidemiology of diabetes

Diabetes mellitus (type 1 and type 2 diabetes, and gestational diabetes) is a group of metabolic diseases characterised by an elevated blood glucose concentration (hyperglycemia) and a result of defects in insulin secretion and/or inability to use insulin (1).

Sustained elevated blood glucose levels place patients at risk for microvascular and macrovascular diseases including neuropathies (peripheral and autonomic) (1).
Epidemiological evidence confirms the rapidly increasing burden of diabetes in Africa, especially in northern Africa (driven by Egypt) and in southern Africa (driven by South Africa) these estimates appeared higher than the global average, whereas estimates for other regions were mostly lower (99).

In South Africa, the prevalence of diabetes is ~11 to 13% among women and ~7.9 to 8% among men, while high proportions of women (64%) and men (66%) were pre-diabetic, increases with age, increasing BMI (91), among rural informal and urban formal residents (92). Of concern is the increased prevalence of diabetes in the past two decades.

Central obesity and insulin resistance often progress to prediabetes, a condition characterised by (a) elevated blood glucose in response to dietary carbohydrates, termed impaired glucose tolerance (IGT), and or (b) elevated blood glucose in the fasting state, termed impaired fasting glucose (IFG) (1).

2.13.1 Measurement of Diabetes

Diabetes is routinely diagnosed by testing an individual's blood for glucose (sugar) after an overnight fast or after performing a glucose tolerance test under the same conditions (1).

Glycated haemoglobin (HbA1c) is the current gold standard test to monitor long-term blood sugar control in people already diagnosed with diabetes. HbA1c has recently been proposed by WHO as another test to detect diabetes in undiagnosed people (1). Table 2.11 illustrates the diagnostic criteria for diabetes mellitus (1).

Table 2.11 Diagnostic criteria for diabetes mellitus (1)

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

HbA1c: Glycated haemoglobin; IFG: Impaired fasting glucose (at least 8 h); IGT: Impaired glucose tolerance; OGTT: Oral glucose tolerance test.

2.14 Comparative effect of HIIT and MICT on fasting glucose and HbA1C (%)

Evidence from a systematic review (94) shows that HIIT (<12 weeks) fasting glucose (SMD −0.35, 95% CI −0.62 to −0.09; $p<0.01$) in overweight/obese populations. Meta-analysis evidence shows no significant effect of HIIT or MICT on fasting blood glucose in short-term interventions (≤12 weeks) (22).

Table 2.12 illustrates the comparative effect of HIIT and MICT on fasting glucose and HbA1C (%). There is a greater reduction in FBG in the HIIT group (Δ ($mmol \cdot L^{-1}$), -0.2 to 0 ; Δ (%) -3 to 0) compared to the MICT group (Δ ($mmol \cdot L^{-1}$), -0.06 to 1.16 ; Δ (%) -1.1 to -2.72) and also there was a higher reduction HbA1C(%) in the HIIT group (Δ HbA1C(%), -0.1 to 0.01 ; Δ(%) -1.8 to 1.9) compared to the MICT group (Δ (HbA1C(%), 0 to 0.2 ; Δ (%) 0 to 3.3) .

Table 2.12 Comparative effect of HIIT and MICT on fasting glucose and HbA1C (%)

			Fasting glucose, mmol·L^{-1}				HbA1C (%)			
Author, date	**Ref**	**Group**	**Pre (mean ± SD, mmol·L^{-1})**	**Post (mean ±SD, mmol·L^{-1})**	**Δ (mmol·L^{-1})**	**Δ (%)**	**Pre (mean ± SD, %)**	**Post (mean ±SD, %)**	**Δ (mmHg)**	**Δ (%)**
Reljic et al (2021)	(95)	HIIT	6.11±0.62 [a]	6.11±0.78 [a]	0	0	5.7±0.5	5.6±0.3	-0.1	-1.8
		MICT	5.89 [a]	6.05 [a]	0.16	2.72	5.8±0.9	5.8±0.9	0	0
		CON	5.56±1 [a]	5.39±0.94 [a]	-0.17	3.1	5.6±0.7	5.5±0.6	-0.1	-1.8
Rugbeer et al (2021)	(61)	HIIT	5.07±0.60	4.92±0.48	-0.2	-3	5.90±0.40	6.01±0.46	0.1	1.9
		SIT	4.86±0.60	4.89±0.54	0.03	0.6	6.02±0.34	5.94±0.36	-0.1	-1.3
		MICT	5.16±0.76	5.28±0.46	0.1	2.3	5.78±0.28	5.97±0.26	0.2	3.3
		CON	5.02±0.43	5.05±0.34	0.03	0.6	5.93±0.31	6.10±0.44	0.2	2.9
Reljic et al (2020)	(96)	HIIT	5.61 ±1	5.67 ±0.67	0.06	1.1	5.6 ± 0.4	5.5 ± 0.4	-0.1	-1.8
		CON	5.5 ±1	5.28 ±0.89	-0.22	-4	5.5 ± 0.4	5.4 ± 0.4	-0.1	-1.8
Cuddy et al (2019)	(64)	REHIIT	5.37±0.37 [a]	5.27±0.31 [a]	-0.1	-1.9	-	-	-	-
		MICT	5.29±0.38 [a]	5.23±0.56 [a]	-0.06	-1.1	-	-	-	-

* (p<0.005), ** (p<0.01), *** (p<0.001) significantly different from pre-intervention. [a] converted to mmol·L^{-1} = (mg·L^{-1}/18).

Data are presented as mean ± SD. CON: Control; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; REHIIT: Reduced-exertion high-intensity interval training.

2.15 Effects of workplace-based PA on CRF

Epidemiological and clinical evidence demonstrates that CRF is inversely related to premature deaths from all-cause mortality and cardiovascular events in a healthy adult population (1); (a) low levels of CRF are associated with increased risk of premature mortality specifically from CVD (1); (b) higher levels of CRF are associated with higher levels of regular PA which in turn is associated with many health-related benefits (1). CRF is a simple method for monitoring the transition from sedentary behaviour to regular physical activity (150 min MVPA/ week) for the prevention of CVD (100).

2.16 Importance of CRF surveillance in the workplace setting

Since CRF can be modified through regular participation in PA and structured exercise, (1) the focus of health promotion interventions such as workplace PA interventions should be on surveillance and improvement of CRF in the working adult population in a workplace setting.

Emerging evidence suggests that employees with a combination of high occupational physical activity (OPA) and low CRF have an increased risk of CVD and all-cause mortality (101). This was demonstrated in a recent study (101) that showed the increased risk for CVD mortality was found for those with (a) low compared to high self-reported cardiorespiratory fitness [hazard ratio (HR) 2.17, 95% confidence interval (95%CI) 1.40–3.38]; (b) those with high compared to low OPA (HR 1.45, 95% CI 1.05–2.00); (c) those with high compared to low OPA within the strata of low self-reported cardiorespiratory fitness (HR 2.83, 95% CI 1.24–6.46); and (d) those with the combination of high OPA and low self-reported cardiorespiratory fitness had an increased risk for CVD mortality compared to those with the combination of low OPA and high self-reported cardiorespiratory fitness (HR 6.22, 95% CI 2.67–14.49).

Although the physiological underlying mechanism of this is still unknown, it is hypothesised that excessive cardiovascular strain from high OPA may lead to harmful stress on the arterial endothelial dysfunction which after prolonged years of exposure may lead to atherosclerosis and eventually CVD (101). Another potential mechanism is that high OPA leads to elevated BP over working hours or several blood spikes due to lifting a load and static postures may lead to CVD (101).

These findings have an important implication for workplace CVD prevention among employees with excessive OPA and low CRF in improving their cardiovascular health.

2.17 Decrease of CRF in the working population

A recent study (102) with a large cohort (n=354 227; age 18-74) between 1995-2017, demonstrated a deteriorating CRF amongst men and women adult working population. Of concern is the decrease in absolute CRF (VO2max) by −6.7% (−0.19 L/min) in the total population and a relative CRF decreased by −10.8% (−4.2 mL/min/kg) with approximately one-third explained by a simultaneous increase in body weight (102). Furthermore, the proportion of low cardiorespiratory fitness almost doubled because of the strong associations between CRF and multiple morbidities and mortality, preventing further decreases in CRF from becoming a public health priority specifically among the vulnerable groups (102).

A systematic review evidence (103) representing (n= 2 525 827, age; 18 to 59), between 1967-2016 from eight high-upper middle-income countries shows a moderate decline of 7.7% (95% CI − 8.4 to − 7.0) or 1.6% per decade (95% CI − 1.7 to − 1.5). Countries that experienced a decline in CRF had a strong negative correlation between CRF trends and BMI trends meaning that countries with the largest increases in adult obesity experienced the largest decline in CRF (103).

It is hypothesised that temporal trends in OPA, for example, increased automation and computerisation of labour may have affected the CRF in the working adult population and this may be more evident in men than in women (103).

2.18 Effect of HIIT and MICT on CRF

A systematic review (94) showed HIIT (<12 weeks) significantly improved maximal oxygen uptake ($VO_{2\ max}$; SMD 0.74, 95% CI 0.36 to 1.12; p<0.001) and HIIT (≥12 weeks) $VO_{2\ max}$ (SMD 1.20, 95% CI 0.57 to 1.83; p<0.001). Meta-analyses evidence of 22 studies (22), showed that compared with MICT, HIIT (≥2 min) can significantly increase VO_{2max} (SMD = 0.444, 95% CI:0.037~0.851, p= 0.032), subgroup of energy expenditure of HIIT equal to MICT can significantly increase VO2max (SMD = 0.399, 95% CI:0.106~0.692, P = 0.008).

Table 2.13 illustrates the comparative effect of HIIT and MICT on CRF. There is a greater VO_{2max} improvement with HIIT (Δ (mL·kg^{-1}), -3.5 to -2.4; Δ (%) -15.6 to -7.6) compared to MICT (Δ (mL·kg^{-1}), -2.4 to -1.2; Δ (%) -7.6 to -5.9).

Table 2.13 Comparative effect of HIIT and MICT on CRF

CRF, (mL·kg^{-1}·min^{-1})						
Author, date	**Ref**	**Group**	**Pre (mean ± SD, mL·kg^{-1}·min^{-1})**	**Post (mean ±SD, mL·kg^{-1}·min^{-1})**	**Δ (mL·kg^{-1}·min^{-1})**	**Δ (%)**
Reljic et al (2021)	(95)	HIIT	21.9±5.3	25.1±5.4***	-3.2	-14.6
		MICT	20.3±3.8	21.5±4.3	-1.2	-5.9
		CON	21.0±7.3	20.7±7.8	0.3	1.4
Reljic et al (2020)	(96)	HIIT	22.5 ± 6.5	26.0 ± 6.6***	-3.5	-15.6
		CON	23.1 ± 8.0	22.5 ± 8.7	0.6	2.6
Cuddy et al (2019)	(64)	REHIIT	25.3±2.9	28.4±3.1*	-3.1	-12.3
		MICT	26.2±6.7	28.0±7.1*	-1.8	-6.9
Shephered et al (2015)	(59)	HIIT	32.0±7.0	34.8±7.1	-2.8	-8.8
		MICT	31.5±7.0	33.9±7.5	-2.4	-7.6

* ($p<0.005$), ** ($p<0.01$), *** ($p<0.001$) significantly different from pre-intervention.

Data are presented as mean ± SD. CRF: Cardiorespiratory fitness; CON: Control; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; REHIIT: Reduced-exertion high-intensity interval training.

2.19 Summary

Epidemiological evidence indicates an increase in the prevalence of cardiovascular diseases (CVD) in low-and middle-income countries particularly Sub-Saharan Africa (SSA). Prolonged unhealthy behaviours lead to cardiometabolic diseases such as hypertension, diabetes, dyslipidemia, and obesity which may lead to the CVD epidemic. Physical inactivity is an established risk of cardiometabolic diseases, and the workplace is suggested as an appropriate setting to improve physical activity amongst employees. Overwhelming evidence demonstrates improvement in anthropometry and cardiometabolic outcomes with HIIT and MICT among adults however, HIIT may be more effective because of shorter protocols which are timesaving in a time-constrained workplace setting.

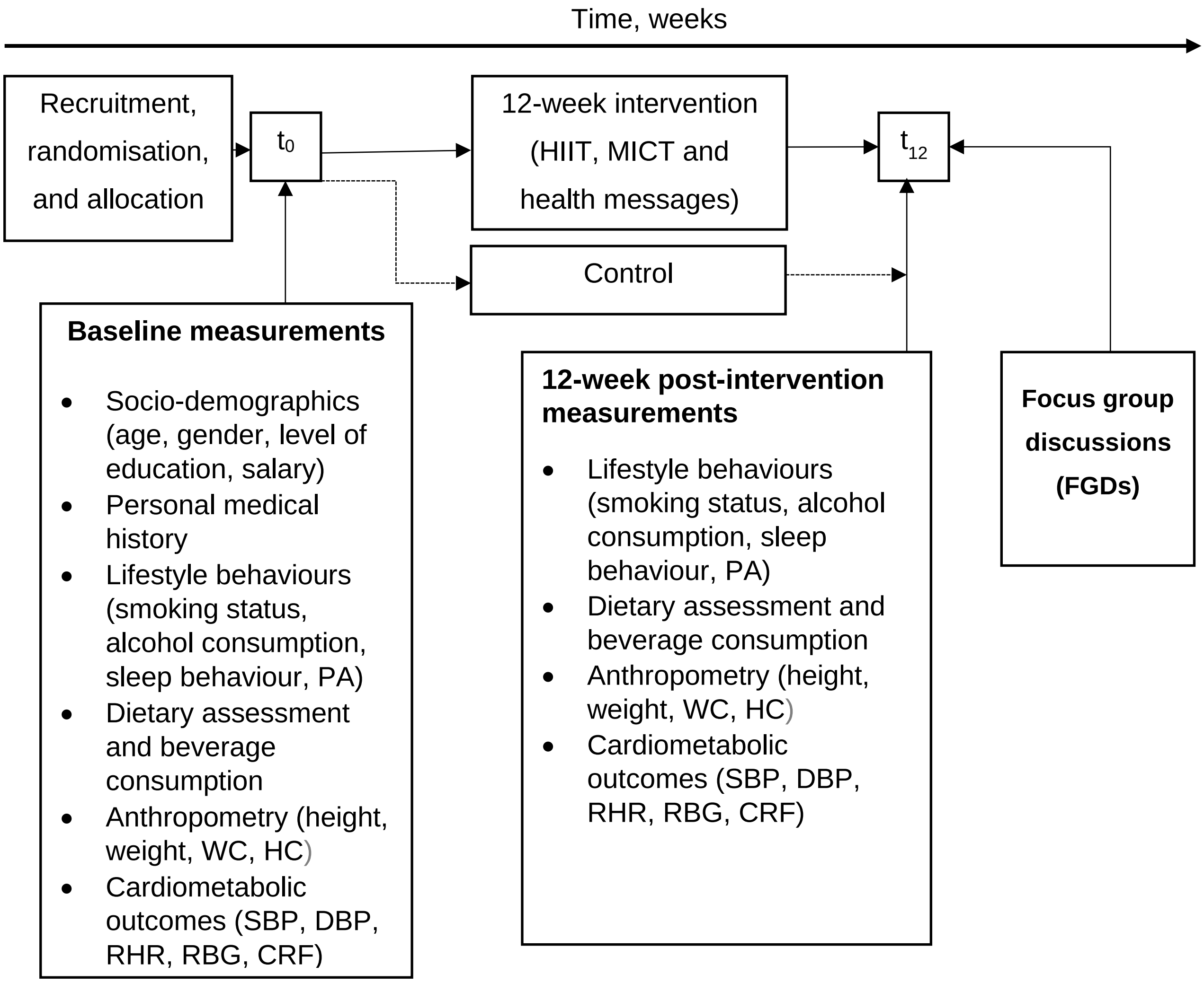
Chapter 3 Methodology

3.1 Introduction

This chapter will present both the methodology of the quantitative research design, randomised controlled trial (RCT), and the qualitative research design, the focus group discussions (FGDs).

3.1.1 The study design

The study used a mixed method research design with a randomised controlled trial (RCT) and focus group discussions (FGDs). The mixed method design used an explanatory sequential approach with an experimental intervention (105). Figure 3.1 illustrates the research design of the study.



CRF: Cardiorespiratory fitness; DBP: Diastolic blood pressure; HC: Hip circumference; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; PA: Physical activity; RBG: Random blood glucose; RHR: Resting heart rate; SBP: Systolic blood pressure; WC: Waist circumference.

Participants allocated in the intervention group participated in either the HIIT or MICT 12-week intervention.

Figure 3.1. The research design of the study

3.1.2 Quantitative (Randomised controlled trial)

The section will describe the study setting and design, population, sampling, and recruitment. Subsequently, the randomisation procedure and implementation of the HIIT, MICT, and health messages interventions will be explained. Furthermore, the HIIT and MICT protocol and safety considerations for the intervention groups will be discussed. Also, the questionnaires used for data collection and the measurement procedures for the anthropometry and cardiometabolic outcomes will be described. Lastly, the section will conclude by presenting the data analysis methods used and ethical considerations of the RCT study.

3.1.3 Study setting

This study was a single-site study conducted at the University of the Witwatersrand, Centre for Exercise Science and Sports Medicine gym, which is situated at Wits Education Campus, 27 St Andrews Road, Parktown, Johannesburg, South Africa.

Johannesburg is the provincial capital of Gauteng province, with an estimated 25% unemployment rate and 72.7% of the population in the working class (104).

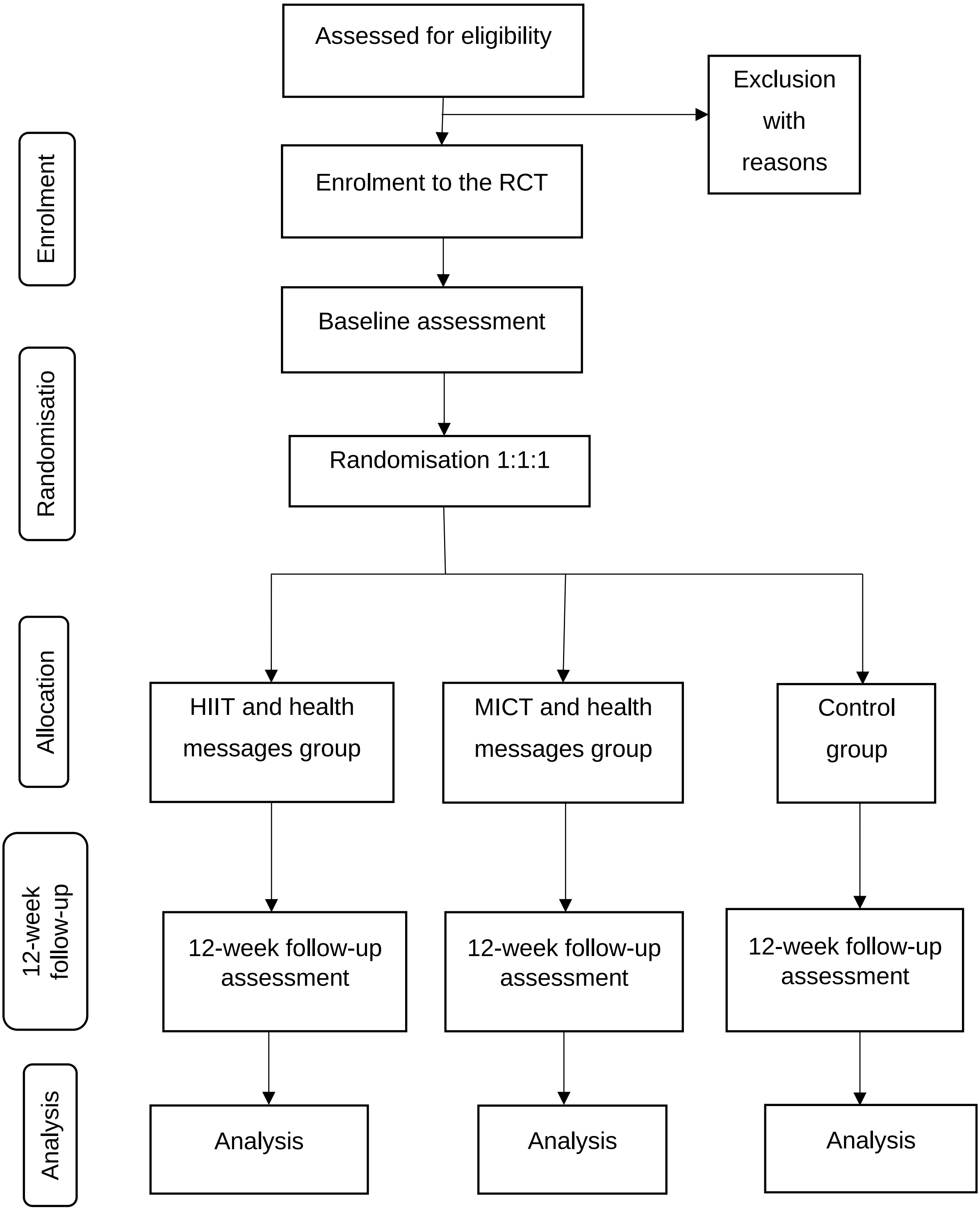
The recent national survey (SADHS) (91) showed an elevated level of cell phone possession among urban residents (95.8%) and 94.4% in non-urban areas in the Gauteng Province (91).

Gauteng province is experiencing a high prevalence of hypertension and obesity. Approximately 42.3% of women and 39.5% of men are hypertensive while two-thirds (65.6%) of women and a third of men (33.5 %) are overweight or obese (BMI ≥25 $kg \cdot m^{-2}$) (91).

Notably, there is also a high prevalence of central obesity among adult women and men, as evidenced by 40.2% of women with a waist circumference ≥88 cm and 10.7% of men with a waist circumference of ≥102 cm (91).

3.1.4 RCT Study design

The RCT was an experimental intervention study that was grounded on the positivist paradigm. Figure 3.2 illustrates the CONSORT flow diagram. The RCT study design used the randomisation technique to generate random allocation of participants to intervention groups or the control group (106). The importance of the randomisation technique is that it induces comparability for known and unknown covariates, mitigates selection bias, and provides a basis for inference (106).



CONSORT: Consolidated standards of reporting trials; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; RCT: Randomised controlled trial.

Figure 3.2. The CONSORT flow diagram

3.1.5 Study population, sampling, and recruitment

3.1.5.1 *Total population*

The study population was defined as professional staff which included cleaners, landscapers, and security officers employed at the University of the Witwatersrand, Johannesburg, and included employees employed full-time, part-time, or as contractors at Parktown campuses.

Security officers (both men and women) employed in the Protection Services division work 12-hour shifts, in a 24-hour cycle from 7 a.m. until 7 p.m. or vice versa. Cleaners and landscapers work for 8 hours a day from 7 a.m. to 3 p.m. and are off from work on weekends.

3.1.5.2 *Sample calculation*

A previous study (37) demonstrated that body mass index (BMI) increased by 7% over 10 years amongst a community of black South African women. Assuming a similar rate of BMI increase in females and males in the control group and a decrease of 1% in a 6 month intervention group, the minimum sample size required was 23 participants per group at a power of 90% and significance of 5%. The expected dropout was 30% during an intervention (23), therefore the target sample was 30 participants per group, and thus 90 participants in total were required for the study. A convenience sampling technique was used to recruit participants.

3.1.5.3 *Inclusion criteria*

- Individuals employed (full-time, part-time, or contractors) as cleaners, landscapers, and security officers at the University of the Witwatersrand, Johannesburg, Parktown campuses (which consists of the Medical School, Faculty of Health Sciences, and the Wits Education Campus).
- Aged ≥18 years.

3.1.5.4 *Exclusion criteria*

- Individuals who were terminally ill.
- Pregnant women were excluded because of changes in anthropometry that may occur during pregnancy.
- Recently (≤ 6 months) diagnosed with cancer.

- Participants who reported impaired ability to exercise (such as uncontrolled hypertension, implanted electronic device, or joint replacement).

3.1.5.5 *Recruitment*

Recruitment was conducted from January to March 2020 with the assistance of the University of the Witwatersrand's Central Human Resources, which was requested to send invitation emails to professional staff. Professional staff were invited to information meetings where the project was described. Parktown campuses included the Medical School, Faculty of Health Sciences, and the Education Campus.

3.1.6 Randomisation in intervention and control group

Participants were randomly assigned to HIIT (n=18), MICT (n=19), and control group (n=17) with a 1:1:1 allocation ratio as per computer-generated software Graphpad QuickCalcs® version 2018 (Graphpad Software, San Diego, California) using blocked randomisation method, with a block size of six.
A Biostatistician from the University of the Witwatersrand Health Sciences Research Office (HSRO) who was not involved in the study conducted the randomisation.

3.1.7 Implementation of the HIIT, MICT, and health messages interventions

The HIIT and MICT interventions were conducted at the University of the Witwatersrand Centre for Exercise Science and Sports Medicine (CESSM) gym.
The Consolidated Standards of Reporting Trials (CONSORT) (107) checklist (appendix P) and Consensus on Exercise Reporting Template (CERT) checklist were used to improve the reporting quality of the study (108).

The training sessions were supervised by the researcher and four research assistants. The researcher has a post-graduate qualification in exercise science and the research assistants had an undergraduate qualification in Biokinetics. The research team had experience with ACSM's guidelines for exercise testing and prescription and familiarity with supervising physical activity intervention in clinical and workplace settings.

All the research assistants attended a 4-hour training session before the intervention and were given a standard operating procedures (SOPs) manual.

The HIIT and MICT intervention was provided individually, to one person at a time (‘one-on-one’) and was delivered face-to-face under the supervision of the researchers.

The participants were requested to exercise with a cloth or surgical disposable face mask covering their mouth and nose as stipulated by the Disaster Management Act regulations during the COVID-19 lockdown was applicable during the data collection period.

The HIIT and MICT sessions were conducted during participants' free time ie during lunch break, before the shift, or end of the shift (for shift workers).

Participants booked their training sessions and confirmed their attendance through a phone call, SMS, or WhatsApp message.

Exercise adherence was defined as the percentage of the supervised sessions completed and was calculated as the number of supervised exercise sessions attended divided by the number of supervised sessions prescribed.

Participant training date and training time was captured on the intervention data collection sheet and captured on the REDCap system. The data flow diagram is illustrated in Appendix Q.

3.1.8 Development and delivery of health messages intervention

A health messages bank was developed for the participants in the intervention groups (HIIT and MICT).

Participants in the MICT and HIIT group received the health messages intervention that included receiving health messages through SMS text messaging and WhatsApp text to motivate them to increase their physical activity and exercise levels and improve lifestyle behaviours such as sleep, diet, alcohol consumption, and smoking status (appendix D).

These messages were sent 5 times per week at random times from the health messages bank during the 12-week intervention from Monday to Friday, at random times between 8 am to 4 pm. A SMS text message had a 160-character limit including spaces and WhatsApp messages had more than 160 characters. After the 12-week intervention, a total of 60 text health messages were delivered.

The health messages text content was developed using behaviour change techniques (BCT) from ACSM's guidelines for exercise prescription (1), WHO guidelines on Physical Activity and Sedentary behaviour(15), and The Heart and Stroke Foundation, South Africa (109).

Participants (end-users) were not engaged in the development of the health messages. The researcher used best practices of communication from peer-reviewed journals to develop behaviour change techniques (BCT) messages to address selected modifiable lifestyle behaviours including physical activity, sedentary behaviour, sleep, diet patterns, alcohol consumption, and smoking status. These measures were collected at baseline using validated questionnaires. The total cost of text messaging per participant was R20.49 for the 12-week intervention.

Participants were given information that included the duration of the intervention, timing, and delivery of the messages, and the health messaging protocol during their baseline assessment visit. Participants confirmed their active mobile numbers which they would receive messages.

Parktown campuses (Medical School, Faculty of Health Sciences, and the Education Campus) are fully covered for Wi-Fi access and network coverage by different network service providers. This is important because it allows 24hr- availability and connectivity to any staff mobile devices connected to the Wi-Fi allowing the participants to have access to SMS and Wi-Fi health messages while in the workplace without any costs.

3.1.9 The HIIT protocol

The HIIT protocol is illustrated in Figure 3.2. The participants performed the HIIT protocol, 3 days per week, cycling on a Recline Excite® stationary recumbent bike (Technogym®, Cesena, Italy). All training sessions were supervised one-on-one by the researcher. Participants commenced the session with a 5-minutes warm-up and cool-down cycling at low intensity (40%-55% HRmax).

The main aim of the HIIT protocol was to achieve three near-maximal (80-90% HR_{max}) intervals of up to 30 sec in duration (59). Participants were encouraged to attain a rated perceived exertion (RPE) of 8 or greater on the Borg CR10 scale and the researcher motivated the participant to maintain the required intensity. A heart rate monitor (S810, Polar, Kempele, Finland) was used to ensure participants achieve at least 80%-90% HR_{max}. Recovery (65%-75% HR_{max}) ranged from 1.5 min to 2 min.

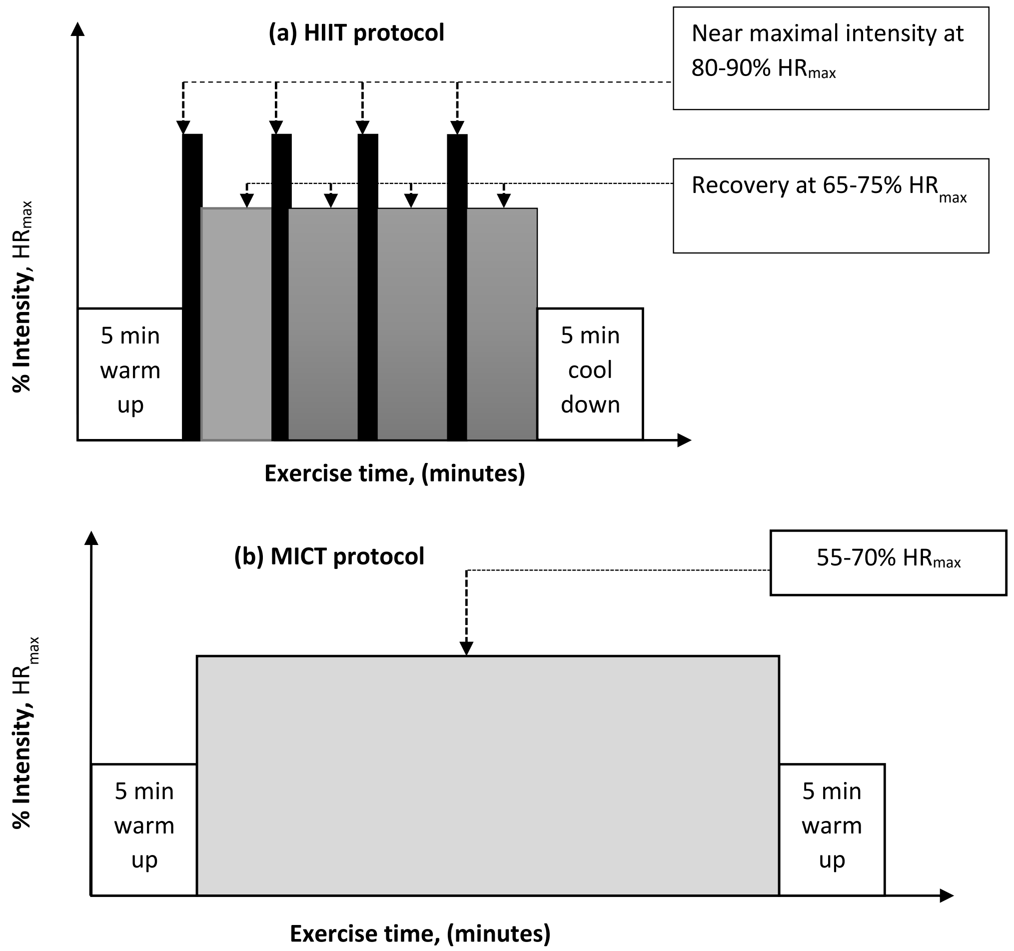
Progression volume for the total working duration ranged from 2 min to 8 min 15 sec (week 1-12), total recovery duration from 8 to 12 min 15 sec (week 1- 12), and numbers of intervals ranged from 4 to 14 (week 1-12). Thus, the exercise session duration ranged from 20 min to 26 min (including the warm-up and cool-down session) from week1 to 12 (appendix B). Exercise progression was individualised using HR_{max} and/or RPE method.

3.1.10 The MICT protocol

The MICT protocol is illustrated in Figure 3.3. Participants in this group were required to participate in a 12-week MICT exercise that includes cycling against self-adjusted resistance on a Recline Excite® stationary recumbent bike (Technogym®, Cesena, Italy) for 30 minutes, 3 days per week, at 55-70% HR_{max} (estimated using the formula: 220-age).

It is demonstrated that this age-predicted HR_{max} equation has a standard error of estimate (SEE) of 12.4 bpm (110).
Prescribing exercise intensity using the heart rate (HR) method: Target HR=HR_{max}^{a} x % desired intensity; $^{a}HR_{max}$ is estimated by using the age-predicted HR_{max} equation (220-age).

MICT sessions began and ended with a 5 min period of low-intensity (40-45% HRmax) cycling during weeks 1 and 2, which was reduced to 2.5 min from week 3 to week 12. The warm-up and cool-down were included in the total duration of the session (Appendix C). Heart rate monitors (S810, Polar, Kempele, Finland) were used to ensure participants achieve the estimated HR_{max}.



HIIT: High-intensity interval training; HR_{rmax}: Maximum heart rate; MICT: Moderate-intensity continuous training.

Figure 3.3. An illustration of the HIIT and MICT protocol

3.1.11 Safety considerations for Intervention groups

Participants with elevated resting systolic blood pressure (≥140 mmHg) or diastolic blood pressure (≥ 90 mmHg) were referred to a physician. Musculoskeletal-related injuries (i.e. muscle strain, bruising, or joint pain) resulting from HIIT or MICT intervention were assessed, recorded, and referred to a physician for treatment if required. Participants were requested to adhere to their medication and nutritional recommendations provided by their treating physician.

3.1.12 Control group

Participants allocated to the control group did not receive advice on improving physical activity, and lifestyle behaviours. The researcher only engaged with participants in the control group to collect baseline data and follow-up data at 12 weeks.

3.1.13 Questionnaires

3.1.13.1 *Socio-demographic status*

Socio-demographics (age, gender; level of education, occupation, and salary) were measured using a questionnaire (Appendix E). The highest level of education was categorised as; (i) no school, (ii) primary school, (iii) incomplete high school, and (iv) completed matric. The occupation was categorised as either security officer, cleaner, or landscaper.

3.1.13.2 *Personal medical history and medication*

Personal medical history and medication were assessed using the Discovery Healthy Company Index questionnaire (Appendix E). Participants were requested to indicate medical conditions they suffered or are suffering from before or at the age of 50 years from the list provided. Participants were also requested to provide current medication and dosage for heart disease, peripheral vascular disease, diabetes, cholesterol, and/or blood pressure.

3.1.13.3 *Smoking status, alcohol consumption, and sleep behaviour*

Smoking status, alcohol consumption, and sleep behaviour were assessed using the Discovery Healthy Company Index questionnaire (Appendix E). Smoking was categorised as never smoked, ex-smoker, current smoker (cigar, pipe, cigarettes, and chewing tobacco/snuff), and regular use of e-cigarettes/vaping.

Alcohol consumption was categorised into 5 responses; (i) by not having alcoholic drinks, (ii) never more than 1-2 drinks per occasion or per day, (iii) 3-4 drinks in a day, only 2-3 per month, (iv) 3-4 drinks in a day, 4 times per month, (v) 3 or more drinks in a day, more than once a week and/or more than 4 drinks at a time.

Sleep behaviour was assessed by the self-reported number of hours of sleep categorised into 5 questions; (i) number of hours of sleep an individual gets on weekdays or workdays, (ii) the time they go to bed at night during the past month, (iii) the time they usually get up in the morning in the past month, (iv) average shortest sleep duration at night in one week during the past month, (v) the average longest sleep duration at night in one week during the past month.

3.1.13.4 *Physical activity*

Self-reported physical activity levels were administered using the Global Physical Activity Questionnaire (GPAQ) version 2 (111). The GPAQ (Appendix E), is a low-cost tool developed for global physical activity surveillance to collect self-reported physical activity data in the following domains; activity at work; travel to and from places; recreational activities; and sedentary behaviour (112). The GPAQ is a reliable instrument that has been validated in the South African adult population (112).

3.1.13.5 *Dietary assessment and beverage consumption*

Self-reported eating habits over the past year were determined by the adapted Discovery Healthy Company Index questionnaire (appendix E), which estimates the frequency of food type (meat/snack, and fruit/vegetable/fibre) in 5 categories; (i) never/once or less than a once per month, (ii) 2-3 times per month, (iii) 1-2 times per week, (iv) 3-4 times per week, (v) 5 or more times per week.

Beverage intake was assessed and estimated using the beverage intake questionnaire (BEVQ-15) (113) which is a 15-item, seven-day recall on sugar-sweetened beverages and total beverage energy intake. The BEVQ-15, (Appendix E), includes 15 categorised beverage items to estimate energy consumption.

3.1.14 Measures

3.1.14.1 *Anthropometry*

International Standards for Anthropometric Assessment (ISAK) guidelines were used to measure the anthropometric outcomes (141).

Standing height was measured to the nearest mm using a wall stadiometer (Seca 213, Hamburg, Germany), and body weight was measured on minimal clothing using a digital scale Omron HN 286, (Omron Corporation, Kyoto, Japan) to the nearest 0.1 kg. Waist and hip circumference was measured using a non-stretch fibreglass tape (Seca 203, Hamburg, Germany) to the nearest cm. Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest (hip bone), and hip circumference was measured at the greatest protuberance below the gluteal line (1).

3.1.14.2 *Blood pressure and resting heart rate*

Resting brachial systolic blood pressure, brachial diastolic blood pressure, and resting heart rate will be measured in triplicate using an automatic blood pressure monitor, Omron M6 (HEM70001, Omron, Kyoto, Japan), and automated oscillometric IntelliSense cuff (HEM-FL31, Omron, Tokyo, Japan) with the participant seated according to ACSM guidelines. The mean of the second and third readings was calculated and recorded on the participant information sheet. The participant rested for three minutes between each of the readings (1).

3.1.14.3 *Mean atrial pressure*

Mean arterial pressure (MAP) is defined as the average arterial pressure throughout one cardiac cycle, systole, and diastole. MAP is influenced by cardiac output and systematic vascular resistance throughout one cardiac cycle (114).
Mean Atrial Pressure (MAP) was derived using the following equation:

$$MAP = DBP + 1/3 \times (SBP - DBP) \quad (114)$$

Where DBP is the diastolic blood pressure, SBP is the systolic blood pressure.
This method is considered quick, cost-effective, and applicable in most clinical settings if the blood pressure is measured. MAP functions to perfuse blood to all the tissues of the body to keep them functional. Mechanisms are in place to ensure that the MAP remains at least 60 mmHg so that blood can effectively reach all tissues (114).

3.1.14.4 Pulse pressure

Pulse pressure (PP) is the difference between systolic and diastolic blood pressures (115) and is derived using the equation:

$$PP= SBP – DBP \ (115)$$

Normal pulse pressure is approximately 40 mmHg (115).

3.1.14.5 Random capillary blood glucose

Finger prick testing to collect ~1.1μL drop of blood to determine random blood glucose was performed using a point-of-care device CardioCheck ® Plus professional analyser (Polymer Technology, Indianapolis, United States of America). Unistick® Touch single-use safety lancets were used to obtain capillary blood samples.

The eGlu glucose test strips were used with the CardioChek Plus analyser when compared to laboratory-obtained results for RBC. In the PTS test strips it was found that the CardioChek device is a reliable device that can be used for clinical screening producing an accuracy value of r > 0.9858 and a coefficient of variation between test strips not greater than 9% (116).

Blood glucose levels vary depending on the food consumed, physical activity, health status, dehydration, medication dosages, and stress levels (116).
However, outcomes depend on the clinician's expertise and training to produce accurate results (116). Before conducting the test, each researcher was trained on how to use the equipment to ensure validity and reliability.

Untreated participants were referred to their doctor for further diagnosis of diabetes when random blood glucose was (≥11.1 mmol/L) (117). Table 3.1 illustrates the interpretation of random capillary blood glucose tests using the Society of Endocrinology, Metabolism, and Diabetes of South Africa (SEMDSA) 2017 guideline (117).

Table 3.1 Interpretation of random capillary blood glucose test (117).

Random capillary blood glucose (RCBG) mmol·L^{-1}	<5.6	5.6-11.0	≥11.1
Interpretation	Diabetes excluded	Inconclusive	Diabetes

3.1.14.6 *Cardiorespiratory fitness*

Cardiorespiratory fitness was assessed using the Queen's College step test (QCT). The step test was performed using a 41.3 cm step with a stepping rate of 24 steps/minute for men and 22 steps/minute for women for 3 minutes (159). The step rate was set using a digital metronome (https://www.metronomeonline.com/).

Within 5 seconds after completing the step test, the recovery heart rate was determined for 15 seconds, using a heart rate monitor (S810, Polar, Kempele, Finland). The estimation of VO_{2max} was calculated from the test results using the McArdle et al. (1972) predictive equation (1,14) (Appendix E).

Female:

$$VO_{2max}\ (mL \cdot kg \cdot min^{-1}) = 65.81 - (0.1847 \times HR \text{ in beats} \cdot min^{-1})$$

Male:

$$VO_{2max}\ (mL \cdot kg \cdot min\text{-}^{1}) = 111.3 - (0.426 \times HR \text{ in beats} \cdot min^{-1})$$

Where: HR- heart rate measured after the step test

The Queens College Step Test has been validated against a graded exercise test (GXT) to volitional exhaustion on a treadmill. A significant correlation was observed between predicted and measured VO_{2max} ($r=0.75$), standard error of prediction ±2.9 mL/kg/min, suggesting an effective method of predicting VO_{2max} (118).

Aerobic capacity (VO_{2max}) is a strong predictor of health and fitness and a key physiological measure in the healthy adult population. The submaximal step test is a safe, simple, and valid method of assessing VO_{2max} in a healthy adult population and clinical setting (1). Evaluation and maintenance of CRF are considered important to reduce the decline in aerobic capacity and reduce associated risk to health (119).

The Queens College Step Test was terminated using the ACSM general indications for stopping an exercise test for example onset of angina or angina-related symptoms, participants' requests to stop the test, signs of poor perfusion, or there are physical or verbal signs of severe fatigue (1).

3.1.14.7 *Rating of perceived exertion (RPE)*

Rating of perceived exertion (RPE) was measured using the Borg CR-10 scale (1) at the end of each HIIT and MICT session.

This scale ranges from ‘‘nothing at all’’ (0) to ‘‘absolute maximum’’ (10) The Borg CR-10 scale has been established as a reliable and valid measure of physical exertion during exercise (test-retest; Spearman’s p= 0.92, concurrent validity with heart rate Spearman’s p=0.91) (120).

3.1.15 Data collection procedure

After ethical approval, the researcher addressed and gave the information sheet to potential participants during information briefing sessions. Participants were invited to participate in the study, and those who were interested were given information sheets (Appendix I) and were asked to complete the informed consent form (Appendix J). All measurements were carried out with the assistance of 2021 fourth year Biokinetics students who received training before data collection.

The researcher and research assistants completed the questionnaire and administered all measurements on behalf of the participants using the specified procedures.

The data was collected during participants’ lunch breaks at the Centre for Exercise Science and Sports Medicine laboratory. All the tests were conducted in the same order at baseline and 12-week follow-up.

The data was collected in the following order:

1. Questionnaires; Socio-demographics status, Personal medical history, and medication, Smoking status, alcohol consumption, and sleep behaviour, Global Physical Activity Questionnaire (GPAQ), Dietary assessment, beverage intake questionnaire (BEVQ-15).
2. Blood pressure was measured in triplicate with three minutes between each of the readings.

3. Anthropometry measurements were collected in the following order: height, weight, waist circumference, and hip circumference.
4. Queen's College step test (QCT) 3- Minute Step Test.

The collected data was captured on a password-protected Research Electronic Capture System (REDCap), which was only accessible to the researcher and the supervisors.

3.1.16 Injuries or adverse effects

Participants in the HIIT and MICT groups were requested to report any injuries or adverse effects as a result of the physical activity intervention. Participants were requested to provide this information before and after each exercise session.

There were no injuries or adverse effects reported or observed in both the HIIT and MICT groups during the 12-week intervention.

3.1.17 Data analysis (RCT)

Statistica version 13 (StataSoft Inc., Tulsa, OK, USA) was used for quantitative statistical analysis. Statistical significance was set at $p < 0.05$.

For objective one, normally distributed continuous variables were presented as mean ± standard deviation (SD), and non-normally distributed variables were presented as median (interquartile range).

For objective two, a mixed-design ANOVA was performed to examine the effect over time and the main effect of time and group interaction. Between factors examined differences between the two groups, whereas, within factors assessed change over time. When a significant main effect (i.e. $p<0.05$) was determined, a post-hoc test was performed using Bonferroni correction for multiple comparisons.

For objective three, ANOVA was used to determine the differences in absolute changes in outcomes of interest between the control group and intervention groups.

3.1.18 Ethical considerations

Permission to conduct the RCT was granted by the Human Research Ethics Committee (Medical) (HREC), University of the Witwatersrand (ethics certificate number: M190409) (Appendix G). The institution gave permission to recruit the participants. The student was given a platform to inform the participants at usual

staffing forums. Consenting participants provided written consent. Data were de-identified for confidentiality. A separate linking file was created to follow up on the participants. All participants were free to withdraw without repercussions.
Participants in the control group were given the opportunity to participate in an exercise programme post-study and data collection period. The participants also received the same health messages that were sent to the HIIT and MICT groups during the 12-week intervention.

3.2 Qualitative (focus group discussion)

3.2.1 Focus group discussion data credibility and trustworthiness model

The research has followed the data credibility and trustworthiness criteria model (154) which includes the following end goals (a) a worthy topic, (b) rich rigour, (c) sincerity, (d) credibility, (e) resonance, (f) significant contribution, (g) ethical, and (h) meaningful coherence.

3.2.1.1 *A worthy topic*

The literature presented in the introduction and literature review warrants a need to investigate the facilitators and barriers of workplace physical intervention thus improving the planning, design, and implementation of workplace physical activity in improving anthropometric and cardiometabolic outcomes. Workplace physical activity interventions are timely, significant, and relevant in combating the persistent increasing prevalence of obesity and cardiometabolic diseases in the South African adult population which has significant health and cost implications for the employee and the employer, respectively.

3.2.1.2 *Rich rigour*

The study used appropriate theoretical constructs, sampling techniques, rigorous data collection, and analysis methods. The researcher adopted appropriate good practices for focus group discussions which include the development of the FGD interview guide, field note taking, adequate FGD duration, and transcription details to ensure transcription accuracy. The researcher was able to critique the interpretation and presentation of the research findings.

3.2.1.3 *Sincerity*

The researcher is aware of their existing subjective values, biases, and inclinations. However, the researcher has exercised transparency in the description of the study methods, limitations, challenges, and strengths of the study.

3.2.1.4 *Credibility*

The study presents an in-depth description of the emerging themes and provides concrete detail through the selected quotes.

3.2.1.5 *Resonance*

The quotes included in data analysis and interpretation have attempted to present the participants' experiences and understanding. In addition, the knowledge generated can still be transferable and useful in similar settings.

3.2.1.6 *Significant contribution*

Due to the lack of information on workplace physical work in South Africa, and Africa, the researcher contends that this study makes a significant contribution to developing effective and efficient workplace physical activity in improving cardiometabolic outcomes and lifestyle behaviours.

3.2.1.7 *Ethical*

The FGDs were conducted ethically. All participants read the study information sheet (appendix I) and were allowed to ask questions related to the study. Written informed consent before the commencement of the FGDs (appendix L) and consent form for audio-recording of study participation (Appendix M). During the FGDs and research process (including analysis and interpretation) attention was paid to situational and cultural ethics.

3.2.1.8 *Meaningful coherence*

The study has achieved its intended aim and objectives using the described methods and procedures. The study findings provide valuable information for the continuation of research into the investigation of facilitators and barriers to workplace physical activity interventions.

3.3 Study design

The qualitative research was reported in guidance of the consolidated criteria for reporting qualitative research (COREQ) (121) and the standards for reporting qualitative research (SRQR) (122).

3.3.1 Theoretical framework

A qualitative approach was used to explore factors that affected participation in the 12-week physical activity and health messaging intervention.

Focus group discussions (FGDs) were selected as the appropriate method that allowed the collection of different perceptions on the research topic, arising from an interaction between participants (123).

This study adopted both the deductive approach (pre-identified themes based on the research question) and inductive (emerging themes from the transcripts and field notes) (123). The study was grounded on Bronfenbrenner’s socio-ecological model (40) and the theory of planned behaviour (124) to understand the dynamic interrelations among various personal and environmental factors, facilitators, and barriers within the domains of active living during the intervention.

3.3.2 FGDs participant's recruitment, eligibility, and exclusion criteria

Participants who participated in the HIIT, MICT health messages intervention were recruited to participate in the FGDs using a convenience sampling strategy.

Eligibility criteria included:

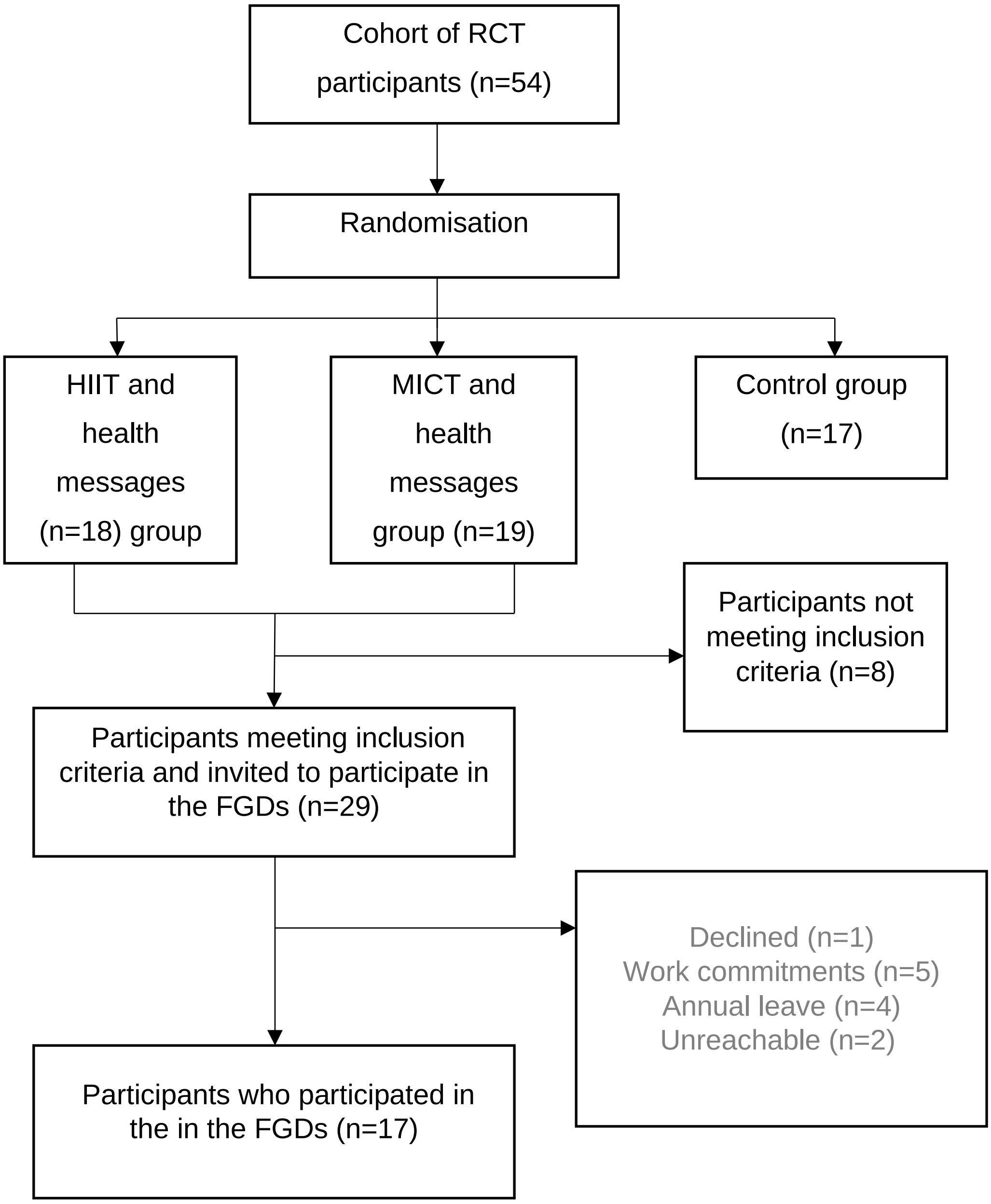
- Participation in the 12-week HIIT and health messages, or MICT and health messages,
- Completed the baseline and post-intervention assessments, and
- Signed the FGD informed consent and consent for audio recording.

Exclusion criteria included:

- The participant was assigned to the control group, and
- Declined to sign the FGD informed consent and/or consent for audio recording.

Participants were recruited through SMS and face-to-face method.

Figure 3.4 illustrates the FGDs sampling, recruitment, and participant flow in the study. Seventeen (58.62%) of the participants who met the inclusion criteria participated in the FGDs. One participant (3.45%) declined to participate in the FGDs while 11 participants (37.93%) were not available due to various reasons including work commitments (n=5), on annual leave (n=4), and unreachable (n=2).



FGDs: Focus group discussions; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; RCT: Randomised controlled trial.

Figure 3.4. Focus group participant flow diagram

3.3.3 Data collection

Six semi-structured FGDs, each with 3-5 participants, were conducted in a private room at the Centre for Exercise Science and Sports Medicine (CESSM).

The researcher facilitated all the FGDs and captured field notes. The FGDs were conducted between November 2021 and February 2022 by the researcher. FGDs were conducted in English and the participants' home language. The researcher was multi-lingual and able to translate questions into participants' home language when required. The audio recording and FGDs transcriptions were checked by the supervisors.

The FGD interview guide is provided in Appendix N. Participants were asked views and opinions on workplace physical activity, and their intentions in participating in the intervention. Open-ended questions were used in the FGDs to facilitate a discussion on understanding participants' barriers and facilitators in the intervention. Participants were asked about their views on the application of the intervention in their work setting.

The duration of each FGD ranged between 30 minutes and 1.5 hours. The discussions were audio-recorded using an audio recording device (Phillips DVT4010 Voice Tracer) and transcribed verbatim by an external transcription company. Translation from the participants' home language to English was conducted by this company, with translation done where necessary. All transcripts were checked against the recordings to verify accuracy and credibility.

3.3.4 Data analysis

Analysis of transcripts was conducted using a reflexive thematic analysis six-step framework (123). Field notes were used to support and contextualise the analysis. This method was selected because it produces a flexible, accessible, and important approach for analysing individual perspectives (123).

The six-step framework does not occur in a linear manner (123). The first step involved familiarising oneself with data which included checking the transcripts with the audio recording and repeated reading of the transcripts. The second step involved generating initial codes. Deductive codes were based on the key domains relating to the FGDs guide. Table 3.2 illustrates the coding framework.

The third step comprised searching for themes in the transcripts. The themes were reviewed, reorganised, and defined in the fourth and fifth steps. Finally, the sixth step involved summarising and describing the themes illustrative quotes for each theme.

A data analysis software tool Nvivo (version 12) was used to organise the codes and themes into a structure for analysis.

Table 3.2 Focus group discussion (FGDs) coding framework

Themes	**Description**
Understanding workplace physical activity	Views and opinions on workplace physical activity
The intention of participating in the intervention	Aim of participating in the workplace physical activity intervention
Barriers to the intervention	Factors that were barriers to employee's ability to participate in the physical activity intervention
Facilitators in the intervention	Factors that were facilitators to employee's ability to participate in the physical activity intervention
Recommendation on the intervention	Views and opinions on how to increase participation in a workplace physical activity programme

3.4 Summary

The chapter has described the study design and theoretical framework underpinnings of research. Furthermore, data collection and data analysis methods used in the study were discussed.

The RCT study design aimed to investigate the effects of physical activity and health messages interventions on anthropometry and selected cardiometabolic outcomes amongst university professional staff employed at the University of the Witwatersrand. The qualitative aspect of the study used FGDs to explore factors that affected participation in the 12-week physical activity and health messaging intervention.

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Chapter 4 Results

4.1 Introduction

The first section of this chapter will present the results of the quantitative results of the randomised controlled trial (RCT). Firstly, the chapter presents the participant's baseline characteristics; sociodemographic, lifestyle behaviours, anthropometric, and cardiometabolic outcomes. Correlational analysis of anthropometric and selected cardiometabolic outcomes is presented. Subsequently, within-group and between-group comparisons of the anthropometric and cardiometabolic outcomes changes in the HIIT, MICT, and control groups will be presented. Results on the effects of the intervention on anthropometric and selected cardiometabolic outcomes adjusting for socio-demographic factors. This chapter will present the results of the qualitative study (Focus Group Discussions). The second section will highlight the characteristics of the participants that participated in the focus group discussions (FGDs). Subsequently, the emerging themes from the FGDs will be presented.

4.1.1 Quantitative results (RCT)

4.1.1.1 *Participant's characteristics, sociodemographic, lifestyle behaviours, anthropometric, and selected cardiometabolic outcomes*

Table 4.1 shows the participants' demographic, lifestyle, and clinical characteristics. The mean age of the participants in the study was 41.87 ± 7.75 years with a mean body mass index (BMI) of 30.75 ± 6.99 kg·m^{-2} and a mean waist circumference (WC) of 96.01 ± 13.43 cm. The prevalence of overweight and obesity (BMI ≥ 25 kg·m^{-2}) was 79.6%, while the prevalence of central obesity as measured by WC cut-points was 1.9% in males and 74.1% in females.

Nearly one-third of the participants (31.48%) presented with ≥2 cardiovascular (CVD) risk factors. The mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 126.32 ± 16.37 and 82.56 ± 11.95 mmHg, respectively; while the prevalence of hypertension was 37.04%, however, only 13% were on blood pressure-lowering medication.

The mean random blood glucose was 6.19 ± 1.43 mmol·L^{-1} and the mean estimated VO_{2max} was 49.15 ± 11.34 mL· kg^{-1}· min^{-1}.

Just over half of the sample reported regular alcohol consumption (53.7%). The proportion reporting a fruit consumption of ≥3 servings/week was 31.48% and 64.8% reported previous unsuccessful attempts to follow healthy diets.

The mean night-time sleep hours were 6.68 ± 1.31 hrs/night.

The prevalence of physical inactivity was 81.13%, the mean sitting time was 4.75 (3.00-8.00) hrs · day^{-1}, and total moderate-vigorous physical activity (MVPA) was 302.00 (150.00-480.00) min · wk^{-1}.

Table 4.1 Participants' demographic, lifestyle, and clinical characteristics (N=54)

Variables	**Mean ± SD or Median (IQR) or n (%)**
Gender	
Male (%)	11 (20.37)
Female (%)	43 (79.63)
Age, years	41.87 ± 7.75
Age quartiles	
<25 (%)	1 (1.85)
26-35 (%)	7 (12.96)
36-45 (%)	28 (51.85)
46-55 (%)	16 (29.63)
56-65 (%)	2 (3.70)
Highest educational	
Primary school (Grade 1 to 7) (%)	1 (1.85)
Incomplete high school (Grade 8 to 11 and did not complete grade 12) (%)	23 (42.59)
Completed matric (%)	30 (55,56)
Occupational type	
Cleaner (%)	20 (37.04)
Security officer (%)	29 (53.70)
Landscaper (%)	5 (9.26)
Salary categories	

Variables	**Mean ± SD or Median (IQR) or n (%)**
<R15k (%)	39 (72.22)
R15k-R20k	4 (7.41)
Personal medical history (diagnosed)	
Hypertension	9 (16.67)
Cholesterol	1 (1.85)
Heart disease	1 (1.85)
Asthma	1 (1.85)
Cancer	1 (1.85)
Currently taking medication for hypertension	7 (12.96)
Cigarette smoking	
Current Cigarette smoking (%)	1 (1.85)
Alcohol consumption	
No alcohol consumption (%)	25 (46.30)
≤ 2 drinks per occasion or day (%)	22 (40.74)
3 to 4 drinks in a day, only 2-3 per month (%)	5 (9.26)
3 to 4 drinks in a day,4 times per month (%)	2 (3.70)
Fruit, vegetable, and fibre intake (≥ 5 times· wk^{-1})	
Brown rice/ whole-wheat pasta (%)	3 (5.56)
Fruit (not including fruit juice) (%)	17 (31.48)
Green salad (%)	6 (11.11)
Potatoes with skin (%)	3 (5.56)
Legumes (%)	3 (5.56)
Other vegetables (%)	14 (25.93)
High-fibre cereal (%)	17 (31.48)
Whole-wheat (%)	19 (35.18)
Healthy diet intention	
No intention of following a healthy diet in the next 6 months (%)	2 (3.70)
Not following a healthy diet but intend to follow a healthy diet in the next 6 months (%)	19 (35.19)
Trying to follow a healthy diet but not always successful (%)	24 (44.44)

Variables	**Mean ± SD or Median (IQR) or n (%)**
Following a healthy diet but less than 6 months (%)	9 (16,67)
Beverage intake	
Water (Kcal)	0 (0-0)
Juice (Kcal)	1.14 (0-2.86)
Sweetened juice (Kcal)	2.27 (0-14.28)
Whole milk (Kcal)	25.90 (0-182.4)
2% milk (Kcal)	0(0-0)
Skim milk (Kcal)	0 (0-0)
Soft drinks (Kcal)	37.98 (0-266)
Diet soft drinks (Kcal)	0 (0-0.852)
Sweetened tea (Kcal)	0 (0-28.56)
Tea/coffee with sugar (Kcal)	23.42 (0-131.2)
Tea/coffee black (Kcal)	0 (0-0)
Beer (Kcal)	0 (0-0)
Hard liquor (Kcal)	0 (0-0)
Wine (Kcal)	0 (0-0)
Energy drinks (Kcal)	0 (0-39.98)
Total SSB (Kcal)	215.76 (91.98-593.53)
Total SSB (g)	938.11 (435.90-1690.45)
Total beverages (Kcal)	418.20 (174.201-721.02)
Total beverages (g)	2118.43 (1856.42-2448.80)
CVD risk factors	
Low risk ≤ 1 (%)	37 (68.52)
Moderate risk 2-3 (%)	15 (27.78)
High risk ≥4 (%)	2 (3.70)
Anthropometry outcomes	
Height (m)	1.63 ± 0.07
Weight (kg)	81.11 ± 17.33
Waist circumference (cm)	96.01 ± 13.43
Hip circumference (cm)	112.13 ± 13.99
Anthropometric indices	
WHR	0.86 ± 0.07

Variables	Mean ± SD or Median (IQR) or n (%)
BMI (kg·m^{-2})	30.75 ± 6.99
WHtR	0.59 ± 0.09
Waist-height-ratio	
WHtR (<0.5)	8 (14,81)
WHtR (≥ (0.5)	46 (85,19)
Waist-hip-ratio	
Men ≥0.90	4 (7.41)
Women ≥0.85	24 (44.44)
Central obesity as defined by waist circumference	
Men ≥ 94 cm	1 (1.85)
Women ≥ 80 cm	40 (74.07)
BMI classification	
Underweight <18.5	1 (1.85)
Normal 18.5-24.9	10 (18.52)
Overweight 25.0-29.9	16 (29.63)
Obesity, class I 30.0-34.9	13 (24.07)
II 35.0-39.9	11 (20.37)
III ≥40.0	3 (5.56)
Blood pressure	
Maximum heart rate (beats·min^{-1})	178.13 ± 7.75
SBP (mmHg)	126.32 ± 16.37
DBP (mmHg)	82.56 ± 11.95
RHR (bpm)	77.69 ± 8.83
Elevated blood pressure (≥130/85 mmHg) (%)	20 (37.04)
Blood pressure indices	
Pulse pressure (mmHg)	43.77 ± 9.93
MAP (mmHg)	97.15 ± 12.75
Random blood glucose	
RBG (mmol ·L^{-1})	6.19 ± 1.43
RBG (>11 mmol·L^{-1}) (%)	0
Cardiorespiratory fitness	

Variables	**Mean ± SD or Median (IQR) or n (%)**
Post-exercise HR (beats·min^{-1}) (n=52)	118.87 ± 17.60
Estimated VO_{2max} (mL· kg^{-1}· min^{-1}) (n=52)	49.15 ± 11.34
CRF percentile classification	
80-85 percentile (%)	4 (7,69)
90-95 percentile (%)	48 (92,31)
Normative CRF categories	
Superior (%)	32 (61.54)
Excellent (%)	19 (36.54)
Good (%)	1 (1.92)
Sleep behaviour	
Sleep duration (hrs)	6.68 ± 1.31
Sleep duration	
≥7 hours (%)	33 (61.11)
5-6 hours (%)	18 (33.33)
< 5 hours (%)	3 (5.56)
Physical activity	
Total work MVPA (min · wk^{-1})	0.0 (0.0-40.0)
Total walking for travel MVPA (min · wk^{-1})	180.0 (75.0-250.0)
Total leisure MVPA (min · wk^{-1})	0.0 (0.0-180.0)
Sitting time (hrs · day^{-1})	4.75 (3.00-8.0)
Total MVPA (min · wk^{-1})	302.0 (150.0-480.0)
WHO active (min · wk^{-1}) (%)	11 (20.75)
GPAQ active (MET-min · wk^{-1}) (%)	10 (18.87)

Data presented as mean ± SD or median (interquartile range (IQR)) or N (total number of participants) %. BMI: Body mass index; CRF: Cardiorespiratory fitness; DBP: Diastolic blood pressure; GPAQ: Global physical activity questionnaire; HR: Heart Rate; MET: Metabolic equivalent; MVPA: Moderate to vigorous physical activity;
PA: Physical activity; RBG: Random blood glucose; SBP: Systolic blood pressure; SSB: Sugar sweetened beverages; WC: Waist circumference; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio.

4.1.2 Physical activity pattern among professional staff

Figure 4.1 illustrates the physical activity pattern among the professional staff. This study demonstrates that professional staff accumulates a higher PA in the travel domain (42%) of the total MVPA compared to 36.6% in the work, and 21.4% in the leisure domain. Females accumulated higher levels of PA (52.9%) compared to males (22.5%). Males accumulate higher levels of PA (57.8%) in the work domain compared to females (25.5%), while both males and females had a lower accumulation of PA in the leisure domain 19.8% and 22.3% respectively.

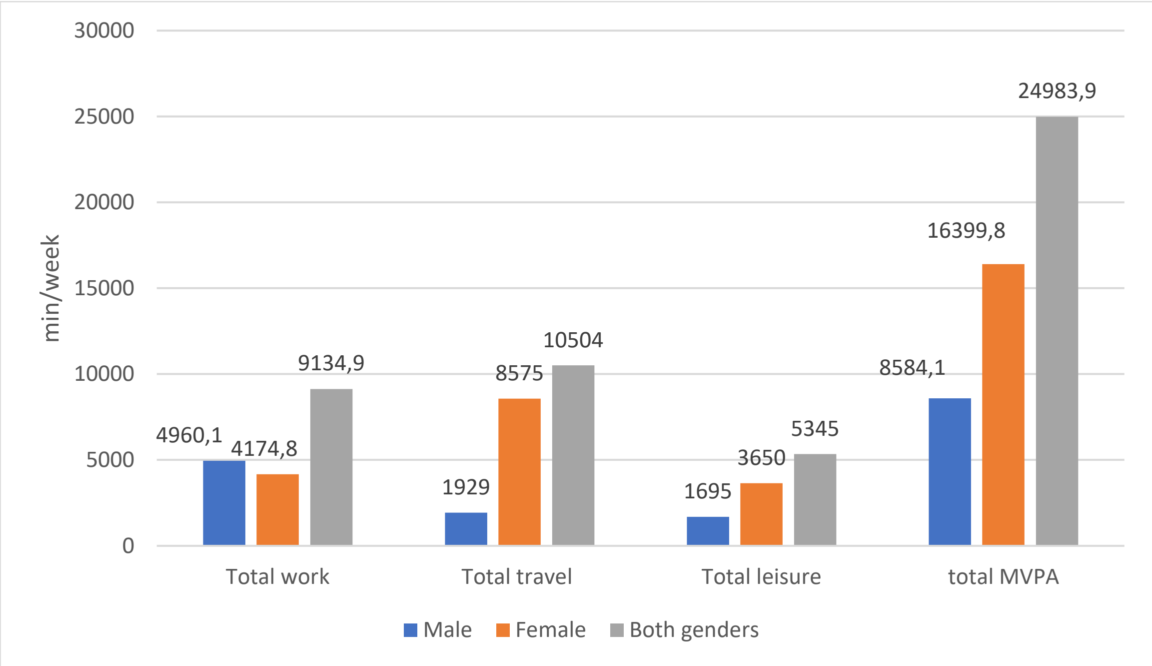


Figure 4.1 Cumulative weekly PA in the occupation-, transport-and recreational time among professional workers

4.1.3 Correlation analysis of anthropometric and selected cardiometabolic outcome

Table 4.2 illustrates the correlation analysis of anthropometric variables and cardiometabolic outcomes.

WC, BMI, PP, and sitting time is positively correlated with RBG ($r=0.44$, $p=0.001$), ($r=0.42$, $p=0.002$), ($r=0.32$, $p=0.019$), ($r=0.34$, $p=0.013$) respectively.

Total leisure MVPA is negatively associated with BMI ($r=-0.33$, $p=0.020$). Sitting time is positively associated with BMI ($r=0.32$, $p=0.023$).

There is a negative correlation between WC, BMI, and estimated VO2 max (r=-0.55, p=0.000), (-0.60, p=0.000) respectively. Total leisure MVPA, total vigorous PA, total MVPA is negatively correlated to WC (r=-0.38, 0.006), (r= -0.30, p=0.035), (r= -0.30, p=0.036) respectively.

RBG is positively correlated with PP (r=0.32, p=0.019). Sitting time is positively correlated with BMI and RBG (r=0.32, p=0.023), (r=0.34, p=0.013) respectively.
Total work MVPA, Total vigorous PA, and Total MVPA are positively correlated to VO2 max (r=0.38, p=0.006).

Table 4.2 Correlation analysis of anthropometric variables and cardiometabolic outcomes

Variables	**BMI**	**WC**	**SBP**	**PP**	**RBG**	**Estimated VO_{2max}**
WC (cm)	-	-	-	-	**0.44 (0.001)***	**-0.55 (0.000)***
BMI ($kg \cdot m^{-2}$)	-	-	-	-	**0.42 (0.002)***	**-0.60 (0.000)***
PP (mmHg)	-	-	-	-	**0.3233 (0.019)***	-
RBG ($mmol \cdot L^{-1}$)	-	-	-	**0.32 (0.019)***	-	-
Total work MVPA ($mins \cdot wk^{-1}$)	-	-	**-0.30 (0.035)***	-	-	**0.38 (0.006)***
Total leisure MVPA ($min \cdot wk^{-1}$)	**-0.33 (0.020)***	**-0.38 (0.006)***	-	-	-	-
Sitting time ($hrs \cdot day^{-1}$)	**0.32 (0.023)***	-	-	-	**0.34 (0.013)***	-
Total vigorous PA ($min \cdot wk^{-1}$)	-	**-0.30 (0.035)***	**-0.28 (0.047)***	-	-	**0.38 (0.006)***
Total MVPA ($min \cdot wk^{-1}$)	-	**-0.30 (0.036)***	**-0.28 (0.044)***	-	-	**0.38 (0.006)***

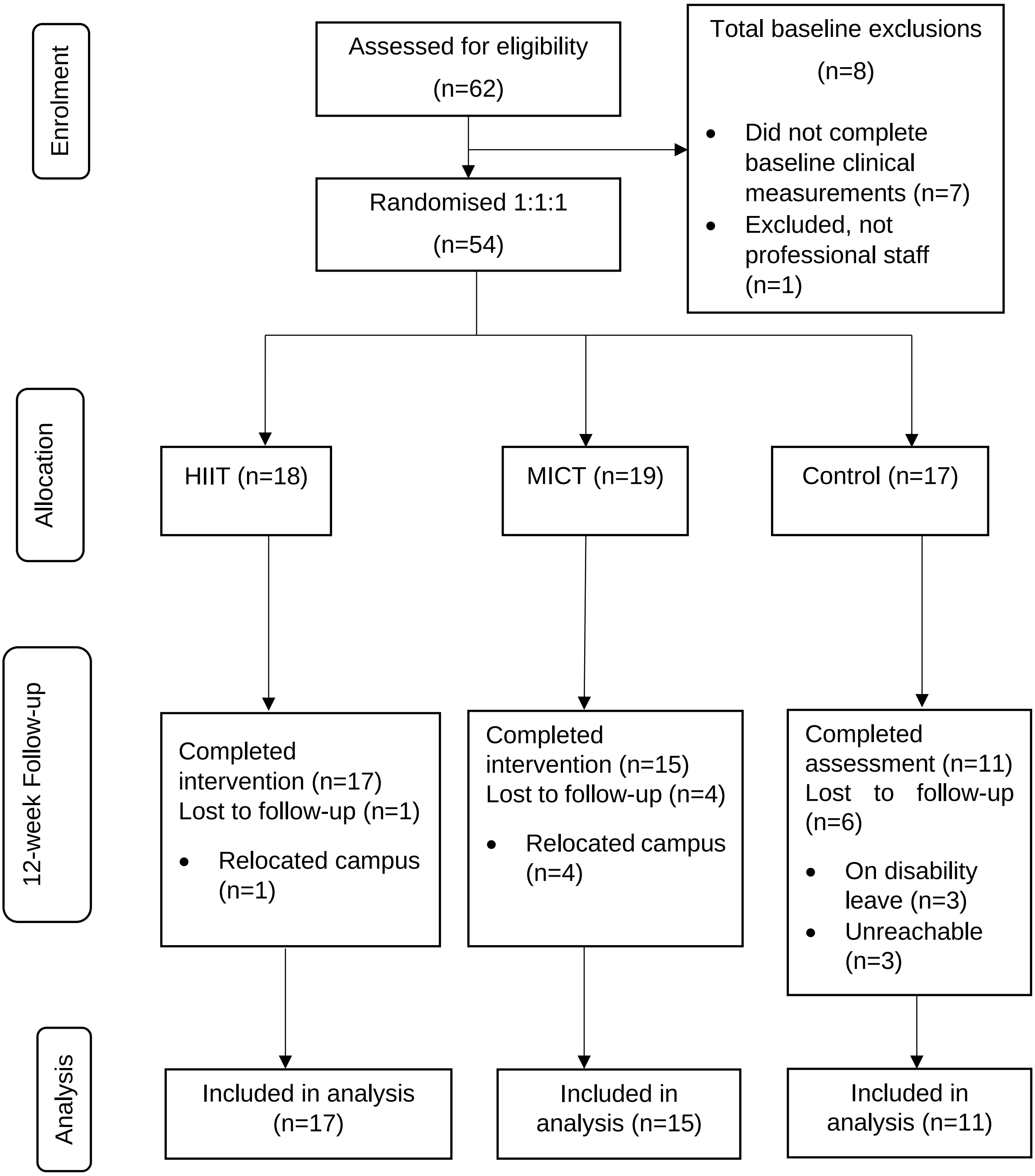
Data presented as Pearson moment of correlation (r), p-value (p). Correlations are significant at $p < 0.05$.

* Indicates statistical significance at $p < 0.05$.

BMI: Body mass index; MVPA: Moderate to vigorous physical activity; PA: Physical activity; PP: Pulse pressure; RBG: Random blood glucose; SBP: Systolic blood pressure; WC: Waist circumference.

4.1.4 Participant flow in the intervention

Figure 4.2 illustrates the flow of participants through each stage of the study A total of 62 participants were assessed for eligibility for the intervention, and 54 participants met the inclusion criteria. The participants were randomised into HIIT (n=18), MICT (n=19), and control (n=17). At the 12-week follow-up, 11 participants (20.37%) were lost. Most of the participants in the three arms were females (79.6%) compared to males (20.4%) and the difference was not statistically significant (p-value=1.00). The majority of the participants in the HIIT and MICT arms were security officers (83.33% and 57.89% respectively) while those in the control arm were cleaners or landscapers (82.35%) and the difference was statistically significant (p-value<0.001).

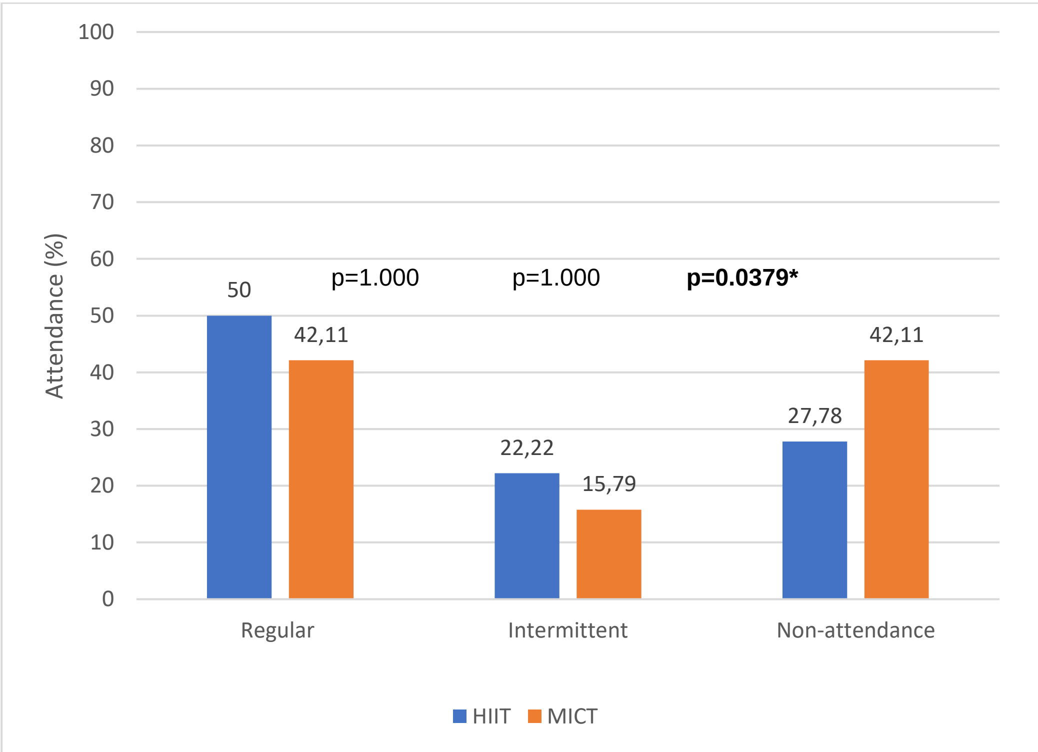


CONSORT: Consolidated standards of reporting trials; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training.

Figure 4.2 The CONSORT flow diagram depicting the flow of participants through each stage of the study

4.1.5 Adherence and intervention fidelity

The adherence to the physical activity intervention is illustrated in Figure 4.3. The intervention adherence for the HIIT and MICT were generally similar except for the non-attendance which was higher in the MICT group compared to the HIIT group and the difference was statistically significant (p=0.0379). Regular and intermittent attendance was higher in the HIIT group compared to the MICT group however, it was not statistically significant (p=1.000).



* Indicates statistical significance at p<0.05

Figure 4.3 Exercise session attendance in HIIT and MICT intervention groups

4.1.6 Training data of participants in the HIIT and MICT intervention

The training data of participants in the HIIT and MICT intervention groups are illustrated in Table 4.3. The results show that the HIIT group had a slightly higher attendance (~72%) compared to MICT (~58%). The time commitment per exercise session over the 12-week intervention was approximately half of the HIIT protocol.

Compared to MICT the HIIT group had a higher estimated energy consumption (14%), distance cycled (21%), and average heart rate (17%). Furthermore, also the rating of perceived exertion was ~29% higher in the HIIT compared to the MICT group.

Table 4.3 Training data of participants in the HIIT and MICT intervention

Variable	**HIIT group**	**MICT group**	**Absolute difference**	**Relative difference [a] (%)**
Adherence (%)	72.22	57.90	14.32	19.82
Time commitment (minutes·wk)	~21	~42.5	-21.5	-102.38
Estimated energy expenditure, Kcal	209.81 ± 55.09	180.97 ± 38.38	28.84	13.75
Distance cycled, km	15.99 ± 11.63	12.71 ± 2.97	3.28	20.51
Average HR, beats·min^{-1}	157.31 ± 8.23	130.27 ± 6.34	27.04	17.19
Average power, W	67.16 ± 13.03	56.49 ± 6.98	10.67	15.89
RPE Borg CR 10 scale (AU)	7 (6 -8)	5 (5-6)	2	28.57

[a] Relative difference= (HIIT-MICT) /HIIT x 100)

AU: Arbitrary unit; HIIT: High-intensity interval training; HR: Heart Rate; MICT: Moderate-intensity continuous training; RPE: Rating of Perceived Exertion; W: Watts.

4.1.7 Within-group comparison of the anthropometric and cardiometabolic outcomes for the three arms

Table 4.4 summarises the within-group comparison of the anthropometric and cardiometabolic outcomes for the three RCT arms.

There was a statistically significant decrease in waist circumference and BMI in the HIIT group -2.81 cm (95%CI; -4.8 to -0.8; p<0.001) and -1.22 kg·m^{-2} (95%CI; -1.67 to -0.76; p<0.001). There was a statistically significant decrease in waist circumference and BMI in the MICT group -2.47 cm (95%CI; -2.8 to -0.18; p=0.016) and -0.69 kg·m^{-2} (95%CI; -1.20 to -0.19; p<0.001). There was a statistically significant increase in waist circumference and BMI in the control group 2.52 cm (95%CI; -0.07 to 5.1; p=0.001) and 1.39 kg·m^{-2} (95%CI; 0.53 to 2.26; p<0.001).

In the HIIT group, there was a statistically significant decrease in SBP -8.29 mmHg (95%CI; -13.8 to -2.72; $p=0.0015$) and non-significant decrease in DBP -0.47 mmHg (95%CI; -4.86 to 3.92; $p=0.19$).

In the MICT group, there was a decrease in SBP and DBP, but this difference was not statistically significant SBP -6 mmHg (95%CI; -10.1 to -1.98; $p=0.071$) and DBP –2 mmHg (95%CI; -5.6 to 1.61; $p=0.076$). In the control group, there was a statistically significant increase in SBP 4.09 mmHg (95%CI; -5.5 to 13.7; $p=0.0151$) and non-significant increase in DBP 5.73 mmHg (95%CI; -1.15 to 12.6; $p=0.07$).

In the HIIT group, there was a statistically significant improvement in RHR, MAP, RBG, and VO_{2max} [(-6.64 beats·min^{-1} (95%CI; -11.9 to -1.34; $p=0.002$); -3.06 mmHg (95%CI; -7.25 to 1.13; $p=0.04$); -0.86 mmol·L^{-1} (95%CI; -1.54 to -0.19; $p=0.01$); 4.49 mL·kg^{-1}·min^{-1} (95%CI; 3.21 to 6.58; $p<0.001$)] respectively. The PP decrease was 7.59 mmHg (95%CI; -12.58 to -2.59; $p=0.222$) and was non-significant.

In the MICT group, there was a statistically significant improvement in RBG, and $VO2_{max}$ [(-0.96 mmol·L-1 (95%CI; -1.68 to -0.24; $p<0.001$); 4.4 mL·kg-1·min-1 (95%CI; 2.91 to 5.95; p=<0.001)] respectively. The improvement in RHR, PP, and MAP was not statistically significant [(-0.27 beats·min^{-1} (95%CI; -5.6 to 6.12; $p=0.273$); -3.87 mmHg (95%CI; -7.77 to 0.04; $p=1.000$); -3.4 mmHg (95%CI; -6.6 to -0.23; $p=0.036$).

In the control group, there was a statistically significant increase in HR, RBG, and a decrease in $VO2_{max}$ [(6.82 beats·min^{-1} (95%CI; 2.46 to 11.18; $p=0.0032$); 1.07 mmol·L^{-1} (95%CI; 0.48 to 1.66; $p=0.002$); -2.62 mL·kg^{-1}·min^{-1} (95%CI; -4.8 to -0.44; p=<0.001)] respectively. There was a decrease in PP, but this decrease was not significant (-1.64 mmHg (95%CI; -6.89 to 3.58; $p=0.1757$)). There was an increase in MAP and this increase was statistically significant (5.27 mmHg (95%CI; -2.23 to -12.8; $p=0.0208$).

Table 4.4 Within-group comparison: anthropometric and selected cardiometabolic outcomes

	HIIT group			MICT group			Control group		[2]P-value
	Mean diff (95%CI)	**% Δ**	**[1]P-value**	**Mean diff (95%CI)**	**% Δ**	**[1]P-value**	**Mean diff (95%CI)**	**% Δ**	
Weight (kg)	-3.22 (-4.4 to -2.1)	-3.95	**<0.001**	-1.72 (-3.1 to -0.37)	-1.97	**<0.001**	3.58(1.29 to 5.86)	4.55	**<0.001**
WC (cm)	-2.81 (-4.8 to -0.8)	-2.95	**0.001**	-1.47(-2.8 to -0.18)	-1.45	**0.016**	2.52(-0.07 to 5.1)	2.57	**0.001**
BMI (kg·m^{-2})	-1.22 (-1.67 to -0.76)	-4.04	**<0.001**	-0.69(-1.20 to -0.19)	-2.02	**<0.001**	1.39(0.53 to 2.26)	4.61	**<0.001**
SBP (mmHg)	-8.29 (-13.8 to -2.72)	-6.52	**0.0015**	-6(-10.1 to -1.98)	-4.85	0.071	4.09(-5.5 to 13.7)	3.29	**0.0151**
DBP (mmHg)	-0.47 (-4.86 to 3.92)	-0.57	0.19	-2(-5.6 to 1.61)	-2.47	0.076	5.73(-1.15 to 12.6)	7.04	0.07
RHR (beats·min$^{-1)}$	-6.64 (-11.9 to -1.34)	-8.18	**0.002**	0.27 (-5.6 to 1.61)	-0.36	0.273	6.82 (2.46 to 11.18)	8.65	**0.0032**
PP (mmHg)	-7.59 (-12.58 to -2.59)	-17.09	0.222	-3.87(-7.77 to 0.04)	-9	1.000	-1.64(-6.89 to 3.58)	-3.77	0.1757
MAP (mmHg)	-3.06 (-7.25 to 1.13)	-17.09	**0.04**	-3.4 (-6.6 to -0.23)	-3.58	0.036	5.27(-2.23 to 12.8)	5.52	0.0208
RBG (mmol·L^{-1})	-0.86 (-1.54 to -0.19)	-3.14	**0.001**	-0.96(-1.68 to -0.24)	-14.37	**<0.001**	1.07(0.48 to 1.66)	19.42	**0.0002**
VO_{2max}	4.9 (3.21 to 6.58)	10.23	**<0.001**	4.4(2.91 to 5.95)	9.28	**<0.001**	-2.62(-4.81 to -0.44)	-5.84	**<0.001**

*difference= post-baseline

*%change=difference/baseline*100

[1]Bonferonni p-value with reference to the control arm (pair-wise comparison)

[2]ANOVA p-value

BMI: Body mass index; CI: Confidence interval; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; PP: Pulse pressure; RBG: Random blood glucose; RHR: Resting heart rate; SBP: Systolic blood pressure; VO2max: Maximum oxygen consumption; WC: Waist circumference.

4.1.8 Between-group comparison of the anthropometric and cardiometabolic outcome changes

There was no significant difference in change in body weight, hip circumference, and anthropometric indices waist-to-height ratio (WHtR) and waist-to-hip ratio (WHR) between the HIIT group and the MICT group. However, there was a significant difference in body weight change, hip circumference, and anthropometric indices (WHtR, WHR) between the HIIT group compared to the control group and in the MICT group compared to the control group ($p<0.05$) (Appendix U).

Table 4.5 illustrates that there was no significant difference in change in waist circumference (WC) and BMI between the HIIT group and the MICT group, p=0.246, and p=0.112 respectively. However, there was a significant difference in change in WC and BMI between the HIIT group compared to the control group p=0.002 and p=0.000 respectively. Also, there was a significant difference change in WC and BMI in the MICT group compared to the control group p=0.008 and p=0.000.

Table 4.5 illustrates that there was no significant difference in change in SBP and DBP between the HIIT group and the MICT group, p=0.471, and p=0.605 respectively. There was a significant difference change in SBP between the HIIT group compared to the control group p=0.026 while the change in DBP was not significant p=0.097. There was no significant difference change in SBP in the MICT group compared to the control group at p=0.052, while the change in DBP was significant at p=0.040.

Table 4.5 illustrates that there was no significant difference in change in PP and MAP between the HIIT group and the MICT group, p=0.219, and p=0.952 respectively. There was a significant difference change in MAP between the HIIT group compared to the control group at p=0.046 while the change in PP was not significant at p=0.078. There was no significant difference change in PP in the MICT group compared to the control group at p=0.444, while the change in MAP was significant at p=0.036.

In Table 4.5, there was no significant difference in change in RBG between the HIIT group and the MICT group p=0.838. There was a significant difference in change in RBG between the HIIT group compared to the control group at p=0.000 and in the MICT group compared to the control group at p=0.000.

In Table 4.5, there was no significant difference in change in VO_{2max} between the HIIT group and the MICT group p=0.665. There was however a significant difference in change in VO_{2max} between the HIIT group compared to the control group at p=0.000 and in the MICT group compared to the control group at p=0.000.

Table 4.5 Between-group comparison of the anthropometric and cardiometabolic outcome changes

Variable	HIIT group vs MICT group	p-value	HIIT group vs Control group	p-value	MICT group vs Control group	p-value
WC (cm)	-1.333	0.246	-5.333	**0.002***	-4.001	**0.008***
BMI ($kg{\cdot}m^{-2}$)	-0.521	0.112	-2.615	**0.000***	-2.094	**0.000***
SBP (mmHg)	-2.328	0.471	-12.431	**0.026***	-10.103	0.052
DBP (mmHg)	1.390	0.605	-6.404	0.097	-7.794	**0.040***
PP (mmHg)	-3.718	0.219	-6.027	0.078	-2.309	0.444
MAP (mmHg)	0.151	0.952	-8.413	**0.046***	-8.563	**0.036***
RBG ($mmol{\cdot}L^{-1}$)	0.095	0.838	-1.937	**0.000***	-2.033	**0.000***
VO_{2max} ($mL{\cdot}kg^{-1}{\cdot}min^{-1}$)	0.465	0.665	7.488	**0.000***	7.022	**0.000***

Difference significant at $p<0.05$

* Indicates statistical significance

BMI: Body mass index; CI: Confidence interval; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; PP: Pulse pressure; RBG: Random blood glucose; RHR: Resting heart rate; SBP: Systolic blood pressure; VO_{2max}: Maximum oxygen consumption; WC: Waist circumference; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio.

4.1.9 Modeling the effect of the intervention on anthropometric and cardiometabolic outcomes adjusting for socio-demographic factors

Multiple linear regression was used to determine the effect of the HIIT, MICT, and health messages intervention on anthropometric and cardiometabolic outcomes adjusting for socio-demographic factors. The level of statistical significance was set at p<0.05.

The socio-demographic variables adjusted were age, gender, level of education, and underlying conditions (diagnosis of cardiovascular disease, peripheral vascular disease, diabetes, and hypertension).

The reference category was the control group, gender (male), level of education (reached secondary level), and not having any underlying conditions.

4.1.10 The effects of the intervention on anthropometry and anthropometric indices adjusting for socio-demographic factors

Participants in the HIIT group had a weight reduction of 7.84 kg at the end of the 12-week intervention while those in the MICT group had a weight reduction of 6.56 kg compared to those in the control arm and these estimates were statistically significant ($p<0.001$) adjusting for the socio-demographic factors (Appendix S). Table 4.6 illustrates the effects of interventions on waist circumference by adjusting for socio-demographic factors. Waist circumference decreased by 6.05cm in the HIIT group; and 5.21cm in the MICT group, respectively this decrease was statistically significant ($p<0.001$) and $p=0.002$ respectively. The effect of the intervention on the waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) is illustrated in Appendix T.

Females had a weight reduction of 4.26 kg compared to males, waist circumference reduction of 0.93 cm, and hip circumference reduction of 1.91 cm, adjusting for the socio-demographic factors. Having underlying conditions led to a statistically significant ($p=0.008$) weight reduction of 2.35kg, and 1.99cm reduction in waist circumference, and a 1.3 cm reduction in hip circumference adjusting for the socio-demographic factors.

In Table 4.7, participants in the HIIT group had a reduction in BMI of 2.99 $kg{\cdot}m^{-2}$ at the end of the 12-week intervention compared to MICT with a reduction of -2.55 $kg{\cdot}m^{-2}$ compared to those in the control group and these estimates were statistically significant ($p<0.001$) adjusting for socio-demographic factors. Females had a reduction of -1.65 $kg{\cdot}m^{-2}$ compared to males adjusting for socio-demographic factors and these estimates were statistically significant ($p<0.001$). Having underlying conditions led to a reduction of 0.89 $kg{\cdot}m^{-2}$ adjusting for socio-demographic factors and these estimates were statistically significant ($p=0.008$).

Table 4.6 The effects of interventions on waist circumference adjusting for socio-demographic factors

Variables	Waist circumference change	
	Adjusted coefficient	**P-value**
Study arm		
Control group	1(ref)	
HIIT group	-6.05(-9.04 to -3.06)	**<0.001**
MICT group	-5.21(-8.41 to -2.03)	**0.002**
Age in years	-0.11(-0.28 to 0.08)	0.255
Gender		
Male	1(ref)	
Female	-0.93(-3.98 to 2.12)	0.543
Education		
Reached secondary	1(ref)	
Completed matric	-0.72 (-3/15 to 1.69)	0.54
Tertiary	0.48(-2.63 to 3.61)	0.32
Have underlying conditions		
No	1(ref)	
Yes	-1.99(-4.74 to 0.75)	0.149

Statistical significance at p<0.05.

HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; Ref: Reference.

Table 4.7 The effects of interventions on BMI adjusting for socio-demographic factors

Variable	BMI change	
	Adjusted coefficient	**P-value**
Study arm		
Control group	1(ref)	
HIIT group	-2.99(-3.7 to -2.31)	**<0.001**
MICT group	-2.55(-3.29 to -1.81)	**<0.001**
Age in years	-0.005(-0.05 to 0.04)	0.828
Gender		
Male	1(ref)	
Female	-1.65(-2.36 to -0.94)	**<0.001**
Education		
Reached secondary	1(ref)	
Completed matric	-0.27(-0.83 to 0.29)	0.343
Tertiary	0.17(-0.55 to 0.89)	0.49
Have underlying conditions	1(ref)	
No	-0.89(-1.52 to -0.25)	**0.008**
Yes		

Statistical significance at p<0.05.

BMI: Body mass index; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; Ref: Reference.

4.1.11 The effects of the intervention on selected cardiometabolic outcomes adjusting for socio-demographic factors

In Table 4.8, participants in the HIIT group had a reduction of ~15 mmHg compared to the MICT group with a reduction of ~ 12 mmHg, and these estimates were statistically significant adjusting for socio-demographic factors.

Those participants who attained tertiary education had an SBP reduction of ~11 mmHg adjusting for socio-demographic factors. Participants in the HIIT had a DBP reduction of ~9 mmHg and those in the MICT had a reduction of ~11 mmHg these estimates were statistically significant adjusting for socio-demographic factors. Participants in the HIIT group had a reduction of resting heart rate of ~11 beats·min^{-1} and those in the MICT group had a reduction of ~3 beats·min^{-1} adjusting for socio-demographic factors and these estimates were statistically significant.
In Table 4.8, participants in the HIIT had a random blood glucose reduction of 2.11 mmol·L$^{-1,}$ and those in the MICT had a reduction of 2.16 mmol·L^{-1} adjusting for socio-demographic factors and these were statistically significant p<0.001 and p=0.001 respectively.

Table 4.8 The effects of interventions on blood pressure, and random blood glucose adjusting for socio-demographic factors

Variable	SBP change, mmHg		DBP change, mmHg		RBG change, $mmol \cdot L^{-1}$	
	Adjusted coefficient	**P-value**	**Adjusted coefficient**	**P-value**	**Adjusted coefficient**	**P-value**
Study arm						
Control group	1(ref)		1(ref)		1(ref)	
HIIT group	-14.77(-23.8 to -5.8)	**0.002**	-8.54(-15.8 to -1.32)	**0.022**	-2.11(-3.19 to -1.02)	**<0.001**
MICT group	-11.97(-21.6 to -2.4)	**0.016**	-10.13(-17.8 to -2.4)	**0.011**	-2.16(-3.32 to -1.01)	**0.001**
Age in years	-0.13(-0.68 to 0.42)	0.639	-0.13(-0.57 to 0.31)	0.554	-0.004(-0.07 to 0.06)	0.913
Gender						
Male	1(ref)		1(ref)		1(ref)	
Female	-3.01(-12.24 to 6.22)	0.5113	-4.21(-11.6 to 3.19)	0.256	-0.15(-1.26 to 0.97)	0.791
Education						
Reached secondary	1(ref)		1(ref)		1(ref)	
Completed matric	0.81(-6.49 to 8.12)	0.823	1.04(-4.8 to 6.89)	0.72	0.44(-0.44 to 1.32)	0.319
Tertiary	-10.7(-20.1 to -1.31)	**0.027**	-4.27(-11.8 to 3.26)	0.257	-0.32 (-1.45 to 0.81)	0.569
Have underlying conditions						
No	1(ref)		1(ref)		1(ref)	
Yes	-2.44(-10.72 to 5.83)	0.553	-3.36(-9.98 to 3.27)	0.31	-0.16(-1.16 to 0.83)	0.74

Statistical significance at $p<0.05$

DBP: Diastolic blood pressure; HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; SBP: Systolic blood pressure; RBG: Random blood glucose; Ref: Reference.

Table 4.9 The effects of interventions on the PP and MAP adjusting for socio-demographic factors

Variable	PP change, mmHg		MAP change, mmHg	
	Adjusted coefficient	P-value	Adjusted coefficient	P-value
Study arm				
Control group	1(ref)		1(ref)	
HIIT group	-6.15(-13.52 to 1.21)	0.099	-10.6(-17.7 to -3.57)	0.004
MICT group	-1.91(-9.76 to 5.93)	0.624	-10.9(-18.4 to -3.35)	0.006
Age in years	-0.04(-0.48 to 4.41)	0.872	-0.12(-0.55 to 0.31)	0.568
Gender				
Male	1(ref)		1(ref)	
Female	1.49(-6.05 to 9.03)	0.69	-3.72(-10.9 to 3.49)	0.302
Education				
Reached secondary	1(ref)		1(ref)	
Completed matric	-0.33(-6.3 to 5.64)	0.91	1.014(-4.69 to 6.72)	0.72
Tertiary	-7.00(-14.67 to 0.67)	0.072	-5.98 (-13.32 to 1.35)	0.107
Have underlying				
conditions	1(ref)		1(ref)	
No	1.0(-5.75 to 7.76)	0.973	-3.12(-9.57 to 3.34)	0.334
Yes				

Statistical significance at $p<0.05$.

HIIT: High-intensity interval training; MAP: Mean arterial pressure; MICT: Moderate-intensity continuous training; PP: Pulse pressure; Ref: Reference.

In table 4.9, adjusting for socio-demographic factors, those in the HIIT group had a decrease in pulse pressure of 6.15 mmHg and this change was not statistically significant (p=0.099) and a decrease in MAP of 10.6 mmHg and this change was significant (p=0.004). Those in the MICT group had a decrease in pulse pressure of 1.91 mmHg and this change was not statistically significant (p=0.624) and a decrease in MAP of 10.9 mmHg and this change was significant (p=0.006). Females compared to males had a decrease in PP decrease of 1.49 mmHg and a decrease in MAP of 3.72 mmHg and this change was not statistically significant (p=0.69) and (p=0.302), respectively. Having underlying conditions led to an increase in PP of 1.0 mmHg and a decrease in MAP of 3.12 mmHg and this change was not statistically significant (p=0.973) and (p=0.334), respectively.

In Table 4.10, participants in the HIIT group had an improvement in VO_{2max} of 8.16 $mL \cdot kg^{-1} \cdot min^{-1}$ at the end of the 12-week intervention compared to MICT with an improvement of 8.01 $mL \cdot kg^{-1} \cdot min^{-1}$ compared to those in the control group and these estimates were statistically significant ($p<0.001$) adjusting for socio-demographic factors. Females had an improvement of -1.64 $mL \cdot kg^{-1} \cdot min^{-1}$ compared to males adjusting for socio-demographic factors and these estimates were not statistically significant (p=0.216). Having underlying conditions led to an improvement of 0.28 $mL \cdot kg^{-1} \cdot min^{-1}$ adjusting for socio-demographic factors and these estimates were not statistically significant (p=0.814). Having completed matric level led to an improvement of 0.16 $mL \cdot kg^{-1} \cdot min^{-1}$ while having reached tertiary education led to a decrease of 1.3 $mL \cdot kg^{-1} \cdot min^{-1}$, these changes were not statistically significant at p=0.877 and p=0.310 respectively.

Table 4.10 The effects of interventions on VO_{2max} adjusting for socio-demographic factors

Variable	VO_{2max} change, $mL \cdot kg^{-1} \cdot min^{-1}$	
	Adjusted coefficient	P-value
Study arm		
Control group	1(ref)	
HIIT group	8.16(5.54 to 10.79)	**<0.001**
MICT group	8.01(5.22 to 10.80)	**<0.001**
Age in years	0.16(0.00 to 0.31)	0.051
Gender		
Male	1(ref)	
Female	-1.64 (-4.28 to 1.00)	0.216
Education		

Variable	VO_{2max} change, $mL \cdot kg^{-1} \cdot min^{-1}$	
	Adjusted coefficient	P-value
Reached secondary Completed matric Tertiary	1(ref) -0.16(-2.27 to 1.95) 1.3(-1.33 to 4.07)	 0.877 0.310
Have underlying conditions No Yes	1(ref) 0.28(-2.11 to 2.66)	 0.814

Statistical significance at $p<0.05$

HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; Ref: Reference; VO_{2max}: Maximum oxygen consumption.

4.2 Qualitative results (Focus Group Discussions)

4.2.1 Characteristics of the participants in the focus group discussions (FGDs)

Table 4.11 illustrates the characteristics of the participants in the focus group discussions (FGDs). There were 17 participants (age, 42.1 ± 4.4 years) who participated in the FGDs. Two (11.8%) of the participants were males, and 15 (88.23%) were female, of these, 14 participants were security officers while three participants were cleaners.

Table 4.11 Characteristics of the participants in the focus group discussions (n=17)

Variable	
Age (years)	42.1± 4.4
Anthropometric outcomes and indices	
Weight, kg	81.5±0.1
Waist-circumference, cm	97.6±11.4
Hip circumference, cm	111.9±11.5
Waist-Hip ratio	0.9±0.1
BMI, $kg \cdot m^{-2}$	31.0±5.7
Waist Height ratio	0.6±0.1
Cardiometabolic outcomes and indices	
SBP, mmHg	121.1±13.4
DBP, mmHg	79.1±10.2
RHR, $beats \cdot min^{-1}$	78.1±11.2
Pulse pressure, $beats \cdot min^{-1}$	42±7.5
MAP, mmHg	93.1±10.8
Random blood glucose $mmol \cdot L^{-1}$	6.3±1.2
Estimated VO_{2max}, $mL \cdot kg^{-1} \cdot min^{-1}$	45.4±8.7

Variable	
Physical activity behaviour	
Total work MVPA (mins·wk^{-1})	0 (0-14)
Total walking for travel MVPA (min·wk^{-1})	210 (125-240)
Total leisure MVPA (min·wk^{-1})	0 (0-135)
Sitting time (hrs·day^{-1})	8 (5-13)
Total vigorous PA (min·wk^{-1})	0 (0-135)
Total moderate PA (min·wk^{-1})	210 (150-330)
Total MVPA (min·wk^{-1})	360 (2010-500)

Data presented as mean ± SD or median (interquartile range (IQR).

BMI: Body Mass Index; DBP: Diastolic blood pressure; HR: HR-Heart Rate; MVPA: Moderate to vigorous physical activity; SBP: Systolic blood pressure; PA: Physical activity; WC: Waist Circumference; WHtR: Waist-to-height ratio; WHR: Waist-to-hip ratio.

4.2.2 Emerging themes

The focus group discussions were centred around the five discussion points; (1) understanding workplace physical activity; (2) the intention in participating in the intervention; (3) barriers in the intervention; (4) facilitators in the intervention; and (5) recommendations on the intervention. Table 4.12 illustrates the themes and sub-themes in the focus group discussions.

Table 4.12 FGDs emerging themes

Theme	**Sub-themes**
Understanding workplace physical activity	Work-related physical activity Active travel
	Role management in promoting physical activity
	Acceptability of intervention Convenient setting Provided motivation Adopting healthy lifestyle
The intention of participating in the intervention	Weight loss and improve fitness Relieve stress Peer influence
Barriers to the intervention	Perceived time constraints Lack of motivation/interest

Theme	Sub-themes
	High workload Fatigue/burnout
Facilitators in the intervention	Guidance through health messages Instructor-led/support Convenient and accessible location
Recommendations on the intervention	Management role Practical solutions for employees to participate in physical activity Long-term strategy to increase participation in physical activity among employees

4.2.3 Understanding workplace physical activity

4.2.3.1.1 Work-related physical activity

All participants indicated that they are employed in active occupations where they can meet the recommended physical activity. Employees encored that they do not see a need to participate in leisure physical activity outside of their job description.

> *"The whole day we spend one hour on lunch, and we are busy working, that's part of the exercise when we are going up and down and going to the offices and it's like a gym." Wits042, FGD 1*

4.2.3.1.2 Active travel

Most participants commented that they participated in enough Physical Activity due to the fact that they walk as a mode of commuting to and from work.

> *" I would say because on our side we use public transport. So I walk from town to Parktown every day and in our department, we don't have time to sit down. Obviously, we are exercising at the time because no one will sit down for more than 2 hours." Wits042, FGD 1*

4.2.4 Role of management support/involvement

All participants expressed the view that the management was not supportive or involved in the promotion of PA participation in the workplace.

> *"I think it should start with them because they don't even do it so that is why they don't even see how important it is. Even if you go to ask for the time to go to the gym, they won't see how important it is. So it should start with them." Wits044, FGD 2*

4.2.4.1.1 Acceptability of the intervention

All the participants expressed that the physical activity and health messages intervention was appropriate to help improve their healthy lifestyle behaviours.

Convenient setting

Participants viewed the workplace as a convenient setting for them to participate in physical activity.

> *"I was more interested because it's at work…There's no excuse if it's at work because you report on duty and then after duty, you go to the gym. It's not the same as having to travel again so you can go to the gym, it's closer." FGD 2*

4.2.4.1.2 Provided motivation

Participants expressed appreciation that the interventions specifically the health messages offered motivation to engage in healthy lifestyle behaviours.

> *"And it was encouraging us, even if you don't want to come to the gym, you feel guilty when you see the message and say you know what, let me just go and do something. Even if you are not in a position of taking your lunch to run or to walk but because of those messages, someway somehow, it makes you feel guilty to do something." Wits041, FGD 6*

4.2.4.1.3 Adopting healthy lifestyle choices

Participants agreed that participating in the intervention enabled them to adopt healthy lifestyles.

"Like the one whereby we should walk that sometimes you have to walk, I have to leave home and walk that one day as part of the exercise on that day. At some times instead of going to the shops by car then I have to walk because that thing keeps on clicking that walking is part of exercise, the diet, that you must eat this and that" Wits044, FGD2.

4.2.5 The intention of participating in the PA intervention

Participants gave an insight into the main reason for participating in this study. The most commonly expressed reason for participation in the study was to lose weight.

4.2.5.1.1 Weight loss and improve fitness

Participants expressed that weight loss because there were aware of being overweight.

"What motivated me to participate in the study is because I was overweight. And when I am overweight, what motivated me is that I wanted to go to the gym so that I can lose weight which I have lost right now." Wits046, FGD5

"I wanted to lose my stomach, that was my main thing. I wanted to lose my stomach and be fit." Wits041, FGD6

4.2.5.1.2 Relieve stress

Other participants expressed the opinion that they were motivated to participate in the intervention to relieve stress.

"I like the gym because it refreshes the mind and after the gym, you're energetic." Wits003, FGD2

4.2.5.1.3 Peer-influence

Another participant expressed that the intention to participate was due to the influence of their colleagues who were participating in the intervention.

"For me first I was drawn by her when she was going to the gym and then I followed her and I also enjoyed what she was doing. The influence, what others see. You see that someone is beautiful and they have a beautiful body because of the gym so I decided to join her and I enjoyed it too. And then I enjoyed it." Wits046, FGD5

4.2.6 Perceived barriers in the Intervention

Participants described factors that were barriers to their ability to participate in the physical activity intervention. These perceived barriers included perceived time constraints, lack of motivation/interest, high workload, and fatigue.

4.2.6.1.1 Perceived time constraints

Most participants expressed the opinion that lack of time was a barrier to participating in physical activity intervention.

> *“I can say it's 80% who are not coming to the gym because they don’t have enough time.” Wits003, FGD1*

> *“Because they are busy working, so they don’t have time to exercise.” Wits039, FGD 3*

> *“Some people get to work just on time to start work and they need to start their work. And when they knock off it’s already late and they are running to catch the taxi or the bus so they don’t have time to train (exercise) at work.” Wits047, FGD 4*

4.2.6.1.2 Lack of interest/motivation

Other participants had a view that lack of interest/motivation decreased their participation in the physical activity intervention.

> *“Yes. Because other departments work normal hours. Someone can go to the gym in the morning or go to the gym in the evening but they decide to come to work late and then they knock off early and then they go home. They aren’t interested.” Wits047, FGD4*

> *“They are lazy. They are behind the fact that they are working long hours.” Wits036, FGD 5*

4.2.6.1.3 High workload

Participants expressed a general view that a high workload decreased participation in physical activity in the workplace setting.

"Sometimes you have to sacrifice your lunchtime just to get work done." Wits030, FGD2

"The issue of exercising comes… as you see at work, the language they use at work says you must do the job, do the job, do the job. So if they could mix that up and say did you train today before you came to work or maybe during lunch, are you going to take 30 minutes for training, and then it can come from our seniors." Wits030, FGD 2

"For others, their work is too much. When it comes to the time that they have to come to the gym they're already tired and they can't come." Wits006, FGD4

4.2.6.1.4 Fatigue/burnout

All the participants who were security officers expressed an opinion that because of the long shift (12 hours) they felt tired, and they needed to rest/sleep after the end of their shift.

"Sometimes you think you come to gym in the morning but when you finish the shift you're so tired you can't even open your eyes" Wits036, FGD5

"For others, their work is too much. When it comes to the time that they have to come to the gym they're already tired and they can't come." Wits006, FGD4

"Yeah, it's going to affect me (shift work) because I stay a little bit far from the campus. I will come home late and I will have to sleep enough. If I don't sleep enough then how will I go to the gym?" Wits036, FGD5

"Sometimes we are very busy at work whereby we get tired sometimes. We feel like you can't go to the gym because some of our posts keep us very busy." Wits006, FGD4

4.2.7 Facilitators in the intervention

Participants discussed factors that were facilitators to their ability to participate in the PA intervention. The health messages were viewed as the most important factor which prompted healthy behavioural decision-making and also played a critical motivational role. Participants strongly agreed that the convenient location of the workplace gym and instructor-led training highly motivated them to participate in the intervention. The following are the quotes relating to the emerging themes:

4.2.7.1.1 Health messages

"Yeah, I think it's helpful because mostly on that message they were guiding us on what to eat, about the diet." Wits050, FGD6

"And it (health messages) was encouraging to us, even if you don't want to come to the gym, you feel guilty when you see the message and say you know what, let me just go and do something. Even if you are not in a position to take your lunch to run or to walk but because of those messages, somehow, it makes you feel guilty to do something." Wits041, FGD6

"*Aha. It is like you were behind me saying get up, get up, get up." Wits001, FGD1*

They were helpful because they remind you that you're doing something like this…I even get bored if you don't send them because I don't have anything which makes me feel guilty that I have this thing which I'm supposed to do." Wits030, FGD 2

"Yeah, it helped, with the message it helped because some of us, you have sent us the message about the diet, the food that we have to choose, you see…… Yeah. It helps a lot, it helps a lot for my side." Wits024, FGD1

"Yeah, it helped, with the message it helped because some of you have sent us the message about the diet, the food that we have to choose, you see. The weight, you need to lose weight to avoid things like high blood pressure". Wits030 FGD 2

"Too much. They were very helpful because I could be guided on what to do and what not to do. What to eat, what to drink, a lot." Wits036, FGD5

Another participant suggested although the health messages were helpful, in the future, they would be written in very simple language, short, and multilingual.

> *"What I didn't like about the messages is that sometimes they could be long… And sometimes they had some bombastic words that would require me to go to the dictionary and I am uneducated…Yeah, sometimes I don't have the meaning, I have to go through the dictionary because I don't understand at all. I could see that sometimes it would be better if you put in some Zulu because most of us speak Zulu. African language…Yeah, I said can they not use scientific healthy words because it's too difficult and you can't even find them in the dictionary." Wits036, FGD5*

Another participant suggested that the health messages should have a feedback system to improve active engagement and monitoring. Furthermore, participants suggested that health messages would be appealing if there was audio-visual functionality.

> *"How about if you can also send something like videos." Wits030, FGD 2*

4.2.7.1.2 Instructor-led exercise sessions

Participants appreciated the supportive and motivational role the instructor played during the intervention period.

> *"So we normally don't get someone who can encourage us to be healthy. So with the messages and your appearance and your approach to us, I think that was what was so helpful." Wits041 FGD 6*

> *"So because you're always there ad you're checking that you're still maintaining the time you have set for us then okay, you can go on to level 5 so that made me honest and not cheat. If I felt like I wanted to cheat then you just turn around and come, Takalani will quickly check if you are still on the right track so I couldn't do it if I was doing it on my own honestly, I wouldn't be able to." Wits030, FGD2*

4.2.7.1.3 Convenient and accessible location

Participants expressed the opinion that the convenient location (at the workplace) highly facilitated their participation in the physical intervention.

> *"Like for me another thing which made me interested in the fact that it's at work and I won't pay but I will have a physical trainer who will monitor me regards what I'm doing. I was more interested because it's at work." Wits030, FGD2*

4.2.8 Recommendation on the intervention

Participants expressed different views and opinions on how to increase participation in a workplace physical activity programme and included recommendations on how the management may play a role in promoting a healthy lifestyle in the workplace. Practical solutions were discussed, and these are illustrated in Table 4.13.

Participants suggested that making gym membership free for the staff would increase their participation in PA in the workplace.

Other participants suggested that the management should play a pivotal role in advocating a healthy lifestyle in the workplace through engagement with the employees and active participation. Participants expressed a view that the management can create events such as a fun day or sports day for the staff to encourage physical activity. Having sporting activities would make physical activity more desirable, increase competition and increase participation of PA as they would need to improve physical conditioning for the competitions in different sports including netball, athletics, tennis, and swimming.

Participants expressed an opinion that the success of promoting PA in the workplace should include the engagement and involvement of both the management and the employees. Also, another theme that emerged was that inter-campus sports competitions and programmes would promote participation in PA.

4.2.9 Role of management play in promoting a healthy lifestyle in the workplace

4.2.9.1 *Management support/involvement*

"they can just give us a specific time, especially if we are working during the day. So that we can gym. They can give us even 1 hour" Wits036, FGD5"Yeah. But it should

be with your senior because it really motivates you that you're gyming with your manager and you're gyming with their head of a department you see. So I will think that let me do it." Wits044, FGD2

Practical solutions for increasing physical activity participation in the workplace

Participants suggested different practical solutions for increasing physical activity in the workplace. Some of the emerging themes were (1) wellness programmes, (2) instructor-led/personal fitness trainers, and (3) providing access to fitness facilities.

4.2.10 Wellness programmes

Other participants suggested wellness programmes that increase participation in physical activity.

> *"I think that if we had wellness programs. It's like the HIV wellness programs, we go there in numbers. Why don't they have physical education, have a wellness program for sports, and call us, tell us about sports, tell us about exercise, tell us about what to do with wellness. Then I think people will be interested. Because some they don't know you know. They don't think if… if they walk from here to MTN (to town) they are fit, they don't need to come to gym you understand. But if you do wellness and physical education and invite people. At least once in a while, maybe once in 3 months, we will come" Wits046 FGD5*

4.2.11 Instructor-led /personal fitness trainer activities

Participants had a strong view that instructor-led activities would increase participation in physical activity in the workplace.

> *"When we knock off there should be time to go to the gym before we go home. There should be someone who will coach us at the gym. Yeah, a personal trainer. So we know that at this time, we are going to the gym for that 30 minutes. That person will be able to show us." Wits040, FGD4*

> *"The personal trainers. If they can just give us those students to be personal trainers. You know if you are working with someone, that person needs to*

have a goal to reach. Even you also. You need to see the difference."Wits041, FGD6

4.2.12 Provide access to gym and exercise facilities

Participants expressed a view that management should provide access to fitness facilities preferably at no cost and at a convenient time.

> *"I think if management can arrange that at least if they open the gym on the weekend I think it would be fine. Because sometimes we will be working and we will be busy during the week Monday till Friday. Then I think Friday… once it's a weekend it's much better. We have the time to go to the gym." Wits006, FDG4*

> *The outdoor gyming equipment, that's the first one. And then again, they must just propose to the university for the gym to be affordable and the medical aid then they will be linked together." Wits 041, FGD6*

4.2.13 Long-term strategy to increase participation in PA among employees

Participants strongly highlighted the need for the management to arrange inter-campus sports competitions.

4.2.14 Sports competitions

> *"Each and every year we have a competition where the whole campus meets and there is sports. A competition every year. December there is a time for sports or November or September, they pick a month. So every year September it's a sports month for Wits." Wits047, FGD4*

4.2.15 Participants' recommendations on the intervention

During the FGDs participants suggested a wide range of recommendations for increasing PA participation in the workplace. Table 4.13 illustrates the participants' recommendations for future intervention.

Table 4.13 Participants' recommendations on the intervention

Objective	Recommendation
Role of management play in promoting a healthy lifestyle in the workplace	• Providing free access to exercise facilities • Creating awareness of the importance of a healthy lifestyle among employees • Improving healthy lifestyle communication
Practical solutions for increasing physical activity participation in the workplace	• Creating a flexi-time schedule for shift staff to reduce workload and increase the time available to participate in physical activity • Adopting PA messages prompt • Including different sports in promoting physical activity
Long-term strategy to increase participation in PA among employees	• Developing an inter-campus sports competitions programme • Conducting regular health risks assessments • Management participation

4.3 Summary

Baseline characteristics demonstrate a high prevalence of overweight and obesity among the professional staff. The prevalence of central obesity is higher in females compared to males. Almost a third of the participants presented with ≥2 CVD risk factors.

Anthropometry is associated with cardiometabolic outcomes; WC and BMI are positively associated with RBG and negatively associated with VO_{2max}. RBG is positively associated with PP and sitting time. BMI and WC are negatively associated with total leisure MVPA while BMI is positively associated with sitting time.

Within-group comparisons show a significant decrease ($p<0.05$) in body weight, WC, and BMI in the HIIT and MICT groups while there was a significant ($p<0.05$) increase in body weight, WC, and BMI in the control group. There was a significant decrease ($p<0.05$) in SBP, MAP, RBG, and VO_{2max} in the HIIT group and a significant decrease

($p<0.05$) in RBG and VO_{2max} in the MICT group. There was a significant increase ($p<0.05$) in SBP, RHR, and RBG and a significant decrease ($p<0.05$) in VO_{2max} in the control group.

The between-group comparison shows that there was no significant difference in change in anthropometry (WC, BMI), cardiometabolic outcomes (SBP, DBP, RBG), RHR, PP, MAP, and VO_{2max} between the HIIT group and the MICT group.

There was a significant difference change in WC, BMI, MAP, RBG, and VO_{2max} between the HIIT and MICT groups compared to the control group.
There was a significant difference change in SBP in the HIIT group compared to the control group while the change in DBP was not significant.

There was a significant difference change in DBP in the MIIT group compared to the control group while the change in SBP was not significant. There was no significant difference in change in PP between the HIIT and MICT groups compared to the control group.

Chapter 5 Discussion

5.1 Introduction

This chapter presents a discussion on the consolidated findings of the dissertation and highlights the strengths and limitations of the study.

5.2 Consolidated findings of the dissertation

This masters study aimed to investigate the effects of physical activity and health messages interventions on anthropometry and selected cardiometabolic outcomes amongst professional staff employed at the University of the Witwatersrand.

The objectives of the study and summary findings are highlighted in Table 5.1.

Table 5.1 Summary table of objectives and findings of the study

Objective	Summary of findings
To determine baseline sociodemographic and behavioural risk factors associated with the anthropometric and cardiometabolic outcomes of interest, i.e. anthropometric variables include body mass index (BMI) and waist circumference; whilst cardiometabolic variables include blood pressure, heart rate, and random blood glucose.	• At baseline, 31.5% of participants were classified as moderate to high-risk CVD risk factors (≥2 CVD risk factors). Most of the participants (79.3%) were physically inactive and 79.6% of participants were overweight or obese and 37% were hypertensive • Central/abdominal obesity was more prevalent in women (74%) compared to men (1.85%) • WC, BMI, and PP are positively correlated with RBG ($p<0.05$) • There is a negative correlation between WC, BMI, and estimated VO_{2max} ($p<0.05$)
To determine the changes in anthropometry and cardiometabolic factors following a 12-week intervention of either; (1) high-intensity interval training (HIIT) and health messages and moderate intensity-intensity continuous training (MICT) and health messages.	• At the 12-week follow-up there was a decrease in anthropometry variables (body weight, BMI, and WC), and selected cardiometabolic outcomes (SBP, RHR, PP, RBG, and estimated VO_{2max}) in both the HIIT and MICT health messages group and these observed changes were statistically significant ($p<0.05$)
To compare the changes in outcome measures of; (1) HIIT and health messages,	• The within-group comparison showed that compared to the control group both the HIIT, MICT, and health messages showed a decrease in

Objective	Summary of findings
(2) MICT and health messages, with a (3) control group.	anthropometry (body weight, BMI, and WC), RBG, estimated VO_{2max}, and the observed difference was statistically significant ($p<0.05$) • The HIIT and health messages group showed a decrease in SBP, RHR, and MAP the observed changes were statistically significant ($p<0.05$) • There was an increase in weight, WC, BMI, SBP, RBG, and a decrease in estimated VO_{2max} in the control group, and these observed changes were statistically significant ($p<0.05$) • The between-group comparison shows that there was no significant difference in change in anthropometry (WC, BMI), cardiometabolic outcomes (SBP, DBP, RBG), RHR, PP, MAP, and VO_{2max}) between the HIIT group and the MICT group • There was a significant difference change in WC, BMI, MAP, RBG, and VO_{2max} between the HIIT and MICT groups compared to the control group
To explore factors that affected participation in the 12-week physical activity and health messaging intervention.	• Participants expressed a strong view that the following were barriers to participation in the physical activity intervention:(1) perceived time constraints, (2) high workload, and (3) fatigue/burnout. • Facilitators for participation included: (1) guidance through the health messages, (2) instructor-led exercise sessions, and (3) convenient and accessible location.

BMI: Body mass index; CVD: Cardiovascular disease; DBP: Diastolic blood pressure; HIIT: High-intensity interval training; MAP: Mean arterial pressure; MICT: Moderate-intensity continuous training; PP: Pulse pressure; RBG: Random blood glucose; RHR: Resting heart rate; SBP: Systolic blood pressure; VO_{2max}: Maximum oxygen consumption; WC: Waist circumference.

5.3 Emerging themes in the dissertation

5.3.1 High prevalence of physical inactivity and obesity among professional staff

This study confirmed a high prevalence of CVD and modifiable behavioural risk factors among the adult population in a South African workplace setting.
Using the ACSM defining criteria (1), findings showed that, 68.52 % of participants were classified at low risk (≤1 CVD risk factor present), 27.78% were at moderate risk (2 to 3 CVD risk factors present), and 3.70% were at high risk (≥4 CVD risk factors present).

A similar trend was observed in cross-sectional studies conducted among academic and non-academic staff in South Africa (32) and in the corporate setting (125). These studies reported showed a high proportion of the adult working population classified at high risk (~30-60%).
Physical inactivity (55-81%) and obesity (39-78%) were the prevalent risk factors among the employees.

In the present study, obesity and overweight (BMI ≥25 $kg \cdot m^{-2}$), were more prevalent in women compared to men. Furthermore, there was an extremely high prevalence (79.63%) of overweight and obese (BMI ≥25 $kg \cdot m^{-2}$), when categorised; 29.63% were overweight while 24.07%, 20.37%, 5.56% were categorised as class 1, 2, and 3 respectively. These data are consistent with the national surveys (SANHANES and DHS) which demonstrate a high prevalence of overweight and obesity among women (65%) and men (31%).

The present study showed that professional staff (both male and female) accumulated more PA in travel time (42.0%) than in occupation (36.6%), and total leisure (21.4%) domains. However, further analysis shows different PA patterns in males and females. Males accumulated higher PA in the occupational PA (57.8%) domain, while females accumulated a greater proportion of total MVPA in the total travel domain. Interestingly, both males and females showed a similarly high proportion of physical inactivity (80%). The study findings are consistent with other findings that have shown high levels of physical inactivity among the working population in South Africa (19,33,63,126).

5.3.2 Association of physical activity and anthropometry and selected cardiometabolic outcomes

This study has demonstrated that total work MVPA (mins·wk^{-1}) is inversely associated with SBP, post-exercise HR, and positively associated with VO_{2max}. These results are consistent with the findings of similar studies (126) in South African adult cohorts. Total leisure PA is inversely associated with body weight, BMI, and WC while total vigorous PA and total MVPA were inversely associated with WC, SBP, and post-exercise HR while positively associated with VO_{2max}. These results confirm the findings of a similar study (37).

Sitting time is positively associated with body weight, BMI, and RBG. The finding of the study demonstrates the negative relationship sitting time may have on anthropometric and cardiometabolic health. The findings of this study are important to address long sitting times in the workplace. Disrupting long sitting times may be beneficial in improving anthropometric and cardiometabolic outcomes. This is important, especially in occupations that are characterised by long sitting hours such as the security personnel.

Total vigorous PA and total MVPA are inversely associated with WC and SBP and positively associated with VO_{2max}. This finding is important for both clinicians and wellness programme designers because promoting physical activity will decrease cardiometabolic risks while improving cardiorespiratory fitness.

CRF, as measured in estimated VO_{2max}, is inversely associated with anthropometric outcomes (weight, BMI, WC), $HR_{rest,}$ and post-exercise HR. The observed finding of this study is confirmed by an SR (129) of 78 studies (n=218 820) which found an inverse relationship between CRF and BMI, body weight, WC, and resting HR. Given the upward trajectory of obesity in South Africa, it is important to create awareness of the importance of improving CRF among adults, furthermore, the workplace should include PA interventions that improve CRF and its measurement (38,100,101,119).

5.3.3 Effect of HIIT, MICT, and health messages intervention on anthropometric and selected cardiometabolic outcomes

After the 12-week intervention, the HIIT and MICT achieved a significant reduction of body weight ranging from 3.95% (HIIT) to 1.97% (MICT), and notably about double (%Δ; 50.13) of the weight loss observed in the HIIT. These observed changes are considered clinically meaningful following average weight loss observed in most overweight or obesity management programmes.
These findings are consistent with similar studies (59,64,130,131) that showed a decrease of between -1.3 % and -3.4% (Δ -1 kg to -4 kg) in the HIIT group and -2 % and -0.6% (Δ-2kg to -0.5 kg) in the MICT.

The study observed a reduction in WC (a surrogate measure of abdominal visceral adipose tissue). The WC reduction was greatest in HIIT (-2.95%) compared to MICT (-1.45%) and control (+2.57%). The findings of the study are consistent with similar studies that found a decrease in WC between -0.3 and -2.4% in HIIT and MICT (61,64).

Reducing BMI by at least 1 unit and maintaining the weight below this minimum amount for at least 1 year is clinically significant in the management of overweight and obesity (134).

The study observed a reduction of 4.04% and 2.02% in the HIIT and MICT groups respectively. These observed data are clinically meaningful. The reduction in BMI was about double than observed in the MICT group.
The study findings are consistent with similar studies(130,131) that found a reduction in BMI of -3.6% to -4.5% in HIIT and -2.2 to -3.4% in MICT.

The present study findings are consistent with the SR (135) that found HIIT was effective in reducing BMI compared to the control (-0.44 kg/m^2 (95%CI: -0.59 to -0.30 kg/m2)); I^2: 57%; P for heterogeneity: <0.001). These data should be interpreted with caution because the study did not use rigorous and accurate methods of body composition such as dual-energy X-ray absorptiometry, and bioelectrical impedance analysis. However, given the practical relevance, i.e. to inform policy change in promoting PA among professional workers in the workplace setting the findings are clinically meaningful.

The practical importance of these observed findings in anthropometric and cardiometabolic changes observed is that regular participation in PA including HIIT or MICT may help control obesity, and reduce the risk of cardiometabolic risks thus preventing or delaying the progression of CVD in overweight or obese individuals (22). Because body composition is affected by exercise intensity and frequency, diet, and lifestyle (1), it is important to highlight the critical role the health messaging may have played in improving diet and lifestyle behaviours.

Elevated blood pressure increases the risk of morbidity and mortality (137). Furthermore, every 10 mmHg reduction in SBP and DBP of 5 mmHg significantly reduces the risk of major cardiovascular disease (137,138) and a 13% reduction in all-cause mortality (137).

This study observed a reduction in SBP of ~ -7% (-8.29 mmHg (95% CI: -13.8 to -2.72)) in the HIIT and a reduction of ~ -5% (-6 mmHg (95%CI: -10.1 to -1.98)) in the MICT. These changes are considered clinically significant.
The MICT largely reduced the DBP by ~ -2.5% (-2 mmHg (-5.6 to 1.61)) while the HIIT had a reduction of ~ -1% (-0.47 mmHg (-4.86 to 3.92) although no statistical difference was observed. The findings of this study are in agreement with a study by Cuddy et al (2019) which found a reduction of -5% in SBP and -2% SBP in HIIT and MICT groups respectively (64).

The study observed the control group increased both the SBP and DBP by ~3.9% and ~7% respectively. This is of concern among employees who are not participating in regular PA. The important finding of the study is that the effects of the HIIT and MICT on SBP and DBP are clinically meaningful and statistically significant adjusting for socio-demographic factors (age, gender, education, and having underlying medical conditions).

There was a significant decrease in MAP and RHR in the HIIT ($p<0.005$) and a significant increase in RHR in the control group. The decrease in MAP, PP, and RHR in both HIIT and MICT are clinically meaningful. These findings are consistent with findings of similar studies (59,61,64,64,130,131) that have observed a decrease in both HIIT and MICT, however, this contradicts the majority of the findings which showed a superior decrease of these variables in the MICT group. The resting heart rate decrease is comparable with a similar study (59).

The MICT greatly improved the RBG % Δ ~ -14 (MD -0.96; 95% CI -1.68 to -0.24; $p<0.001$) compared to the HIIT %Δ ~ -3 (MD -0.86; 95%CI -1.54 to -0.09; $p<0.001$), this observed reduction in RBG in both HIIT and MICT was clinically meaningful compared to an %Δ ~19 (MD 1.07; 95%CI 0.48 to 1.66; $p<0.0002$).
Although this study used the RBG to assess blood glucose, the findings conflicted with the meta-analysis evidence which found that there were no significant differences between HIIT and MICT in the reduction of FBG and insulin levels (22) and also similar study by Rugbeer et al (61) that found a superior reduction of FBG in HIIT, an increase in MICT and Control of -3%, 2.3%, and 0.6% respectively.

It is worth mentioning the limitation of the finger-prick point-of-care RBG method in assessing blood glucose compared to a rigorous method such as glycated haemoglobin. RBG test is affected by physical activity levels, type of food, and smoking before performing the test, of which these factors were not controlled for during the test (1).

The present study demonstrated a clinically meaningful effect on $VO_{2\ max}$ by 10.23%, 4.9 mL/kg/min (90%CI: 3.21 to 6.58 mL/kg/min) in HIIT compared with 9.28% improvement, 4.4 mL/kg/min (90%CI: 2.91 to 5.95 mL/kg/min) in MICT, and a decrease in the control, -5.84%, -2.62 mL/kg/min (90%CI: 4.81 to 0.44).
The improvement in VO_{2max} observed in this study is slightly similar to ~9% to 12% increase in VO_{2max} reported in HIIT and MICT interventions in non-laboratory real-world settings (59,64).

Furthermore, this study showed that HIIT provided more improvement in VO_{2max} compared to MICT. This finding is consistent with the meta-analyses data which have shown that HIIT provides superior benefits for improving CRF (VO_{2max}/ VO_{2peak}) (72,73,94,139). However, these finding contradicts a novel finding in a recent systematic review and meta-analysis (140) which found that MICT was significantly better at improving CRF compared with HIIT (mean difference = −0.92; 9% CI, −1.63 to −0.21; P = .01; I2 = 10%) (140).

This finding has clinical importance given that a 1-MET (3.5 mL/kg/min) increase is associated with a 15% decrease in CVD risk (142). Since CRF is an easily modifiable risk factor (73) and an established predictor of numerous adverse health outcomes (38), the findings of this study suggest that both HIIT and MICT and health messaging tailored toward educating and creating awareness on the importance of improving CRF may be an effective intervention in cardiometabolic risk reductions.

The mechanism of explaining the significant improvement of $VO2_{max}$ in HIIT compared to MICT is not fully understood however, it is suggested that peripheral (cellular stress, molecular responses, mitochondrial content, and capillary density) and central physiological adaptation (maximum cardiac output, maximum stroke volume, blood volume) are mediated by the exercise intensity (73,143).

5.4 Emerging themes from the focus group discussions

The purpose of this portion of the dissertation was to explore the factors that affected participation in the 12-week physical activity and health messaging intervention. A socio-ecological model (SEM) was used to conceptualise the barriers and facilitators. The SEM posits that behaviour results from influences at multiple levels including intrapersonal factors, interpersonal/cultural factors, organisational factors, physical environment, and policies (40,41).

Participants suggested that they participated in enough physical activity accumulated during working hours and active travel. However, these behaviours are expected to rapidly change as countries experience economic development (145) which is characterised by the transition toward more sedentary lifestyles.

Participants in security occupations viewed their roles as sedentary, causing them to sit for long hours, while participants in cleaning positions indicated that their jobs involved high levels of occupational physical activity.
The health messaging reminders and information on the importance of disrupting prolonged sitting behaviour were well accepted among participants who were security officers, as they were made aware of the risks. While most of the participants who were cleaners perceived receiving enough PA because as accumulated during working hours. Generally, participants showed awareness of the health benefits of adopting

healthy lifestyle behaviours including regular participation in physical activity and healthy dietary choices.

Although, employees perceived that they were meeting the recommended because they participated in active occupations when compared to the WHO PA guidelines only about a fifth (20.75%) met the WHO PA guidelines. Contrary to the participants' belief the study findings indicate that higher levels of PA were cumulated in the travel domain of the total MVPA compared to in the work and leisure domain.

Most participants indicated that they were participating in enough PA because they were walking to and from work. This is confirmed by the findings that participants spend a total walking for travel MVPA median of 180 min/week. The findings are consistent with a South African study (6) that found the domain that contributed most to overall weekly physical activity was walking for travel in a South African urban population. Promoting walking for transportation among working adults may be an effective strategy because walking for transportation can assist people in meeting recommended levels of physical activity (70). Most importantly this may allow individuals to overcome commonly perceived barriers to exercise participation such as time constraints and accessibility to exercise facilities (152).

There was a general agreement among participants that the intervention was appropriate in promoting a healthy lifestyle in the workplace. The common reason provided was that the physical activity intervention was the convenient and easily accessible location offered on the workplace/campus which may have increased the participation in the intervention. This is consistent with previous studies that reported proximity as a central factor in adherence to a PA intervention in the workplace setting (147).

Overall participants expressed a belief that the management was not supportive or involved in the promotion of PA participation in the workplace. This finding is consistent with findings of a study that revealed an overall lack of motivation within the workplace and dissatisfaction with management, facilities, and wellness initiatives currently in a South African university (133). The management support for PA promotion in the workplace is important particularly in many countries, including SA, with policy focuses on occupational health and safety rather than on disease prevention in the workplace (136).

Participants highlighted the causes of their lack of participation in PA. Most participants reported lack of time as the main reason for lack of participation. Other reasons given included a perceived lack of support from the organisation/ management. This may be interpreted as the failure of the organisation to communicate or implement the health and wellness policy.

Perceived leadership involvement, buy-in, and support for PA promotion programmes are important because employees repeatedly noted that if management was not involved or supporting this was a major barrier to PA promotion, and did not feel supported to change their behaviour (144). A recent study (151) demonstrated that over 75% of the participants reported a lack of management support as one of the perceived barriers to their PA engagement in the workplace. This was particularly salient in the inactive participants and female participants. The finding is consistent with research that found that perceived low acceptance of PA promotion due to organisational norms including reduced productivity, and fear of management disapproval (128).

Barriers to physical activity participation included perceived time constraints, lack of interest/motivation (which are within participant’s control), high workload, and fatigue/burnout (which may be in the control of the management).

Facilitators identified included instructor-led exercise, guidance received through health messages, and convenient and accessible (workplace) location of the gym.
The finding of the study suggests that an accessible workplace gym may increase physical activity participation among professional staff. The finds of the present study indicate that the supervision of the HIIT and MICT sessions was key to increasing motivation.

These findings are supported by previous research investigating the instructor’s role in facilitating an autonomy/need supportive environment (1). The identification of barriers and facilitators in a workplace PA intervention is important in increasing participation and acceptance of the intervention.

5.4.1 Impact of health messaging intervention on lifestyle behaviour changes

Most of the participants highlighted that the health messaging played an important role in assisting them to adopt healthy lifestyle behaviours through improved decision-making in dietary choices and engaging in physical activity. Furthermore, participants mentioned that the health messaging helped motivate and sustain positive lifestyle choices.

This is important in light of emerging evidence that suggests that health messaging grounded on behaviour change theories (84) may play a significant role in targeting individual factors (86) thus supporting modification of lifestyle factors such as physical activity (28,148). The is no established mechanism for this change, however evidence suggests that message content, and message delivery has an effect on immediate impact (awareness and recall of the message), short-term impact (intent, motivation, self-efficacy, and knowledge), and PA behaviour (86).

Other participants suggested dissatisfaction with the lack of audio-visual function of health messaging which may improve end-user interaction and health behaviour communication. Another participant mentioned that the health messages should be adapted to local languages and should use simple language. This is an important aspect in tailoring health messaging for future studies thus, message tailoring should be cognisant of the target population and socio-demographic factors (e.g level of education), and individual preferences.

5.5 Strengths of the study

1. A major strength of this masters study is that the data adds to an obvious lack of evidence in the field of workplace interventions, particularly for blue-collar workers in South Africa.
2. Despite the fact that the Covid-19 lockdown measures the limited movement of these participants, the majority remained connected to the study and completed the intervention.

3 The focus group discussions were conducted in the participants' home language and without the participants' line managers to ensure freedom of discussion prompts. Through the use of FGDs, the study presents a unique exploration of factors that affected participation in physical activity and health messaging intervention among professional staff. This is a novel contribution, especially in the South African setting where there is limited research conducted in PA and health messaging intervention in the workplace.

5.6 Limitations of the study

There are however limitations worth noting. First, the FGDs explored the perceptions of the employees and not those of the management. The views are management may have introduced novel perspectives to managing the health and wellness of the participants, however, these should be explored separately by subordinates.

Second, the sample of male participants in this study was low compared to females, indicating there may not have been adequate representation, however, the sample included in the focus group discussion were treated as a group, suggesting that the participants in this phase of the study were sufficient.

Third, self-reported questionnaires were used to collect data on sleep, physical activity, and beverage consumption. These data should be interpreted with caution as there may have been reporting bias.

Fourth, in the RCT study, the control group consisted mainly of the ‘active work’ individuals compared to the HIIT, MICT, and health messages group who consisted mainly of sedentary work of the security staff.

Fifth, the menopausal status of the women has not been collected, however previous data suggest that fat mass is lower in pre-menopausal compared to post-menopausal African women, indicating the need for targeted behaviour modification in women as they transition into menopause.

5.7 Summary

The study findings suggest a high prevalence of physical inactivity among professional staff employed at the University of Witwatersrand. Central/abdominal obesity is more prevalent among women compared to men. Waist circumference and BMI is positively associated with random blood glucose.

At the end of the 12-week follow up there was a decrease in anthropometry variables (body weight, BMI, and WC), and selected cardiometabolic outcomes (SBP, RHR, PP, RBG, and estimated VO_{2max}) in both the HIIT and MICT health messages group and these changes were statistically significant.

There was an increase in anthropometry (WC, BMI) and cardiometabolic outcomes (SBP, and RBG) and a decrease in estimated VO_{2max} in the control group.

Participants in the FGDs expressed perceived time constraints, high workloads, and fatigue/burnout as barriers to participation in PA intervention. Facilitators for participation in PA included guidance through the health messages, instructor-led exercise sessions, and convenient and accessible location.

Chapter 6 Conclusion and Recommendations

6.1 Introduction

This chapter presents the conclusion of the study and provides recommendations for future studies.

6.2 Conclusion of the study

This study confirmed a high prevalence of cardiometabolic risk factors among the adult population in a similar setting in South Africa. Physical inactivity and obesity were the most prevalent risk factors.

The study established an association between anthropometry (waist circumference, body mass index) and selected cardiometabolic outcomes (random blood glucose, cardiorespiratory fitness, and pulse pressure, and modifiable lifestyle behaviours such as physical activity and sitting time are associated with cardiorespiratory fitness and anthropometry (waist circumference and body mass index).

Participants in the intervention groups improved body composition and cardiometabolic outcomes, suggesting that physical activity and health messages intervention are effective in improving body composition and cardiometabolic outcomes among professional staff.

Post-intervention focus group discussions showed that participants viewed time constraints, lack of interest/motivation, high workload, and fatigue/burnout as barriers to physical activity. Facilitators of physical activity were guided through the health messages, instructor-led exercise sessions, and convenient and accessible location suggesting that further investigation is needed to develop employee wellness programmes in this workplace setting. Participants identified recommendations that may inform future intervention design, implementation, and policy changes in the workplace setting.

6.3 Recommendation for future research

Future research should investigate the impact of long shift work hours on the cardiometabolic health of security personnel.

Further exploration is required for the adaptability of HIIT and MICT interventions in various settings that may not necessarily require equipment as in our study. This concept would be applicable in communities with low access to resources.

Qualitative studies are required to explore the perceptions of supervisory staff and management towards physical activity programmes during work hours.

6.4 Summary

The study confirms the high prevalence of cardiometabolic risk factors among professional staff. The findings of the study demonstrate the association between anthropometry and selected cardiometabolic outcomes. Participants who participated in either the HIIT, MICT, and health messages intervention showed improved body composition and selected cardiometabolic outcomes, suggesting the effectiveness of the physical activity and health messages intervention in the workplace setting among the professional staff. Findings from the FGDs suggest that removing perceived barriers and promoting perceived facilitators to physical activity may be effective strategies in promoting employee wellness programmes in this workplace setting.

References

1. American College of Sports Medicine (ACSM). ACSM's guidelines for exercise testing and prescription. 9th ed. Philadelphia, USA: Lippincott Williams & Wilkins; 2010.

2. Bull F, Goenka S, Lambert V, Pratt M. Physical activity for the prevention of cardiometabolic disease. In: Prabhakaran D, Anand S, Gaziano TA, Mbanya J-C, Wu Y, Nugent R, editors. Cardiovascular, respiratory, and related disorders. 3rd ed. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2017. Chapter 5.

3. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, Carty C, Chaput JP, Chastin S, Chou R, Dempsey PC. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. British Journal of Sports Medicine. 2020;54(24):1451-62.

4. Thivel D, Tremblay A, Genin PM, Panahi S, Rivière D, Duclos M. Physical activity, inactivity, and sedentary behaviors: definitions and implications in occupational health. Frontiers in Public Health. 2018;6:288.

5. Gillen JB, Gibala MJ. Interval training: A time-efficient exercise strategy to improve cardiometabolic health. Applied physiology, nutrition, and metabolism. 2018;43(10):3-4

6. Gradidge, P.JL., Crowther, N.J., Chirwa, E.D., Norris S.A., Micklesfield, L.K. Patterns, levels and correlates of self-reported physical activity in urban black Soweto women. BMC Public Health. 2014;14:934.

7. World Health Organization (WHO). Physical Activity. 2020.[cited 2021 October 9]. Available from: https://www.who.int/news-room/fact-sheets/detail/physical-activity

8. Ding D, Kolbe-Alexander T, Nguyen B, Katzmarzyk PT, Pratt M, Lawson KD. The economic burden of physical inactivity: a systematic review and critical appraisal. British Journal of Sports Medicine. 2017;51(19):1392–1409.

9. Thorndike A.N. Workplace Interventions to reduce obesity and cardiometabolic risk. Current Cardiovascular Risk Reports. 2011;5: 79-85.

10. Mulchandani R, Chandrasekaran AM, Shivashankar R, Kondal D, Agrawal A, Panniyammakal J, Tandon N, Prabhakaran D, Sharma M, Goenka S. Effect of workplace physical activity interventions on the cardio-metabolic health of working adults: systematic review and meta-analysis. International Journal of Behavioral Nutrition and Physical Activity. 2019;16(1):134.

11. Proper KI, van Oostrom SH. The effectiveness of workplace health promotion interventions on physical and mental health outcomes-a systematic review of reviews. Scandinavian Journal of Work, Environment & Health. 2019; 45:(6):546-559.

12. Atakan MM, Li Y, Koşar ŞN, Turnagöl HH, Yan X. Evidence-based effects of high-intensity interval training on exercise capacity and health: A review with historical perspective. International Journal of Environmental Research and Public Health. 2021;18(13):7201.

13. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. The Lancet Global Health. 2018;6(10):e1077–86.

14. Abdossaleh Z, AHmadi F. Assessment of the validity of Queens Step Test for estimation maximum oxygen uptake (VO2 max). International Journal of Sport Studies. 2013;3(6):617-22.

15. WHO guidelines on physical activity and sedentary behaviour: Web Annex. Evidence profiles. Geneva: World Health Organization; 2020.

16. Maredza M, Hofman KJ, Tollman SM. A hidden menace: Cardiovascular disease in South Africa and the costs of an inadequate policy response. South Africa Heart Journal. 2017;7(4).

17. The heart and stroke foundation South Africa Cardiovascular disease statistics reference document [Internet].2016. [cited 2021 Jun 23]. Available from: https://www.heartfoundation.co.za/wp-content/uploads/2017/10/CVD-Stats-Reference-Document-2016-FOR-MEDIA-1.pdf

18. Sartorius B, Veerman LJ, Manyema M, Chola L, Hofman K. Determinants of obesity and associated population attributability, South Africa: Empirical Evidence from a National Panel Survey, 2008-2012. Zeeb H, editor. PLoS ONE. 2015;10(6):e0130218.

19. Da Silva R, Milner K, Kolbe-Alexander T, Greyling M, Patel D. The prevalence of chronic conditions associated with modifiable health risk factors in corporate employees in South Africa. South African Actuarial Journal. 2015;14(1):101.

20. Shaw R, Bosworth H. Short message service (SMS) text messaging as an intervention medium for weight loss: A literature review. Health Informatics Journal. 2012;18(4):235–50.

21. Silina V, Tessma MK, Senkane S, Krievina G, Bahs G. Text messaging (SMS) as a tool to facilitate weight loss and prevent metabolic deterioration in clinically healthy overweight and obese subjects: a randomised controlled trial. Scandinavian Journal of Primary Health Care. 2017;35(3):262–70.

22. Su L, Fu J, Sun S, Zhao G, Cheng W, Dou C, Quan M. Effects of HIIT and MICT on cardiovascular risk factors in adults with overweight and/or obesity: A meta-analysis. PLoS ONE. 2019;14(1):e0210644.

23. Roy M, Williams SM, Brown RC, Meredith-Jones KA, Osborne H, Jospe M, Taylor RW. High-intensity interval training in the real world: outcomes from a 12-month intervention in overweight adults. Medicine & Science in Sports & Exercise. 2018;50(9):1818–26.

24. Vincent GE, Jay SM, Sargent C, Vandelanotte C, Ridgers ND, Ferguson SA. Improving cardiometabolic health with diet, physical activity, and breaking up sitting: what about sleep? Frontiers in Physiology. 2017;8:865.

25. Steyn NP, Nel JH, Parker W-A, Ayah R, Mbithe D. Dietary, social, and environmental determinants of obesity in Kenyan women. Scandinavian Journal Public Health. 2011;39(1):88–97.

26. World Health Organisation. Hypertension [Internet]. 2021 [cited 2022 Feb 6]. Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension

27. Keadle SK, Conroy DE, Buman MP, Dustan DW, Matthews CE. Targeting reductions in sitting time to increase physical activity and improve health. Medicine & Science in Sports & Exercise. 2017;49(8):1572.

28. Maddison R, Rawstorn JC, Shariful Islam SM, Ball K, Tighe S, Gant N, Whittaker RM, Chow CK. mHealth interventions for exercise and risk factor modification in cardiovascular disease. Exercise and Sport Sciences Reviews. 2019;47(2):86–90.

29. Proper K, van Mechelen W. Background paper prepared for the WHO/WEF joint event on preventing noncommunicable diseases in the workplace. Publications of the World Health Organization. 2007;4(92):1-52.

30. Lear SA, Hu W, Rangarajan S, Gasevic D, Leong D, Iqbal R, Casanova A, Swaminathan S, Anjana RM, Kumar R, Rosengren A. The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: the PURE study. The Lancet. 2017;390(10113):2643–54.

31. Koen N, Philips L, Potgieter S, Smit Y, van Niekerk E, Nel DG, Visser J. Staff and student health and wellness at the Faculty of Medicine and Health Sciences, Stellenbosch University: current status and needs assessment. South African Family Practice. 2018;60(3):84–90.

32. Reddy V, Naidoo R. The lifestyle habits and cardiovascular disease risk factor profiles of staff within a provincial tertiary institution in South Africa. Global Journal of Health Science. 2018;10(6):102.

33. Rugbeer N, Pila TE. Occupational cardiovascular disease risk profile and physical activity categories of university cleaners: research. Occupational Health Southern Africa. 2018;24(4):101–4.

34. Katz AS, Pronk NP. The relationship between physical activity and care-seeking behavior among employed adults. Journal of Physical Activity and Health. 2014;11(2):313–9.

35. Martland R, Mondelli V, Gaughran F, Stubbs B. Can high-intensity interval training improve physical and mental health outcomes? A meta-review of 33

systematic reviews across the lifespan. Journal of Sports Sciences. 2020;38(4):430–69.

36. Campbell WW, Kraus WE, Powell KE, Haskell WL, Janz KF, Jakicic JM, Troiano RP, Sprow K, Torres A, Piercy KL, Bartlett DB. High-intensity interval training for cardiometabolic disease prevention. Medicine and Science in Sports and Exercise. 2019;51(6):1220-6.

37. Gradidge PJ-L. Factors associated with obesity and metabolic syndrome in ageing black South African women. Global Health Action. 2017;10(1):1359922.

38. Zeiher J, Ombrellaro KJ, Perumal N, Keil T, Mensink GBM, Finger JD. Correlates and determinants of cardiorespiratory fitness in adults: A systematic review. Sports Medicine - Open. 2019;5(1):39.

39. Serrat O. Knowledge solutions: Tools, methods, and approaches to drive organizational performance. Springer Nature; 2017.

40. Bronfenbrenner U. Toward an experimental ecology of human development. American Psychologist. 1977;32(7):513–31.

41. King KM, Gonzalez GB. Increasing physical activity using an ecological model. ACSM'S Health & Fitness Journal. 2018;22(4):29–32.

42. Katzmarzyk PT. Physical activity, sedentary behavior, and health: Paradigm paralysis or paradigm shift? Diabetes. 2010;59(11):2717–25.

43. Katzmarzyk PT, Friedenreich C, Shiroma EJ, Lee IM. Physical inactivity and non-communicable disease burden in low-income, middle-income and high-income countries. British Journal of Sports Medicine. 2022;56(2):101–6.

44. Gersh BJ, Sliwa K, Mayosi BM, Yusuf S. Novel therapeutic concepts: the epidemic of cardiovascular disease in the developing world: global implications. European Heart Journal. 2010;31(6):642–8.

45. Contractor A, Sarkar BK, Arora M, Saluja K. Addressing cardiovascular disease burden in low- and middle-income countries (LMICs). Current Cardiovascular Risk Reports. 2014;8(11):405.

46. Cappuccio FP, Miller MA. Cardiovascular disease and hypertension in sub-Saharan Africa: burden, risk and interventions. Internal Emergency Medicine. 2016;11:299–305.

47. World Health Organisation. Noncommunicable diseases: progress monitor 2020 [Internet]. 2020. [cited 2021 June 26]. Available from: https://apps.who.int/iris/handle/10665/330805

48. Hamid S, Groot W, Pavlova M. Trends in cardiovascular diseases and associated risks in sub-Saharan Africa: a review of the evidence for Ghana, Nigeria, South Africa, Sudan and Tanzania. International Society for the Study of the Aging Male. 2019;22(3):169–76.

49. Lawana N, Booysen F, Tsegaye A, Kapingura FM, Hongoro C. Lifestyle risk factors, non-communicable diseases and labour force participation in South Africa. Development Southern Africa. 2020;37(3):446–61.

50. Miranda JJ, Barrientos-Gutiérrez T, Corvalan C, Hyder AA, Lazo-Porras M, Oni T, Wells JC. Understanding the rise of cardiometabolic diseases in low- and middle-income countries. Nature Medicine. 2019;25(11):1667–79.

51. Batt ME. Physical activity interventions in the workplace: the rationale and future direction for workplace wellness. British Journal of Sports Medicine. 2009;43(1):47.

52. Pronk NP. Physical activity promotion in business and industry: Evidence, context, and recommendations for a national plan. Journal of Physical Activity and Health. 2009;6(s2):S220–35.

53. Jirathananuwat A, Pongpirul K. Promoting physical activity in the workplace: A systematic meta-review. Journal of Occupational Health. 2017;59(5):385–93.

54. Milton K, Cavill N, Chalkley A, Foster C, Gomersall S, Hagstromer M, Kelly P, Kolbe-Alexander T, Mair J, McLaughlin M, Nobles J. Eight investments that work for physical activity. Journal of Physical Activity and Health. 2021;18(6):625–30.

55. Peñalvo JL, Sagastume D, Mertens E, Uzhova I, Smith J, Wu JHY, Bishop E, Onopa J, Shi P, Micha R, Mozaffarian D. Effectiveness of workplace wellness programmes for dietary habits, overweight, and cardiometabolic health: a systematic review and meta-analysis. The Lancet Public Health. 2021;6:13.

56. Conn VS, Hafdahl AR, Cooper PS, Brown LM, Lusk SL. Meta-Analysis of workplace physical activity interventions. American Journal of Preventive Medicine. 2009;37(4):330–9.

57. Holtermann A, Stamatakis E. Do all daily metabolic equivalent task units (METs) bring the same health benefits? British Journal of Sports Medicine. 2019;53(16):991–2.

58. Sieberhagen C, Rothmann S, Pienaar J. Employee health and wellness in South Africa: The role of legislation and management standards. South Africa Journal of Human Resource Management. 2009;7(1):1-9

59. Shepherd SO, Wilson OJ, Taylor AS, Thøgersen-Ntoumani C, Adlan AM, Wagenmakers AJM, Shaw CS. Low-Volume High-Intensity Interval Training in a Gym Setting Improves Cardio-Metabolic and Psychological Health. PLoS ONE. 2015;10(9):e0139056.

60. Torres G, Gradidge PJ, Constantinou D. Changes in cardiorespiratory fitness and cardiovascular health in the workplace: a case study. South African Journal of Sports Medicine. 2020;32(1):1–4.

61. Rugbeer N, Constantinou D, Torres G. Effect of the 90-second ‘Gear’ exercise programme on cardiometabolic risk factors in persons with an elevated risk of cardiovascular disease. South African Journal of Sports Medicine. 2021;33(1):1–8.

62. Gradidge PJ, Golele PN. Walking as a feasible means of effecting positive changes in BMI, waist, and blood pressure in black South African women. African Health Sciences. 2018;18(4):917–21.

63. Torres G, Fouche J, Redelinghuys R, Brussow B, Cronson D, Zanuso S, Constantinou D. The effectiveness of a corporate exercise intervention programme on cardiovascular risk profile, fitness and productivity: A South African view. South African Medical Journal.2020;110(10):1045-9.

64. Cuddy TF, Ramos JS, Dalleck LC. reduced exertion high-intensity interval training is more effective at improving cardiorespiratory fitness and cardiometabolic health than traditional moderate-intensity continuous training. International Journal of Environmental Research and Public Health. 2019;16(3):483.

65. Burn NL, Weston M, Atkinson G, Graham M, Weston KL. Brief exercise at work (BE@Work): A mixed-methods pilot trial of a workplace high-intensity interval training intervention. Frontiers in Sports and Active Living. 2021;3:699608.

66. Corbett DB, Fennell C, Peroutky K, Kingsley JD, Glickman EL. The effects of a 12-week worksite physical activity intervention on anthropometric indices, blood pressure indices, and plasma biomarkers of cardiovascular disease risk among university employees. BMC Research Notes. 2018;11(1):80.

67. Lunt H, Draper N, Marshall HC, Logan FJ, Hamlin MJ, Shearman JP, Cotter JD, Kimber NE, Blackwell G, Frampton CM. High intensity interval training in a real world setting: A randomized controlled feasibility study in overweight inactive adults, measuring change in maximal oxygen uptake. PLoS ONE. 2014;9(1):e83256.

68. Korshøj M, Lidegaard M, Skotte JH, Krustrup P, Krause N, Søgaard K, Holtermann A. Does aerobic exercise improve or impair cardiorespiratory fitness and health among cleaners? A cluster randomized controlled trial. Scandinavian Journal of Work Environment & Health. 2015;41(2):140–52.

69. Williams CJ, Gurd BJ, Bonafiglia JT, Voisin S, Li Z, Harvey N, Croci I, Taylor JL, Gajanand T, Ramos JS, Fassett RG. A multi-center comparison of O_{2peak} trainability between interval training and moderate intensity continuous training. Frontiers in Physiology. 2019;10:19.

70. Zwald ML, Hipp JA, Corseuil MW, Dondson EA. Correlates of walking for transportation and use of public transportation among adults in St Louis, Missouri, 2012. Preventing Chronic Diseases. 2014;11:140125.

71. Gripp F, Nava RC, Cassilhas RC, Esteves EA, Magalhães COD, Dias-Peixoto MF, de Castro Magalhães F, Amorim FT. HIIT is superior than MICT on cardiometabolic health during training and detraining. European Journal of Applied Physiology. 2021;121(1):159–72.

72. Gist NH, Fedewa MV, Dishman RK, Cureton KJ. Sprint interval training effects on aerobic capacity: A systematic review and meta-analysis. Sports Medicine. 2014;44(2):269–79.

73. Weston M, Taylor KL, Batterham AM, Hopkins WG. Effects of low-volume high-intensity interval training (hit) on fitness in adults: A meta-analysis of controlled and non-controlled trials. Sports Medicine. 2014;44(7):1005–17.

74. Cassidy S, Thoma C, Houghton D, Trenell MI. High-intensity interval training: a review of its impact on glucose control and cardiometabolic health. Diabetologia. 2017;60(1):7–23.

75. Keating SE, Johnson NA, Mielke GI, Coombes JS. A systematic review and meta-analysis of interval training versus moderate-intensity continuous training on body adiposity: Exercise for body fat reduction. Obesity Reviews. 2017;18(8):943–64.

76. Wewege M, van den Berg R, Ward RE, Keech A. The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: A systematic review and meta-analysis: Exercise for improving body composition. Obesity Reviews. 2017;18(6):635–46.

77. Martland R, Mondelli V, Gaughran F, Stubbs B. Can high-intensity interval training improve physical and mental health outcomes? A meta-review of 33 systematic reviews across the lifespan. Journal of Sport Sciences. 2020;38(4):430–69.

78. Maturana FM, Martus P, Zipfel S, Nieb AM. Effectiveness of HIIE versus MICT in improving cardiometabolic risk factors in health and disease: A Meta-analysis. Medicine & Science in Sports & Exercise. 2020;53(3):559-73.

79. Green DJ, Hopman MTE, Padilla J, Laughlin MH, Thijssen DHJ. Vascular adaptation to exercise in humans: Role of hemodynamic stimuli. Physiological Reviews. 2017;97(2):495–528.

80. Mlangeni L, Makola L, Naidoo I, Chibi B, Sokhela Z, Silimfe Z, Mabaso M. Factors associated with physical activity in South Africa: evidence from a national population based survey. The Open Public Health Journal. 2018;11(1):516–25.

81. Mabweazara ZS, Leach LL, Smith M, Tsolekile L, Puoane T. Ellisras Longitudinal Study 2017: patterns of physical activity in an urban and rural setting among black South African adults (ELS 23). Cardiovascular Journal of Africa. 2019;30(5):262–7.

82. World Health Organization. Noncommunicable diseases country profiles 2018 [Internet] 2021 [cited 2022 September 29]. Available from; https://apps.who.int/iris/handle/10665/274512

83. Pila TE, Rugbeer N. Occupational cardiovascular disease risk profile and physical activity categories of university cleaners. Occupational Health Southern Africa. 2018;24(4):101-4.

84. Cho Y-M, Lee S, Islam SMS, Kim S-Y. Theories applied to m-Health interventions for behavior change in Low- and Middle-Income Countries: A systematic review. Telemedicine and e-Health. 2018;24(10):727–41.

85. Müller AM, Alley S, Schoeppe S, Vandelanotte C. The effectiveness of e-& mHealth interventions to promote physical activity and healthy diets in

developing countries: A systematic review. International Journal of Behavioral Nutrition and Physical Activity. 2016;13(1):109.

86. Williamson C, Baker G, Mutrie N, Niven A, Kelly P. Get the message? A scoping review of physical activity messaging. International Journal of Behavioral Nutrition and Physical Activity. 2020;17(1):51.

87. Independent Communications Authority of South Africa (ICASA). The State of the ICT Sector Report in South Africa. 2020.

88. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nature Reviews Nephrology. 2020;16(4):223–37.

89. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, Chen J, He J. Global disparities of hypertension prevalence and control: A systematic analysis of population-based studies from 90 countries. Circulation. 2016;134(6):441–50.

90. Seedat YK, Rayner BL, Veriava Y. South African hypertension practice guideline 2014. Cardiovascular Journal of Africa. 2014;25(6):288–94.

91. National Department of Health (NDoH), Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC), and ICF. South Africa demographic and health survey 2016. Pretoria, South Africa and Rockville, Maryland, USA. 2019.

92. Shisana O, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hongoro C, Mchiza Z, Steyn NP, Dwane N, Makoae M, Maluleke T, Ramlagan S, Zungu N, Evans MG, Jacobs L, Faber M, & SANHANES-1 Team (2013) South African National Health and Nutrition Examination Survey (SANHANES-1). Cape Town: HSRC Press

93. Kandala NB, Nnanatu CC, Dukhi N, Sewpaul R, Davids A, Reddy SP. Mapping the Burden of Hypertension in South Africa: A comparative analysis of the National 2012 SANHANES and the 2016 Demographic and Health Survey. International Journal Environmental Research and Public Health. 2021;18(10):5445.

94. Batacan RB, Duncan MJ, Dalbo VJ, Tucker PS, Fenning AS. Effects of high-intensity interval training on cardiometabolic health: A systematic review and meta-analysis of intervention studies. British Journal of Sports Medicine. 2017;51(6):494–503.

95. Reljic D, Frenk F, Herrmann HJ, Neurath MF, Zopf Y. Effects of very low volume high intensity versus moderate intensity interval training in obese metabolic syndrome patients: A randomized controlled study. Scientific Reports. 2021;11(1):2836.

96. Reljic D, Frenk F, Herrmann HJ, Neurath MF, Zopf Y. Low-volume high-intensity interval training improves cardiometabolic health, work ability and well-being in severely obese individuals: a randomized-controlled trial sub-study. Journal of Translational Medicine. 2020;18(1):419.

97. The Global Health Observatory (GHO) Prevalence of insufficient physical activity among adults data by country [Internet]. 2022 [cited 2022 Jan 9]. Available from: https://apps.who.int/gho/data/node.main.A893?lang=en

98. Williamson DA, Bray GA, Ryan DH. Is 5% weight loss a satisfactory criterion to define clinically significant weight loss? Obesity. 2015;23(12):2319–20.

99. NCD Risk Factor Collaboration (NCD-RisC) – Africa Working Group, Kengne AP, Bentham J, Zhou B, Peer N, Matsha TE, et al. Trends in obesity and diabetes across Africa from 1980 to 2014: an analysis of pooled population-based studies. International Journal of Epidemiology. 2017;46(5):1421–32.

100. Torres G, Gradidge PJ, Constantinou D. Changes in cardiorespiratory fitness and cardiovascular health in the workplace: a case study. South African Journal of Sports Medicine. 2020;32(1):1–4.

101. Holtermann A, Marott JL, Gyntelberg F, Søgaard K, Mortensen OS, Prescott E, Schnohr P. Self-reported occupational physical activity and cardiorespiratory fitness: Importance for cardiovascular disease and all-cause mortality. Scandinavian Journal of Work, Environment & Health. 2016;42(4)291-8.

102. Ekblom-Bak E, Ekblom Ö, Andersson G, Wallin P, Söderling J, Hemmingsson E, Ekblom B. Decline in cardiorespiratory fitness in the Swedish working force between 1995 and 2017. Scandinavian Journal of Medicine and Science in Sports. 2019;29(2):232–9.

103. Lamoureux NR, Fitzgerald JS, Norton KI, Sabato T, Tremblay MS, Tomkinson GR. Temporal trends in the cardiorespiratory fitness of 2,525,827 adults between 1967 and 2016: A systematic review. Sports Medicine. 2019;49(1):41–55.

104. Statistics South Africa. Local Municipality. 2021.[cited 2021 November 2] Available from:https://www.statssa.gov/?page_id=993&id=city-of-johannesburg-municipality

105. Schoonenboom J, Johnson RB. How to construct a mixed methods research design. Kolner Z Soz Sozpsychol. 2017;69(2):107-31.

106. Hilgers RD, Uschner D, Rosenberger WF, Heussen N. ERDO - a framework to select an appropriate randomization procedure for clinical trials. BMC Medical Research Methodology. 2017;17(1):159.

107. Moher D, Hopewell S, Schulz KF, Montori V, Gotzsche PC, Devereaux PJ, Elbourne D, Egger M, Altman DG. CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials. British Medical Journal. 2010;340:c869

108. Slade SC, Dionne CE, Underwood M, Buchbinder R, Beck B, Bennell K, Brosseau L, Costa L, Cramp F, Cup E, Feehan L. Consensus on Exercise Reporting Template (CERT): Modified Delphi Study. Physical Therapy. 2016;96(10):1514–24.

109. Heart & Stroke Foundation | South Africa | Heart & Stroke Foundation | South Africa [Internet]. [cited 2022 Mar 30]. Available from: https://www.heartfoundation.co.za/

110. Sarzynski MA, Rankinen T, Earnest CP, Leon AS, Rao DC, Skinner JS, Bouchard C. Measured maximal heart rates compared to commonly used age-based prediction equations in the heritage family study: Comparison of Measured and Predicted HR $_{max}$. American Journal of Human Biology. 2013;25(5):695–701.

111. Global Physical Activity Questionnaire (GPAQ) Analysis Guide [Internet]. 2021 [cited 2021 Jun 23]. Available from: https://www.who.int/ncds/surveillance/steps/resources/GPAQ_Analysis_Guide.pdf

112. Bull FC, Maslin TS, Armstrong T. Global Physical Activity Questionnaire (GPAQ): Nine country reliability and validity study. Journal of Physical Activity and Health. 2009;6(6):790–804.

113. Hedrick VE, Savla J, Comber DL, Flack KD, Estabrooks PA, Nsiah-Kumi PA, Ortmeier S, Davy BM. Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): sugar-sweetened beverages and total beverage energy intake. Journal of the Academy of Nutrition and Dietetics. 2012;112(6):840–9.

114. DeMers D, Wachs D. Physiology, Mean Arterial Pressure. InStatPearls. Treasure Island (FL): StatPearls Publishing; 2021.

115. Homan TD, Bordes S, Cichowski E. Physiology, Pulse Pressure. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2021.

116. Cardiocheck Plus eGLU glucose test strips. Golden Valley, Minnesota: Stat Technologies; 2021. Available from: https://ptsdiagnostics.com/wp-content/uploads/2021/10/PS-004580-English-Pkg-Insert-eGLU-Rev_3.pdf

117. Webb D. 2017 SEMDSA diabetes management guidelines. South African Journal of Diabetes and Vascular Disease. 2018;15(1):37–40.

118. Chatterjee S, Chatterjee P, Mukherjee PS, Bandyopadhyay A. Validity of Queen's College step test for use with young Indian men. British Journal of Sports Medicine. 2004;38(3):289–91.

119. Ross R, Blair SN, Arena R, Church TS, Després JP, Franklin BA, Haskell WL, Kaminsky LA, Levine BD, Lavie CJ, Myers J. Importance of assessing cardiorespiratory fitness in clinical practice: A case for fitness as a clinical vital sign: A scientific statement from the American Heart Association. Circulation. 2016;134(24)e653-99.

120. Williams N. The Borg Rating of Perceived Exertion (RPE) scale. Occupational Medicine. 2017;67(5):404–5.

121. 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;19(6):349–57.

122. O'Brien BC, Harris IB, Thomas J. Beckman, Cook DA. Standards for Reporting Qualitative Research: A Synthesis of recommendations. Academic Medicine. 2014;89(9):1245-51.

123. Bauman A, Nutbeam D. Evaluation in a nutshell: a practical guide to the evaluation of health promotion programs. McGraw-hill; 2013.

124. Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes. 1991;50(2):179–211.

125. Torres G, Fouche J, Redelinghuys R, Brussow B, Cronson D, Zanuso S, Constantinou D. The effectiveness of a corporate exercise intervention programme on cardiovascular risk profile, fitness and productivity: A South African view. South African Medical Journal. 2020;110(10):1045-9.

126. Koen N, Philips L, Potgieter S, Smit Y, van Niekerk E, Nel DG, Visser J. Staff and student health and wellness at the Faculty of Medicine and Health Sciences, Stellenbosch University: current status and needs assessment. South African Family Practice. 2018;60(3):84–90.

127. Prioreschi A, Brage S, Westgate K, Norris SA, Micklesfield LK. Cardiorespiratory fitness levels and associations with physical activity and body composition in young South African adults from Soweto. BMC Public Health. 2017;17(1):301.

128. Planchard JH, Corrion K, Lehmann L, d'Arripe-Longueville F. Worksite physical activity barriers and facilitators: a qualitative study based on the Transtheoretical model of change. Frontiers in public health. 2018;6:326.

129. Hung TH, Liao PA, Chang HH, Wang JH, Wu MC. Examining the relationship between cardiorespiratory fitness and body weight status: empirical evidence from a population-based survey of adults in Taiwan. The Scientific World Journal. 2014;2014:463736.

130. Reljic D, Frenk F, Herrmann HJ, Neurath MF, Zopf Y. Low-volume high-intensity interval training improves cardiometabolic health, work ability and well-being in severely obese individuals: a randomized-controlled trial sub-study. Journal of Translational Medicine 2020;18(1):1–15.

131. Reljic D, Frenk F, Herrmann HJ, Neurath MF, Zopf Y. Effects of very low volume high intensity versus moderate intensity interval training in obese metabolic syndrome patients: a randomized controlled study. Scientific Reports. 2021;11(1):2836.

132. Ross R, Neeland IJ, Yamashita S, Shai I, Seidell J, Magni P, Santos RD, Arsenault B, Cuevas A, Hu FB, Griffin BA. Waist circumference as a vital sign in clinical practice: a Consensus Statement from the IAS and ICCR Working Group on Visceral Obesity. Nature Reviews Endocrinology. 2020;16(3):177–89.

133. Koen N, Philips L, Potgieter S, Smit Y, Van Niekerk E, Nel DG, Visser J. Staff and student health and wellness at the Faculty of Medicine and Health Sciences, Stellenbosch University: current status and needs assessment. South African Family Practice. 2018;60(3):84-90.

134. Montesi L, El Ghoch M, Brodosi L, Calugi S, Marchesini G, Dalle Grave R. Long-term weight loss maintenance for obesity: a multidisciplinary approach. Diabetes Metabolic Syndrome Obesity: Targets and therapy. 2016;9:37–46.

135. Andreato LV, Esteves JV, Coimbra DR, Moraes AJP, de Carvalho T. The influence of high-intensity interval training on anthropometric variables of adults with overweight or obesity: a systematic review and network meta-analysis. Obesity Reviews. 2019;20(1):142–55.

136. Mash R, Schouw DD. Cost and consequence analysis of the Healthy Choices at Work programme to prevent non-communicable diseases in a commercial power plant, South Africa. African Journal of Primary Health Care and Family Medicine. 2020;12(1):1-8.

137. Ettehad D, Emdin CA, Kiran A, Anderson SG, Callender T, Emberson J, Chalmers J, Rodgers A, Rahimi K. Blood pressure lowering for prevention of cardiovascular disease and death: a systematic review and meta-analysis. The Lancet. 2016;387(10022):957–67.

138. Law MR, Morris JK, Wald NJ. Use of blood pressure lowering drugs in the prevention of cardiovascular disease: meta-analysis of 147 randomised trials in the context of expectations from prospective epidemiological studies. British Medical Journal. 2009;338:b1665–b1665.

139. Costa EC, Hay JL, Kehler DS, Boreskie KF, Arora RC, Umpierre D, et al. Effects of High-Intensity Interval Training Versus Moderate-Intensity Continuous Training on Blood Pressure in Adults with Pre- to Established Hypertension: A Systematic Review and Meta-Analysis of Randomized Trials. Sports Medicine. 2018;48(9):2127–42.

140. Rugbeer N, Constantinou D, Torres G. Comparison of High-Intensity Training Versus Moderate-Intensity Continuous Training on Cardiorespiratory Fitness and Body Fat Percentage in Persons with Overweight or Obesity: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Journal of Physical Activity and Health. 2021;18(5):610-623

141. Tracy SJ. Qualitative quality: Eight “big-tent” criteria for excellent qualitative research. Qualitative inquiry. 2010; 16(10):837-51.

142. Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, Sugawara A, Totsuka K, Shimano H, Ohashi Y, Yamada N. Cardiorespiratory Fitness as a Quantitative Predictor of All-Cause Mortality and Cardiovascular Events in Healthy Men and Women: A Meta-analysis. Journal of the American Medical Association. 2009;301(19):2024–35.

143. Macinnis MJ, Gibala MJ. Physiological adaptations to interval training and the role of exercise intensity. The Journal of Physiology. 2016;595(9):2915-30.

144. Stevens M, Rees T, Cruwys T, Olive L. Equipping physical activity leaders to facilitate behaviour change: An overview, call to action, and roadmap for future research. Sports Medicine-Open. 2022;8(1):1-9.

145. Atkinson K, Lowe S, Moore S. Human development, occupational structure and physical inactivity among 47 low and middle-income countries. Preventive Medicine Reports. 2016;3:40–5.

146. Guthold R, Louazani SA, Riley LM, Cowan MJ, Bovet P, Damasceno A, Sambo BH, Tesfaye F, Armstrong TP. Physical Activity in 22 African Countries. American Journal of Preventive Medicine. 2011;41(1):52–60.

147. Kinnafick FE, Thøgersen-Ntoumani C, Shepherd SO, Wilson OJ, Wagenmakers AJM, Shaw CS. In It Together: A qualitative evaluation of participant experiences of a 10-week, group-based, workplace HIIT program for insufficiently active adults. Journal of Sport and Exercise Psychology. 2018;40(1):10–9.

148. Hall AK, Cole-Lewis H, Bernhardt JM. Mobile text messaging for health: A systematic review of reviews. Annual Review Public Health. 2015;36(1):393–415.

149. op den Akker H, Cabrita M, op den Akker R, Jones VM, Hermens HJ. Tailored motivational message generation: A model and practical framework for real-time physical activity coaching. Journal of Biomedical Informatics. 2015;55:104–15.

150. Moher D, Hopewell S, Schulz KF, Montori V, Gotzsche PC, Devereaux PJ, et al. CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials. British Medical Journal. 2010;340(1):c869–c869.

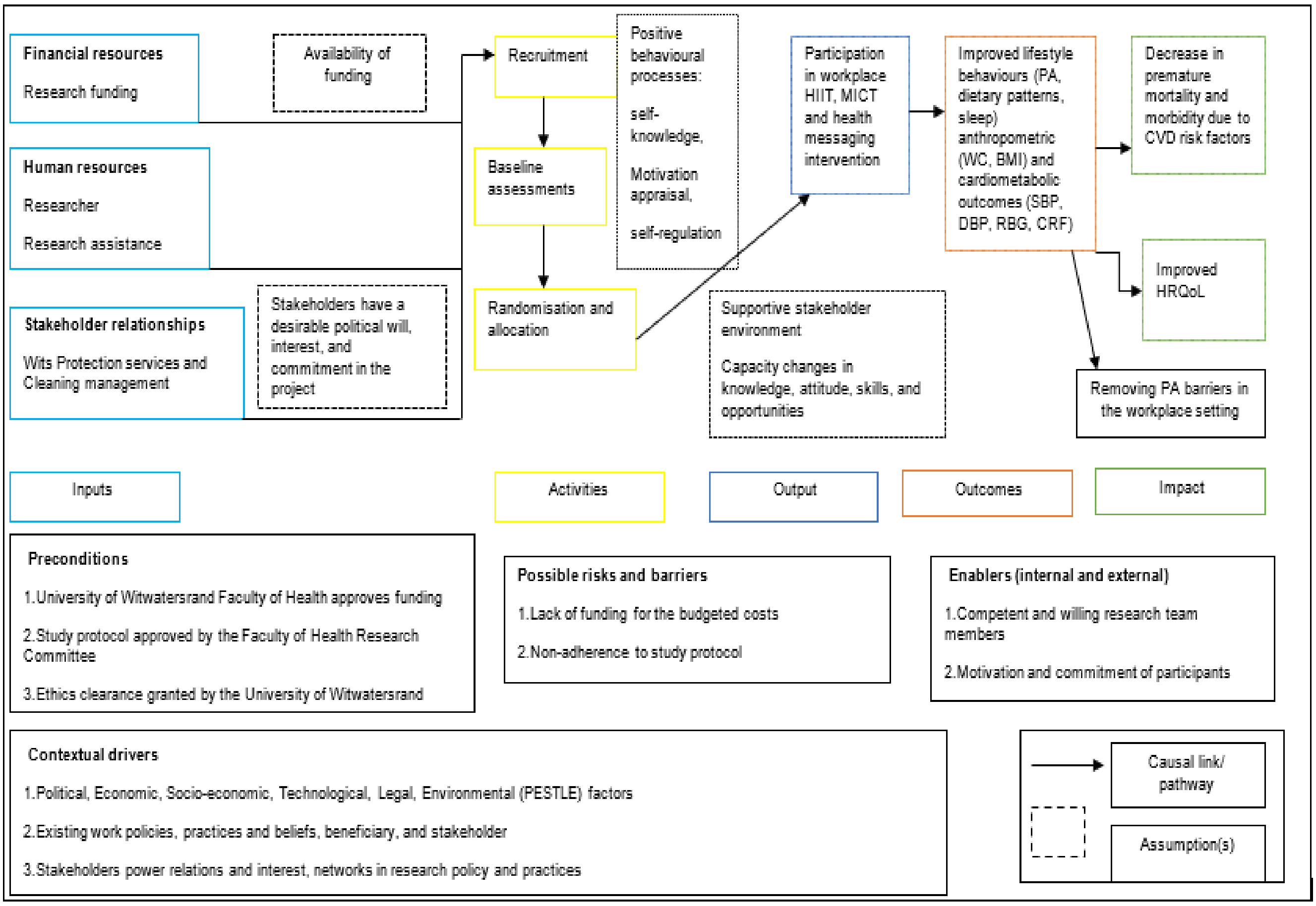
151. Safi A, Cole M, Kelly AL, Zariwala MG, Walker NC. Workplace Physical Activity Barriers and Facilitators: A Qualitative Study Based on Employees Physical Activity Levels. International Journal of Environmental Research and Public Health. 2022;19(15):9442.

152. Butler CE, Clark BR, Burlis TL, Castillo JC, Racette SB. Physical activity for campus employees: a university worksite wellness program. Journal of physical activity & health. 2015;12(4):470.

153. Marfell-Jones MJ, Stewart AD, De Ridder JH. International standards for anthropometric assessment. 2012.

Appendices

Appendix A Theory of Change (ToC) for the physical activity and health messaging intervention



BMI: Body mass index; CRF: Cardiorespiratory fitness; CVD: Cardiovascular disease; DBP: Diastolic blood pressure; HIIT: High-intensity interval training; HRQoL: Health-related quality of life; MICT: Moderate-intensity continuous training; PA: Physical activity; RBG: Random blood glucose; SBP: Systolic blood pressure; WC: Waist circumference.

Appendix B High-intensity interval training (HIIT) exercise protocol

Week	Session	Session duration (min:sec)	Number of sessions per week
1	30 s HIIT, 2 min recovery; repeat 4x	20:00	3
2	15 s HIIT, 45 s recovery; repeat 8x	18:00	3
3	30 s HIIT, 90 s recovery; repeat 5x	20:00	3
4	60 s HIIT, 60 s recovery; repeat 5x	20:00	3
5	30 s HIIT, 60 s recovery; repeat 7x	22:00	3
6	15 s HIIT, 45 s recovery; repeat 12x	22:30	3
7	30 s HIIT, 60 s recovery; repeat 9x	24:00	3
8	60 s HIIT, 60 s recovery; repeat 7x	24:00	3
9	30 s HIIT, 60 s recovery; repeat 6x followed by 15 s HIIT, 45 s recovery; repeat 5x	24:00	3
10	60 s HIIT, 60 s recovery; repeat 5x followed by 15 s HIIT, 45 s recovery; repeat 5x	25:00	3
11	30 s HIIT, 60 s recovery; repeat 7x followed by 15 s HIIT, 45 s recovery; repeat 6x	26:30	3
12	60 s HIIT, 60 s recovery; repeat 7x followed by 15 s HIIT, 45 s recovery; repeat 7x	31:00	3

HIIT: High-intensity interval training

Appendix C Moderate-intensity continuous (MICT) training exercise protocol

Week	Session duration (min: sec)	Number of sessions per week
1	30:00	3
2	30:00	3
3	35:00	3
4	35:00	3
5	40:00	3
6	40:00	3
7	45:00	3
8	45:00	3
9	50:00	3
10	50:00	3
11	55:00	3
12	55:00	3

MICT sessions commenced and concluded with a 5 min period of low intensity cycling during weeks 1 and 2, which was reduced to 2.5 min from week 3 onwards, this time was included in the session time.
MICT: Moderate-intensity continuous training.

Appendix D List of health messages

1. Exercising regularly will help you to maintain a healthy weight and reduce cardiometabolic diseases.
2. Walking is a form of physical activity. Aim to walk for at least 10 minutes continuously to get to and from places.
3. Physical activity burns calories and helps maintain weight. Think about using stairs instead of a lift.
4. Vary your exercise: walk, cycle, use a treadmill or join an aerobics class. It will help you stay motivated and have fun!
5. Stay motivated! At the beginning of the week plan your exercise sessions and treat them like you would any other appointment.
6. When you don't feel like working out, bargain with yourself to exercise for just 10 minutes then see how you feel.
7. Any exercise is better than no exercise. Use a strategy to find a way to get in at least some exercise.
8. Lifestyle behaviours (Physical inactivity, alcohol, smoking, family history, hypertension, and obesity) increases the risk of cardiometabolic diseases.
9. Sleep is just as important as diet and exercise. Aim to get good quality sleep.
10. Sitting for a long time is not good for your health. Take regular breaks, stand and stretch.

Appendix E Questionnaires

Title of the research study: ***"A randomised controlled trial of physical activity and health messages on anthropometric and cardiometabolic outcomes amongst South African university professional staff."***

SECTION 1: DEMOGRAPHIC AND SOCIOECONOMIC STATUS

Surname

____

Name

____

What is your Age (years)?

____

What is your gender? Please tick the appropriate box

○ Male
○ Female

What is your highest level of education?

○ No school
○ Primary school (Grade 1 to 7)
○ Incomplete high school (Grade 8 to Grade 11, and did not complete grade 12)
○ Completed matric
○ College/technical school diploma
○ University degree
○ Postgraduate qualification
○ Other

What is your occupation type?

____

What is your current net salary after deductions?

- Prefer not to answer
- <R15 000
- R15 000 to R20 000
- R20 000 to R30 000
- >R 30 000

Personal medical history: Have you suffered or do you suffer from any of these medical conditions?

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

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

Are you currently on medication for heart disease, peripheral vascular disease, diabetes, cholesterol and/or blood pressure?

○ Yes
○ No

Please write your medical condition, name of medication, and dosages below
E.g. Cholesterol, Lipitor, 10mg 1/day

____

SECTION 3: BEHAVIOURS

Smoking status

Please tick the appropriate box relating to your smoking...

Never smoked?

○ Never smoked
○ Ex-Smoker

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

Are you a current smoker?

○ Yes
○ No

Current Smokers

	10 per day	10-20 per day	21-30 per day	> 30 per day
Cigarette smoking	○	○	○	○
Cigar	○	○	○	○
Pipe	○	○	○	○
Chewing tobacco	○	○	○	○

	Never	Less than weekly but at least once/months	Less than daily	Usually every day
Regular use E- cigarette/ vaping	○	○	○	○

	Nicotine	1-6 mg nicotine/mL	7-12 mg nicotine/mL	13-18 mg nicotine/mL	Over 18 mg nicotine/mL	I don't know
What strength(s) of nicotine do do you currently vape with?	○	○	○	○	○	○

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

○ 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.

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

○ I don't have any alcoholic drinks.
○ Never more than 1-2 drinks per occasion or per day.
○ 3-4 drinks in a day, only 2-3 per month.
○ 3-4 drinks in a day, 4 times per month.
○ 3 or more drinks in a day, more than once a week, and/or more than 4 drinks at a time.

Sleep behaviour

How many hours of sleep do you usually get on weekdays or workdays?

____

During the past month, what time do you usually go to bed at night?

____

During the past month, what time do you usually get up in the morning?

During the past month, what was the average shortest sleep duration at night in one week?

___

During the past month, what was the average longest sleep duration at night in one week?

___

Global Physical Activity Questionnaire

This questionnaire is going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself to be physically active.

Think about the time you spend you spend doing work, studying/training, household chores, harvesting food, fishing, hunting, seeking employment. In answering the following questions 'vigorous-intensity activities are activities that require hard physical effort and cause large increase in breathing or heart rate, moderate activities are activities that require moderate physical effort and cause small increases in breathing.

Physical activity at work/school

Does you work involve vigorous-intensity activity that causes large increases in breathing or heart rate (like carrying or lifting heavy loads, digging, construction at work) for at least 10 minutes continuously?	Yes ◯ No ◯
In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	___
How much time do you spend doing vigorous-intensity activities at work on a typical day?	___
Does your work involve a moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking (or carrying light load or at least 10 minutes continuously?	Yes ◯ No ◯
In a typical week, on how many days do you do moderate-intensity activities as part of your work?	___
How much time do you spend doing moderate-intensity activities at work on a typical day?	___

Travel to and from places

The next question excludes the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. Example to work, for shopping, to market or church.

Do you walk, or use a bicycle for at least 10 minutes continuously to get to and from places?	Yes No

In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places? ____________number of days ________________________________

How much time do you spend walking or bicycling for travel on a typical day?____________________ hours ________________________________

RECREATIONAL ACTIVITIES

The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities(leisure)

Do you do any vigorous-intensity sports, fitness or recreational activities that cause large increase in breathing or heart rate like running, jogging, soccer or netball for at least 10 minutes continuously?

Yes ○
No ○

In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational activities? ________________________________

How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day? ________________________________

Do you do any moderate-intensity sports, fitness or recreational activities that cause a small increase in breathing or heart rate such as brisk walking, jogging, cycling, and soccer for at least 10 minutes continuously?

Yes ○
No ○

In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational activities? ________________________________

How much time do you spend doing moderate-intensity sports, fitness or recreational activities on a typical day? ________________________________

SEDENTARY BEHAVIOUR

The following question is about sitting or reclining at work, at home, getting to and from work places, or with friends including time spent sitting at a desk, sitting with friends, traveling in a car, bus, taxi, reading, playing cards or watching TV, but do not include time spent sleeping.

How much time do you usually spend sitting or reclining on a typical day? ________________________________

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.

	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.	○	○	○	○	○
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, but 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.

HOW OFTEN (MARK ONE)

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

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

	Never or less than 1 time per week (go to next beverage)	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
Water	○	○	○	○	○	○	○
100% Fruit Juice	○	○	○	○	○	○	○
Sweetened Juice Beverage/ Drink (fruitades, 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	○	○	○	○	○	○	○

Beverage intake questionnaire: HOW MUCH AT EACH TIME Instructions:

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

1. **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".**
2. **Do not count beverages used in cooking or other preparations, such as milk in cereal.**
3. **Count milk added to tea and coffee in the tea/coffee with cream beverage category**

	Less than 6 fl oz (3/4 cup)	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 cups)
Water	○	○	○	○	○
100% Fruit Juice	○	○	○	○	○
Sweetened Juice Beverage/ Drink (fruitades, 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	○	○	○	○	○

Appendix F Data collection sheet

1. Participant code

2) Gender

3) Name and Surname

4) Cellphone Number

5) Telephone number

6) Email address

7) Height (cm)

8) Weight (kg)

4. Waist circumference (cm)

10) Hip circumference (cm)

11) SBP/ DBP/ Pulse 1

12) SBP/ DBP/ Pulse 2

13) SBP/ DBP/ Pulse 3

14) Random blood glucose (mmol/L)

Queens College Step Test

15) Post-exercise heart rate (BPM)

____
____

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 G Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Philippe Gradidge

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M190409

NAME: (Principal Investigator)	Dr Philippe Gradidge
DEPARTMENT:	Centre for Exercise and Sports Medicine
PROJECT TITLE:	The effects of physical activity and health messages interventions on anthropometry and selected cardiometabolic diseases in overweight and obese university professional staff
DATE CONSIDERED:	2019/04/26
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	
APPROVED BY:	CB Penny Dr C Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	11/12/2019

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 in Room 301, 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 April and will therefore be due in the month of April 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 H Permission to conduct the study

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

OFFICE OF THE DEPUTY REGISTRAR

27 February 2019

Philippe Gradidge
Staff number: A0016736

TO WHOM IT MAY CONCERN

"To explore the effects of physical activity and health messages interventions on anthropometry and selected cardiometabolic diseases in university professional staff"

This letter serves to confirm that the above project has received permission to be conducted on University premises, and/or involving staff and/or students of the University as research participants. In undertaking this research, you agree to abide by all University regulations for conducting research on campus and to respect participants' rights to withdraw from participation at any time.

If you are conducting research on certain student cohorts, year groups, courses or with academic staff within specific Schools and within the teaching term, permission must be sought from Heads of School or individual academics.

No research can commence until ethical clearance has been obtained. Please forward a copy of the ethical clearance certificate.

Nicoleen Potgieter
UNIVERSITY DEPUTY REGISTRAR

Private Bag 3, Wits, 2050, South Africa | T +27 11 717 1204/8 | F +27 86 553 2271 | www.wits.ac.za

Appendix I Information sheet

Good day, my name is David Khumalo, a Masters student at the University of the Witwatersrand. As part of my studies, I am doing research. My supervisors are Associate Professor Philippe Gradidge, Adjunct Professor Demitri Constantinou, and Ms Merling Phaswana, who are employed at the University of the Witwatersrand Centre for Exercise Science and Sports Medicine. I would like to invite you to think about taking part in my research study. The title is "**A randomised controlled trial of physical activity and health messages on anthropometric and cardiometabolic outcomes amongst South African university professional staff**."

Please consider reading and understanding more about the study before you make a decision about participating in the study. Please feel free to ask any questions about information you are not sure about otherwise, you can ask for details about the study. I appreciate you taking the time to read this information document.

Invitation to participate:

Overweight and obesity are increasing in the South African population and this is linked to more complicated diseases such as diabetes or high blood pressure. These diseases can cause people to become ill, and if you are working can lead to sick days taken from work. Our team of researchers wants to find out if there is a problem of obesity and other related diseases in your workplace in order to work with you to improve your health and well-being. This study is important as the findings will help the management and other similar companies with ensuring the health of their workers.

Where will the study take place?

The study will take place at your place of employment, i.e. the University of the Witwatersrand, Johannesburg.

What is the purpose of the research?

The purpose of this study is to develop an intervention programme to lower extended sitting time and risk factors associated with cardiovascular disease.

Participant selection

Professional staff employed by the University of the Witwatersrand, Johannesburg will be invited to take part in this study.

Do I have to take part?

Participation in this study is voluntary. You will be invited to participate, however after consenting to take part; you may still decide to leave the study at any time without any consequences.

What would I be asked to do if I took part?

Once you have read and understood the purpose of the study, and are willing to volunteer to take part, you will be asked to sign a consent form. You will then be guided through a questionnaire related to your health, conducted in a private room provided by the human resources department of the University of the Witwatersrand, which will take approximately 45 to 60 minutes to administer during a convenient time or lunch break. One of the research assistants will then take some measurements including height, weight, waist and hip circumferences, blood pressure, and blood glucose. There are no risks involved. Any identifying information will be kept strictly confidential.

Risks or side effects

Taking part in this study will not result in risks or complications.

Benefits

Those taking part in this study will not benefit immediately, however, there may be medium and long-term benefits to cardiovascular health for those participants involved in the intervention groups.

What happens to the data collected?

The information collected by the research team will be kept confidential and password protected by me. Any identifiable information collected during the course of the study will not be shared with the employer; only collective anonymised information may be presented to the employer. This information will help the research team with planning and developing future worksite interventions at the University of the Witwatersrand. Discussions with representatives of the workers and the management will take place to ensure that the objectives of the intervention are appropriate for your company. The information of the whole group will also be presented at conferences and written in peer-reviewed journals.

Ethical considerations

The proposal for this intervention study has been submitted and approved by the University of the Witwatersrand, Human Research Ethics Committee (HREC), Medical. For further information regarding this, contact the HREC chairman Prof Clement Penny on 0114883820 or email: Clement.Penny@wits.ac.za

Contact details

You can contact us for more details:

Mr. David Khumalo
Telephone: 078 022 9565 Email: david.khumalo@gmail.com

Supervisors;

Associate Professor Philippe Gradidge
Telephone: 011 717 3363 Email: philippe.gradidge@wits.ac.za

Adjunct Professor Demitri Constantinou
Telephone: 011 717 3372 E-mail: demitri.constantinou@wits.ac.za

Ms. Merling Phaswana
Telephone: 011 717 3231 Email: merling.phaswana@wits.ac.za

Appendix J Informed consent form

Title of the research study**: "A randomised controlled trial of physical activity and health messages on anthropometric and cardiometabolic outcomes amongst South African university professional staff."**

Name of participant: ____

Participant's involvement: You are requested to take part in a 12-week intervention of either (1) Moderate-intensity continuous training (MICT); (2) low volume, high intensity interval training (HIIT); or (3) health messages and (4) control group, which will determine baseline measurements of physical activity, diet, smoking consumption, alcohol consumption, sleep patterns, point of care bloods (blood glucose) and body composition (weight, waist and hip circumference).

Nature of the research: This is a randomised controlled trial involving intervention groups to better understand lifestyle factors associated with cardiometabolic diseases.

What's involved? This study involves measurements of height, weight, waist, hip, circumference, blood pressure, blood glucose; also, I will be asking questions around socioeconomic status, smoking, physical activity level, diet and sleep behaviour.

Risks: The risk and discomfort associated with participation in this study are no greater than those ordinarily encountered in daily life during routine physical examination tests. The intervention is expected to be 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, and you may also form part of Stats South Africa for Health patterning. However, there are no direct benefits to participating in this research project.

- I hereby confirm that I have been informed by the researcher, Mr David Khumalo about the nature, conduct, benefits and risks of the study
- I am aware that the results of the study, including personal details regarding my gender, 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 K Focus group discussion participant information sheet

Study title: *A randomised controlled trial of physical activity and health messages on anthropometric and cardiometabolic outcomes amongst South African university professional staff*

Introduction

Good day, my name is David Khumalo, a Masters student at the University of the Witwatersrand. As part of my studies, I am doing research. My supervisors are Associate Professor Philippe Gradidge, Adjunct Professor Demitri Constantinou, and Ms. Merling Phaswana, who are employed at the University of the Witwatersrand Centre for Exercise Science and Sports Medicine.

I would like to invite you to take part in a Focus Group discussion. A Focus Group is just a number of people who assemble voluntarily to discuss a pre-determined topic. Anonymity cannot be guaranteed in a Focus Group, as some of the participants may recognize one another. The following information is to help you decide whether you would be a willing participant in a Focus Group. Please feel free to ask any of the people listed below if you still have questions after reading this Information Sheet.

You are requested to take part in a post-intervention Focus Group discussion of either (1) Moderate-intensity continuous training (MICT) and health messages group or (2) high-intensity interval training (HIIT) and health messages group.

This Focus Group discussion aims to better understand the factors that affected your participation in the 12-week physical activity and health messaging intervention.

Where will the study take place?

The study will take place at your place of employment, the University of the Witwatersrand, Johannesburg. With your consent, the discussion will be recorded so that all the required information is captured. The recording will be erased after 2 years if a publication arises from the study, or 6 years if there is no publication. This recording will be subject to the safekeeping details outlined below.

What is the purpose of the study?

In this study, I will be asking questions to gain further understanding of your intention to participate in the intervention and understanding of factors that reduced or increased your participation in the 12-week physical activity and health messaging intervention.

Who is requested to participate?

Professional staff employed by the University of the Witwatersrand, Johannesburg who participated in the 12-week intervention study will be invited to take part in this study.

Do I have to take part?

Participation in this study is voluntary. Even if you consent to take part; you may still decide to leave the study at any time without any consequences. In that event, any information which has been collected about you during the Focus Group will be destroyed, unless you consent to its retention.

What would I be asked to do if I took part?

Once you have read and understood the purpose of the study and if you are willing to volunteer to take part, you will be asked to sign a consent form. You will then join a group of people for a guided discussion, which will be conducted in a private room provided by the human resources department of the University of the Witwatersrand. This will take approximately 45 to 60 minutes during a convenient time or lunch break.

What are the risks or side effects?

Taking part in this study is not expected to result in any risks or side effects.

Benefits

There are no immediate benefits to participating in the study. Your participation in this study is important as the findings may help the management and other similar companies with ensuring the health of their workers.

What happens to the data collected?

Any identifying information will be kept strictly confidential and you will not be identified in any way.
The information collected by the research team will be kept confidential and password protected by me. Any identifiable information collected during the study will not be shared with the employer; only collective anonymised information may be presented to the employer, or in any report or publication. This information may help the research team with planning and developing future workplace interventions at the University of the Witwatersrand.
The information of the whole group will also be presented at conferences and written in peer-reviewed journals.

Ethical considerations

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.
If you have any concerns over the way the study is being conducted, please contact the Chairperson of this Committee who is Dr Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Contact details:
You can contact us for more details:
Mr. David Khumalo
Telephone: 078 022 9565
Email: david.khumalo@gmail.com

Supervisors:
Associate Professor Philippe Gradidge
Telephone: 011 717 3363
Email: philippe.gradidge@wits.ac.za

Adjunct Professor Demitri Constantinou
Telephone: 011 717 3372
E-mail: demitri.constantinou@wits.ac.za

Ms Merling Phaswana
Telephone: 011 717 3231
Email: merling.phaswana@wits.ac.za

Thank you for reading this Study Information Sheet.

November 2021

Appendix L Participant consent sheet- focus group

WITS UNIVERSITY

PARTICIPANT CONSENT SHEET – FOCUS GROUP

Project Title*: *A randomised controlled trial of physical activity and health messages on anthropometric and cardiometabolic outcomes amongst South African university professional staff

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

David Khumalo, Principal Investigator, telephone no. 0780229565, or by e-mail at david.khumalo@gmail.com,

Philippe Gradidge, Supervisor, telephone no. 0117173372, or by e-mail at Philippe.gradidge@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr. Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: __________________________________
Date: __________________________________
Place: __________________________________
Signature or mark __________________________________

Witnessed by:

Name of Witness: __________________________________
Signature: __________________________________
Date: __________________________________

Appendix M Consent form for audio recording of study participation

Title of the research study: *A randomised controlled trial of physical activity and health messages on anthropometric and cardiometabolic outcomes amongst South African university professional staff*

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 N Focus group interview guide

Research title: *A randomised controlled trial of physical activity and health messages on anthropometric and cardiometabolic outcomes amongst South African university professional staff.*

General introduction

- What is the purpose of this study and the interviews?
- How long is the interview going to last?
- How will the data be used and how will it be kept safe?

Understanding workplace physical activity

- Do you think people are participating in enough physical activity in your workplace?
  - Why is this so?
- Do you think the management is doing enough to promote physical activity in the workplace?
- Do you think this type of intervention is appropriate to promote a healthy lifestyle in the workplace?

Understanding the intention in participation in the intervention

- What was the main reason for participating in this study?
- What would help motivate you to participate in physical activity program in the workplace?

Understanding barriers and facilitators in the intervention

- Did you find the physical activity intervention helpful?
- Did you find the health messaging intervention helpful?
- What changes did you see after the intervention?
- What did you like about the exercises or the health messages?
  - What factors led you to participate in the physical activity intervention?
- What did you not like about the physical activity intervention or the health messages?
  - What factors decreased your participation in the physical activity intervention?

Recommendations on the intervention

- What role should management play in promoting a healthy lifestyle in the workplace?
- What would make it more practical for workers to perform exercises at work?
- What would help workers perform exercises over the long term?
- What other comments can you make regarding this intervention?

Conclusion

Thank you for participating in the focus group discussion. Your opinions on the physical activity and health messaging intervention are very important.

Appendix O Focus group discussion HREC (medical) ethics clearance certificate

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

2021/11/18

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:** M190409
Protocol Title: *The effects of physical activity and health messages interventions on anthropometry and selected cardio- metabolic diseases in overweight and obese University professional staff*
Principal Investigator: See attached

Thank you for your letter of 2021/10/12.

I confirm that we have noted and approved of your proposal to assemble some of your study participants to hold a Focus Group Discussion.

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 P CONSORT Checklist

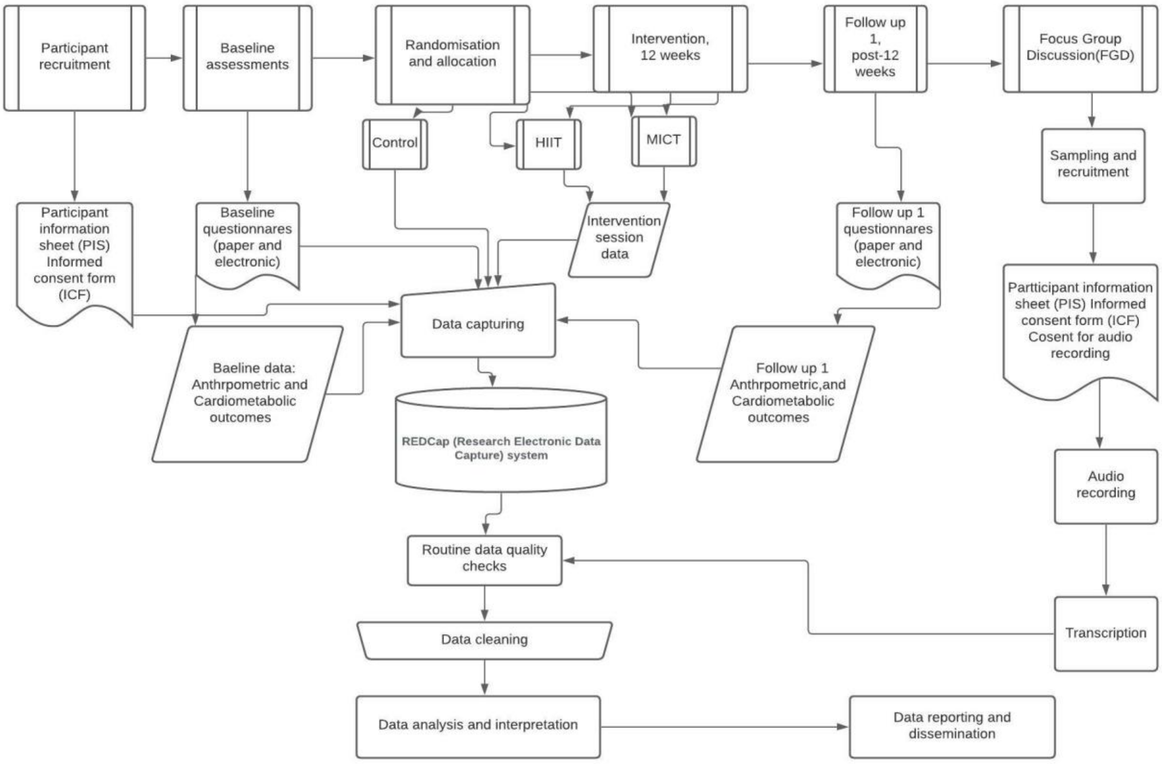
CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	i
	1b	Structured summary of trial design, methods, results, and conclusions	iv
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	1-4
	2b	Specific objectives or hypotheses	4
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	44-45
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	n/a
Participants	4a	Eligibility criteria for participants	46
	4b	Settings and locations where the data were collected	44
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	49-51
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	52-57
	6b	Any changes to trial outcomes after the trial commenced, with reasons	n/a
Sample size	7a	How sample size was determined	46
	7b	When applicable, explanation of any interim analyses and stopping guidelines	n/a
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	47

	8b	Type of randomisation; details of any restriction (such as blocking and block size)	47
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	47
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	47
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	n/a
	11b	If relevant, description of the similarity of interventions	n/a
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	58
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	80-87
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	74
	13b	For each group, losses and exclusions after randomisation, together with reasons	74
Recruitment	14a	Dates defining the periods of recruitment and follow-up	47
	14b	Why the trial ended or was stopped	n/a
Baseline data	15	A Table showing baseline demographic and clinical characteristics for each group	66-70
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	74
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	58

	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	78
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	80-87
Harms	19	All important harms or unintended effects in each group	58
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	114
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	116
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	116
Other information			
Registration	23	Registration number and name of trial registry	n/a
Protocol	24	Where the full trial protocol can be accessed, if available	n/a
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	

Appendix Q Data flow diagram



Appendix R Turnitin report

31 March Turnitin DV Khumalo.docx

ORIGINALITY REPORT

13%	9%	10%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.science.gov Internet Source	1%
2	&NA;, . "Abst D-FreeCommPosters :", Medicine & Science in Sports & Exercise, 2012. Publication	1%
3	C.E. Draper, E. Bosire, A. Prioreschi, L.J. Ware, E. Cohen, S.J. Lye, S.A. Norris. "Urban young women's preferences for intervention strategies to promote physical and mental health preconception: A Healthy Life Trajectories Initiative (HeLTI)", Preventive Medicine Reports, 2019 Publication	1%
4	journals.plos.org Internet Source	<1%
5	worldwidescience.org Internet Source	<1%
6	antoinedl.com Internet Source	<1%
7	www.ncbi.nlm.nih.gov	

Appendix S The effects of interventions on the weight, and hip circumference change adjusting for socio-demographic factors

Variables	Weight change		Hip circumference change	
	Adjusted coefficient	P-value	Adjusted coefficient	P-value
Study arm				
Control group	1(ref)		1(ref)	
HIIT group	-7.84(-9.7 to -5.9)	**<0.001**	-4.34(-6.59 to -2.08)	**<0.001**
MICT group	-6.56 (-8.53 to -4.59)	**<0.001**	-4.18(-6.58 to -1.78)	**0.001**
Age in years	-0.02(-0.13 to 0.09)	0.723	-0.005(-0.14 to 0.13)	0.931
Gender				
Male	1(ref)		1(ref)	
Female	-4.26(-6.15 to -2.36)	**<0.001**	-1.91(-4.22 to 0.39)	0.102
Education				
Reached secondary	1(ref)		1(ref)	
Completed matric	-0.69(-2.19 to 0.81)	0.352	-0.85(-2.67 to 0.98)	0.352
Tertiary	0.45(-1.47 to 2.37)	0.64	1.66(-0.69 to 4.01)	0.16
Have underlying conditions				
No	1(ref)		1(ref)	
Yes	-2.35(-4.05 to -0.65)	0.008	-1.3(-3.37 to 0.76)	0.209

Difference significant at p<0.05.

HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; Ref: Reference.

Appendix T The effects of interventions on the waist-to-hip ratio, and waist-to-height ratio adjusting for socio-demographic factors

Variable	Waist-to-hip ratio change		waist-height ratio change	
	Adjusted coefficient	P-value	Adjusted coefficient	P-value
Study arm				
Control	1(ref)		1(ref)	
HIIT group	-0.02(-0.04 to 0.002)	0.073	-0.04(-0.06 to -0.02)	**<0.001**
MICT group	-0.017(-0.041 to 0.01)	0.166	-0.03(-0.05 to -0.01)	**0.003**
Age in years	-0.001(-0.002 to 0.0001)	0.221	-0.006(-0.02 to 0.006)	0.319
Gender				
Male	1(ref)		1(ref)	
Female	0.01(-0.02 to 0.03)	0.59	-0.007(-0.03 to 0.012)	0.484
Education				
Reached secondary	1(ref)		1(ref)	
Completed matric	0.001(-0.02 to 0.02)	0.897	-0.004(-0.019 to 0.012)	0.644
Tertiary	-0.01(-0.033 to 0.013)	0.393	0.002(-0.02 to 0.02)	0.876
Have underlying conditions				
No	1(ref)		1(ref)	
Yes	-0.01(-0.03 to 0.014)	0.52	-0.012(-0.03 to 0.06)	0.175

Difference significant at $p<0.05$.

HIIT: High-intensity interval training; MICT: Moderate-intensity continuous training; Ref: Reference.

Appendix U Between-group comparison of body weight and anthropometric indices

Variable	HIIT group vs MICT group	p-value	HIIT group vs Control group	p-value	MICT group vs Control group	p-value
Weight (kg)	-1.504	0.083	-6.805	**0.000**	-5.302	**0.000**
HC (cm)	-0.443	0.670	-4.086	**0.000**	-3.642	**0.001**
WHR	-0.008	0.360	0.017	0.125	-0.009	0.420
WHtR	-0.008	0.250	-0.033	**0.001**	-0.025	**0.007**

Difference significant at $p<0.05$.

* Indicates statistical significance

HC: Hip circumference; WHtR: Waist-to-height ratio; WHR: Waist-to-hip ratio.

Appendix V Plagiarism declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I DAVID VUSUMUZI KHUMALO (Student number: 1510679) am a student

registered for the degree of MSc (Med) in the academic year 2022.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: Date: 22/09/22