

THE EFFECT OF A 12-WEEK EXERCISE TRAINING INTERVENTION ON PHYSICAL
BEHAVIOUR PATTERNS AND PERCEPTIONS OF BODY IMAGE IN BLACK SOUTH
AFRICAN WOMEN LIVING WITH OVERWEIGHT AND OBESITY

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of

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AUTHOR'S DECLARATION

I, **Lindokuhle Pellegreen Phiri**, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature

Date: 06 December 2024

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ABBREVIATIONS

ACSM	: American College of Sport Medicine
AIDS	: Acquired Immune Deficiency Syndrome
AU	: Arbitrary Units
β	: Beta-coefficient
BMI	: Body Mass Index
BPM	: Beats per minute
CI	: Confidence intervals
CVD	: Cardiovascular diseases
CFM	: Central fat mass
CRF	: Cardio-respiratory fitness
DBP	: Diastolic blood pressure
DXA	: Dual energy x-ray absorptiometry
EDTA	: Ethylenediamine tetraacetic acid
ENMO:	:Euclidean Norm Minus One
FG	: Fasting glucose
FID	: “Feel-ideal” discrepancy
FGD	: Focus group discussions
FFSTM	: Fat-free soft tissue mass
FM	: Fat mass
FRS	: Figure Rating Scale
GCP	: Good Clinical Practice

GPAQ	: Global Physical Activity Questionnaire
GSE	: Generalized self-efficacy
ICH	: International Conference on Harmonization
IDIs	: In-depth interviews
IHD	: Ischaemic heart disease
IPAQ	: International Physical Activity Questionnaire
Hb	: Haemoglobin
HbA1	: Glycated haemoglobin A1c
HDL-C	: High-density lipoprotein cholesterol
HFIAS	: Household food insecurity access scale
HIC	: High-income countries
HIIT	: High Intensity interval training
HIV	: Human immune deficiency virus
HOMA-IR	: Homeostatic model assessment of insulin resistance
HR	: Heart rate
HR _{max}	: Maximum heart rate
%HR _{max}	: Percentage of maximum heart rate
HRR	: Heart rate reserve
KZN	: KwaZulu-Natal
LDL-C	: low-density lipoprotein cholesterol
LIPA	: Light intensity physical activity
LMIC	: Lower-middle income country
MetS	: Metabolic syndrome

METs	: Metabolic equivalents
Mg	: Milligravitational
MHR	: Maximum heart rate
MICT	: Moderate intensity continuous training
Mod PA	: Moderate intensity physical activity
MVPA	: Moderate and vigorous intensity physical activity
NCDs	: Non-communicable diseases
NEPA	: Non-exercise physical activity
OGTT	: Oral glucose tolerance test
PA	: Physical activity
PAEE	: Physical activity energy expenditure
PI	: Physical Inactivity
SA	: South Africa
SADHS	: South African Demographic and Health Survey
SANHANES	: South African National Health and Nutrition Survey
SADoH	: South African National Department of Health
SAT	: Subcutaneous adipose tissue
SB	: Sedentary behaviour
SBP	: Systolic blood pressure
SCT	: Social cognitive theory
SD	: Standard deviations
SDT	: Self-determination theory
SES	: Socio-economic status

SET	: Self-efficacy theory
SST	: Serum separator tubes
SSISA	: Sport Science Institute of South Africa
T2DM	: Type 2 Diabetes Mellitus
TC	: Total cholesterol
TB	: Tuberculosis
TG	: Triglycerides
UK	: United Kingdom
USA	: United States of America
VAT	: Visceral adipose tissue
Vig PA	: Vigorous intensity physical activity
VO _{2max}	: Maximum oxygen consumption
VO _{2peak}	: Peak oxygen consumption
WC	: Waist circumference
WHO	: World health organization
WHR	: Waist-to-Hip Ratio

GLOSSARY OF TERMS

Body Image: A degree of satisfaction with physical appearance (size, shape and general appearance) (1), or how a person feels about his/her appearance (2).

Cardiorespiratory fitness: The ability of the body to transport and use oxygen during prolonged strenuous exercises and/or work (3). In addition, cardiorespiratory fitness reflects the integrated ability of the cardiopulmonary system to transport oxygen from the atmosphere to the mitochondria for the purpose of performing physical work (4).

Exercise: A subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate improvement and/or maintenance of physical fitness components, which are health related fitness and skill-related fitness (5).

Exercise self-efficacy: Beliefs in one's abilities to carry out the steps involved in performing exercise, such as scheduling regular exercise sessions, completing physical activities, and overcoming worries about exercise (6).

General self-efficacy: A universal construct that demonstrates the belief in one's competence to cope with a broad range of stressful and/or challenging demands, whereas specific self-efficacy is constrained to a particular task at hand (7).

Overweight and obesity: According to the World Health Organization (WHO), normal weight is classified as body mass index (BMI) between 18.5-24.9kg/m², while overweight is classified as BMI 25-29.9 kg/m² and obesity is defined as BMI \geq 30 kg/m². Obesity may be further categorised into class I (30-34.9 kg/m²); class II (35-39.9 kg/m²) and obese class III (\geq 40kg/m²) (8).

Physical inactivity: Failure to meet the World Health Organization's physical activity (PA) guidelines for adults comprising of 150-300 minutes (min) of moderate intensity aerobic PA or at least 75-150 min of vigorous intensity PA or an equal combination throughout the week (9).

Self-efficacy: Individuals' beliefs in their capabilities to demonstrate control over challenging demands and over their own functioning (7).

SCIENTIFIC OUTPUTS FROM THIS THESIS

Presentations at local conferences

L.P Phiri, A.E. Mendham, S.A Tomaz, J. Goedecke, L.K Micklesfield. The effect of a 12-week exercise intervention on body composition and sedentary behaviour in obese black South African women. International Society of Behavioural Nutrition and Physical Activity (ISBNPA), Cape Town, South Africa, June 2016 (Poster presentation).

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Publications in scientific journals

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ABSTRACT

Background: This thesis aimed to evaluate the effects of a 12-week combined (aerobic and resistance) exercise training intervention on: i) the changes in physical behaviours and ii) body image and self-efficacy. Lastly, iii) this thesis explored the perceptions and experiences of the women after participating in the 12-week combined exercise training intervention.

Methods: Forty-five young (18-35 years) apparently healthy Black SA women living with overweight and obesity were randomised into either an exercise (EXE; n=23) or a control group (CON; n=22). The EXE group participated in 12-week aerobic and resistance supervised exercise training (40-60 min/session, 4 days/week), while the control group maintain their usual physical behaviour patterns. Generalized self-efficacy (GSE) questionnaire and Stunkard's silhouettes were used to measure general self-efficacy and perceptions of body image. Participants wore ActiGraph and ActivPAL accelerometers simultaneously for 7 days to quantify physical activity (PA) and sedentary behaviour (SB) at baseline, week 4, 8 and 12, considering all days, exercise days and non-exercise days. Focus group discussions (FGDs) and in-depth interviews (IDIs) were conducted to investigate the participants' perceptions and experiences of the intervention.

Results: Thirty-five participants, EXE (n=20) and CON (n=15) completed the intervention. There was a group x time interaction for body weight and CRF, whereby weight decreased by ~1 kg ($p=0.007$) and cardiorespiratory fitness (CRF) increased by ~2.7 ml/kg/min ($p=0.001$) in the EXE group only. Considering only exercise days, moderate-to- vigorous physical activity and total physical activity (%) increased from baseline to weeks 4, 8 and 12 in the EXE group, but did not change in the CON group ($p<0.001$ for group x time interaction). Daily steps accumulated during the exercise days increased from baseline, (mean \pm standard deviation; 9429 \pm 4019 steps/day) to week 4 (15050 \pm 3167 steps/day; $p<0.001$), week 8 (14780 \pm 4224 steps/day; $p<0.001$) and week 12 (15695 \pm 3550 steps/day; $p<0.001$), but did not change in the CON group (10131 \pm 4561

steps/day). There was a significant decrease in SB (% of awake time) from baseline to week 12 ($58.9 \pm 9.4\%$ to $48.9 \pm 9.1\%$; $p < 0.001$ for group x time interaction) among the EXE group considering exercise days only.

Despite the average measured body mass index of $33.8 \pm 2.7 \text{ kg/m}^2$ for both groups at baseline, 31.4% of the women classified themselves as normal weight, 65.7% as overweight and only 2.9% as living with obesity. None of the women perceived themselves as living with obesity after the intervention. The Stunkard's silhouettes showed that women from both groups presented with body size discordance, such that at baseline, most participants desired a smaller body size and this did not change in response to the intervention. A significant decline in general self-efficacy was observed in both groups post intervention ($p = 0.021$, time effect), and this did not differ between groups ($p = 0.801$, for group x time interaction).

Qualitative findings showed that weight loss (anticipated and actual) and financial remuneration for travelling costs and time (nominal) were reported as motivators for enrolling and staying in the intervention. Improvement in psychological wellbeing (improved mood and self-esteem) and perceived level of self-efficacy were other reported benefits of the intervention. Lack of time, distance to the training venue and limited transport to the training venue were some of the barriers to attending the exercise sessions.

Conclusion: To the best of our knowledge, this is the first study in SA to show significant increases in TPA and MVPA, with compensatory reduction in SB in response to combined exercise training among women living with overweight and obesity. A clear indication that the overall changes in the physical behaviour patterns among the exercise group were largely due to the participation in the exercise sessions. Furthermore, the positive changes in physical behaviour patterns and CRF experienced by the exercise group have the potential to improve the cardiometabolic health of this population. In addition, findings from this thesis show promise of the positive impact of exercise

on improving psychological wellbeing. Lastly, majority of the women in the study desired to be smaller in body size, suggesting that these women may be receptive to health and weight-loss exercise interventions.

Chapter 1
Introduction

1. 1 INTRODUCTION

South Africa (SA) is reported to have the highest overweight and obesity prevalence in Sub-Saharan Africa (SSA) (10). This prevalence is reflected in the latest South African Demographic and Health Survey (SADHS) reporting that 68% of women and 31% of men were living with overweight and obesity based on body mass index cut-points (BMI) (11). Notably, as many as 40.9% of Black SA women were living with obesity (11). This is despite the fact that majority of Black SA women meet the World Health Organization (WHO) recommended physical activity (PA) guidelines of 150 minutes per week (min/wk) of moderate intensity PA and are classified as physically active (12-16). However, a large percentage of the PA accumulated by this population is through walking for transport (12, 14), which is undertaken at a low-to-moderate intensity. Research has also shown that less than a half of Black SA women participate in leisure time PA, which is usually performed at higher intensities PA (13).

Leisure time PA, which may be achieved through structured exercise interventions, increases moderate-to-vigorous intensity physical activity (MVPA) (17) and has also been associated with reduced sedentary behaviour (SB) (18), and improvements in body composition (19), cardiorespiratory fitness (CRF) (20, 21), perceptions of body image (22-24) and self-efficacy (6, 24) in women living with overweight and obesity. However, there is limited research from SSA and low-resourced settings on this topic. Additionally, there is paucity of research reporting on the barriers and facilitators that influence participation in a structured exercise programs among women living with overweight and obesity from low-resourced settings.

Therefore, the overall aim of this thesis was to evaluate the effects of a 12-week combined (aerobic and resistance) exercise training intervention on: i) the changes in physical behaviours and ii) body image and self-efficacy in a sample of young Black SA women living with overweight and obesity

from a low socio-economic setting. Lastly, iii) this thesis also explored the perceptions and experiences of these women after participating in the 12-week combined exercise training intervention. To the best of our knowledge, this is one of the first studies conducted among Black SA women investigating the effect of a 12-week combined (aerobic and resistance) exercise intervention on objectively measured physical behaviours. In addition, this is the first study to explore the women's perceptions and experiences of the exercise intervention and its effects on perceived body image and self-efficacy.

This thesis comprises 7 chapters, with the first chapter being the introduction chapter, providing an overview of the entire thesis. The second chapter of this thesis is a literature review discussing the literature pertaining to the thesis topic with a particular focus on Black SA women as this is an under-studied population who present with a high and increasing prevalence of overweight and obesity. The literature review firstly describes the prevalence of overweight and obesity among Black African women and then highlights the contributing socio-demographic and lifestyle factors among this population. The review also summarises the various tools used to measure physical behaviours, associations between overweight, obesity and physical behaviours and the effects of exercise training on body composition and CRF. Within the review, I also highlight the gaps in literature relating to the effects of exercise training interventions on physical behaviours, perceptions of body image and self-efficacy among women living with overweight and obesity from a low-resourced setting. Chapter 3 of this thesis outlines the ethical considerations, participant recruitment processes, methods and measurement tools used to collect the data presented in this thesis. The research chapters included in this thesis, including their aims, objectives and hypothesis are outlined below.

Chapter 4

Aim: To investigate changes in PA and SB patterns in response to the 12-week aerobic and resistance exercise intervention among women living with overweight and obesity from a low-

resourced setting. The secondary aim was to determine the associations between changes in PA and SB patterns with exercise dose and changes in CRF and weight.

Objectives: To examine the differences in PA and SB between the exercise and control group at baseline (week 0), week 4, 8 and 12.

Hypothesis: We hypothesize that exercise training will increase total physical activity (TPA), particularly MVPA, which may result in less time spent in SB among the exercise intervention group compared to the control group.

Chapter 5

Aim: To determine the effects of a 12-week combined (aerobic and resistance) exercise training on perceived body image and generalized self-efficacy in young Black SA women living with overweight and obesity from low-socio-economic settings.

Objectives: To examine the differences in perceived body image and generalized self-efficacy between the exercise and control group pre and post the 12-week intervention.

Hypothesis: We hypothesize that the 12-week combined exercise intervention will result in improved perceived body image and generalized self-efficacy in the exercise group when compared to the control group.

Chapter 6

Aim: To explore the perceptions and experiences following a 12-week structured exercise intervention in a group of young Black SA women living with overweight and obesity from a low socio-economic setting.

Objectives: To investigate the barriers and facilitators that influenced participation and adherence to the exercise intervention.

Hypothesis: We hypothesized that the participants would have encountered a positive experience from the 12-week exercise intervention.

The final chapter of this thesis (chapter 7) synthesises and discusses the main and significant findings from the three chapters, integrating these findings with the available literature. This chapter also discusses the strengths and limitations of the research conducted and recommendations for potential future research. All the scientific sources cited in this thesis are listed under the references list and all documents used either for ethics approval and data collection are included as appendices.

CHAPTER 2

Literature review

Research articles for this narrative review and the various chapters included in this thesis were identified by means of a computerised search in the health sciences online library databases including MEDLINE (Ovid), PubMed, EBSCOHOST and GOOGLE SCHOLAR. Various combinations of the following key words ‘Prevalence of overweight and obesity in adults’; ‘Contributing risk factors to overweight and obesity’; ‘Tools to measure and quantify PA and sedentary behaviour’; ‘Habitual PA in adults’, ‘Sedentary behaviour in adults’; ‘Changes in PA OR SB in adults’; ‘Lifestyle interventions among adults’; ‘Body image in adults’, ‘Self-efficacy in adults’; ‘Perceptions OR experiences of a lifestyle intervention’.

2.1. PREVALANCE OF OVERWEIGHT AND OBESITY

Overweight and obesity are a growing health concern globally and are reported to be associated with numerous chronic diseases, such as type diabetes mellitus (T2DM), cardiovascular diseases (CVD) (25), insulin resistance (26) and metabolic syndrome (MetS) in adults. According to the World Health Organization, in 2016, more than 1.9 billion adults were living with overweight or obesity with a BMI ≥ 25 kilograms per square meter (kg/m^2) (10). Global projections by the recent World Obesity Atlas indicate that 1 in 5 women and 1 in 7 men will be living with obesity by 2030 (27). Furthermore, the World Obesity Atlas indicates that the greatest number of people with obesity live in low-and middle-income countries (LMICs) (27). Notably, within the African region, 1 in 5 women (20.4%) and 1 in 13 men (7.8%) are predicted to be living with obesity ($\geq 30\text{kg}/\text{m}^2$) by 2030 (27). This is of relevance as ~23% of daily preventable non-communicable diseases (NCDs) and 22% of deaths are attributed to high BMI in the African region (27). South Africa is reported to have the highest overweight and obesity prevalence in SSA (10). Additionally, it is predicted that by 2030, SA will have a 50% increase in obesity, which is expected to be the highest in SSA (27).

Previous research by Bradshaw and colleagues show that there is an increasing prevalence of overweight and obesity among SA adults 20 years and older between the year 2000 and 2012, with BMI increasing from 27.2 kg/m² in 2000 to 29.4kg/m² in 2012 among women (28). Similar findings were reported from a study that analysed three SA national cross-sectional surveys, where the prevalence of obesity was reported to have increased from 23.5% in 2008 to 27.2% in 2012 (p<0.001) among women (29). Comparatively, the prevalence of obesity in men increased from 11.1% in 2008 to 13% in 2012 (29). The 2016 SADHS reported an alarming prevalence of 68% overweight and obesity among women compared to the 31% prevalence of overweight and obesity among men (11). Furthermore, findings from the 2016 SADHS showed that compared to other ethnicities, Black SA women presented with the third highest prevalence of overweight (26.5%) and obesity (40.9%) (11) (figure 1)

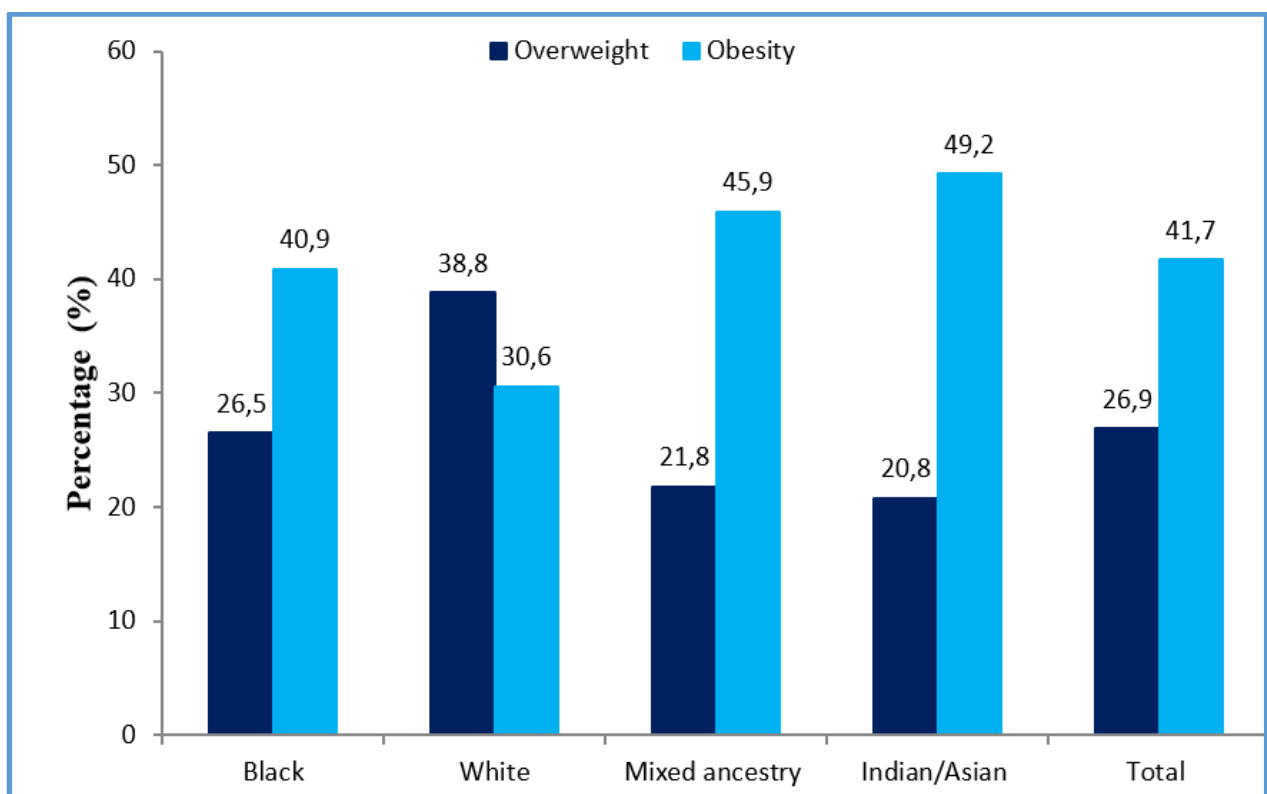


Figure 1: Prevalence (%) of overweight and obesity in SA adult women (SADHS 2016)

Several cross-sectional studies have also reported on the high prevalence of overweight and obesity among young Black SA adults (16), premenopausal SA women (30, 31) and middle-aged women (± 41 years) (14, 32, 33). Prioreshi and colleagues reported a prevalence of 26% overweight and 9% obesity among young SA adults (19-20 years) from the Birth to Twenty (Bt20) cohort study (16). Similar findings were reported from the caregivers of the Bt20 cohort study, where (50.1%) of participants were classified as living with obesity (30). Findings from the above-mentioned cross-sectional studies evidently demonstrate a high prevalence of overweight and obesity among Black SA women. Thus, it is imperative to understand the causes of the high prevalence of obesity in this population and to implement effective preventative measures such as modification to lifestyle behaviours (promoting and increasing PA).

2.2 SOCIO-DEMOGRAPHIC AND LIFESTYLE FACTORS THAT CONTRIBUTE TO THE PREVALENCE OF OVERWEIGHT AND OBESITY

Various sociodemographic and lifestyle factors have been associated with the high and increasing prevalence of overweight and obesity among Black SA women. These contributing factors include but are not limited to, socioeconomic status (SES) (31, 34-38), PA (12, 14, 35, 39, 40), SB (14, 41), and perceptions of body image (42-49). Socioeconomic status is defined as a combined economic and sociological measure of a person's position within a social hierarchical structure, based on income, education, and occupation (50). According to Berkam and colleagues (51), there is a “gradient” in health across the SES hierarchy, such that the lower an individual’s position in the occupational hierarchy of a workplace and level of education, the worse their health status. Hence some authors suggest that overweight and obesity should be considered as a socially-generated disease and an indicator of socioeconomic disadvantage (52). Low SES is not only a phenomenon experienced in low-income countries (LICs) and LMICs, but it is also experienced in high-income countries (HICs) such as the United States of America (USA) (53). Findings from the Black

Women's health Study in the USA monitoring weight change among 48 359 women aged between 21-69 years reported that lower neighborhood SES was significantly associated with 10-year weight gain after adjustment for individual SES and behavioral variables, such as caloric intake and PA (53).

Insufficient PA has consistently been reported as one of the major contributing factors of overweight and obesity (54, 55). Cultural norms and fewer opportunities to access safe, affordable and appropriate opportunities to be active are cited as some of the contributing factors to insufficient PA amongst populations from a low-resourced setting (56). Women living with obesity from a low-resourced setting perceive increased crime rates in their neighbourhood as the reason for not engaging in physical exercise or play during the day (57, 58). Malambo and colleagues found that fear of walking for leisure due to high levels of crime was one of the contributing factors to living with overweight/obesity (OR = 2.41; 1.09–5.29) among adults residing in a low-resourced suburb in Cape Town, SA (57). Similar findings were reported by Zhifei and colleagues, where perceived unsafety during the day was associated with lower odds of physical exercise in both men (OR=0.776, $p < 0.001$) and women (OR=0.874, $p < 0.001$) residing in the Gauteng province of SA (58). The negative influence of unsafe neighbourhood in low-resourced settings in SA suggest that safe exercise environments need to be considered for this population. This could possibly result in changes in physical behaviours such as increases in leisure time PA and reductions in SB and decreased prevalence of living with overweight and obesity among this population.

Dietary intake (59-61) and food security (62, 63) are also some of the most important contributing factors to the increased prevalence of overweight obesity in low-resourced communities. Food security is described as a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (64). While food insecurity is understood to mean

“insufficient access to food” or hunger (65). Food insecurity has been reported to be associated with diet quality even in HICs such as France, and includes the consumption of high dense energy food that are affordable but provide little nutritional value (66).

Recent findings from an SA study comprising of young (18-25 years) women from a low socioeconomic setting reported that only half of the women were consuming healthy foods such as fruit, vegetables and fish at least once per week (67). In addition, findings from the above-mentioned study reported an association between food insecurity and low diet quality and diversity, but showed no association with body size (67). Similarly, recent findings by Ware and colleagues found that young Black SA women from a historically disadvantaged township were frequently exposed to household food insecurity (62). The cost of a healthy diet in SA is 69% more expensive than an unhealthy diet (68), therefore, making a healthy diet unaffordable for most South Africans.

Findings from a review on socio-cultural, environmental and behavioural determinants of health in Black SA women reported that the most convenient place to purchase food is from informal vendors who sell inexpensive and less varied foods of poor quality (59). These findings are echoed by Nedzingahe and colleagues in a recent cross-sectional study aimed at understanding food environments, food choices, food security and nutrition transition among a population from a low socioeconomic setting in Limpopo, SA (69). Dietary intake and quality of diet are associated with overweight and obesity in adults (70, 71), including women and young adults from a low socioeconomic setting in SA (72, 73). However, the association between the dietary intake and/or quality of diet and obesity is beyond the scope of this thesis.

2.3 PHYSICAL BEHAVIORS

Physical behaviours, collectively described as PA and SB (74), are modifiable lifestyle behaviours (12, 14, 35, 39, 40). Physical activity is defined as meeting the World Health Organization's PA guidelines for adults comprising of 150-300 minutes (min) of moderate intensity aerobic PA or at least 75-150 min of vigorous intensity aerobic PA or an equal combination throughout the week (9). Physical activity also encompasses of exercise, sports, and physical activities executed as part of daily living, occupation, leisure and active transportation (75). While SB is defined as activities that do not increase energy expenditure substantially above the resting level and includes behaviours such as sitting and laying down (76). Physical activity can be classified into various intensities including light, moderate and vigorous. Metabolic equivalents (METs) are a measure of energy cost equal to an oxygen consumption of 3.5 millilitres per kilogram per minute ($\text{mL.kg}^{-1}.\text{min}^{-1}$) resting energy expenditure during lying in adults (3, 77). In addition, METs in minutes per week (min/wk) can also be classified as low, moderate or high (78) and is used as reference thresholds to define light, moderate and vigorous intensities (79). With light intensity physical activity (LIPA) equivalent to 2-3 METs and moderate intensity PA (Mod PA) equivalent to 3-6 METs, vigorous intensity PA (Vig PA) ≥ 6 METs (79) and (MVPA) ≥ 3 METs (80), while SB is ≤ 2 METs (76). Light intensity physical activity is defined as the intensity range between SB and moderate intensity, comprising of activities with 1.5–2.9 METs (81). Moderate-to-vigorous intensity physical activity is a combination of Mod PA and Vig PA (9, 79) and is often expressed as METs (82). The MVPA METs cut-points vary, with the updated recommendations for adults from American College of Sports Medicine (ACSM) and American Heart Association indicating ≥ 3 METs for MVPA for all ages (79).

According to the latest 2020 WHO PA guidelines, all healthy adults (18-65 years) should accumulate between 150–300 min of moderate-intensity aerobic PA or at least 75–150 min of vigorous-intensity aerobic PA; or an equivalent combination of MVPA throughout the week (9).

Additionally the WHO guidelines recommend limiting the amount of time spent in SB and replacing sedentary time with PA to help reduce the detrimental effects of high levels of SB (9). Unfortunately, there is still insufficient evidence to set time-based guidelines on SB (83). This is despite calls as far back as 2008 to introduce public health guidelines on prolonged sitting (84). High-income countries such as Australia (85), Germany (86), New Zealand (87) and Canada (88) have included SB guidelines in their national public health PA guidelines for children, youth (88) and adults (86, 87). However, there are no current guidelines relevant to the African continent.

2.3.1 Measurement tools and methods used to quantify physical behaviours

Various methods and equipment are used to measure and quantify physical behaviours, these include commonly used subjective tools (questionnaires) such as the International Physical Activity Questionnaire (IPAQ) (89) and the Global Physical Activity Questionnaire GPAQ (78, 90). Both the IPAQ and the GPAQ have been validated in the SA population (91). The GPAQ has shown to overestimate PA levels in adults (24-64 years) (92) and is reported to be a less valid measure of changes in PA patterns and SB in comparison to the ActiGraph (90) and ActivPAL (93) accelerometers. The use of a questionnaire for self-reporting PA and SB is also susceptible to recall bias (94), and false reporting due to cultural norms and perceived social desirability (95).

The ActiGraph and ActivPAL accelerometers are the most commonly used objective measures of PA and SB (96), respectively. It is recommended that at least 7 days of monitoring be obtained for reliable estimates of habitual time spent 'inactive' by adults (97). However, 3-5 days of accelerometer monitoring is sufficient to estimate habitual PA in adult populations at a reliability level of 0.80 (98). The ActivPAL is reported to be accurate in detecting and quantifying sitting, standing, and stepping time (99). While the ActiGraph provides acceleration in three individual orthogonal planes; vertical (VT) anterior-posterior (AP), and medio-lateral (ML) and provides activity counts as a composite vector magnitude of these three axes, tri-axial vector magnitude

(VM3) (100). Furthermore, the ActiGraph accelerometer provides an objective estimate of multiple PA intensities, which include LIPA, Mod PA, Vig PA and MVPA (101-103). The amount of PA measured by the accelerometer is presented in counts per minutes (cpm) that is calculated from the raw data (102). The major advantages of using objective measures of physical behaviours as opposed to subjective measurement tools is the high reliability and validity (95). Furthermore, both the ActiGraph and ActivPAL accelerometers have been widely used in research to investigate the association between physical behaviour patterns, overweight and obesity among adults in both HICs (104, 105) and LMICs (39, 103, 106, 107). Physical behaviour patterns derived from both accelerometers can provide researchers with the appropriate PA intensity and SB recommendations for curbing the rise in the prevalence of overweight and obesity.

It is important to note that the utilisation of objective tools such as the accelerometers do not come without limitations which include the high expense and increased burden on the participant from wearing the devices (95, 108). Furthermore, the various accelerometers present with some limitations. The limitation of the ActiGraph is the inability to detect body postures, thus cannot distinguish between sitting and standing (109) and inaccuracies may occur from estimating sedentary time from ActiGraph due to the misclassification of standing activity as sitting (110). Additionally, the ActiGraph is reported to underestimate sitting time by 4.9% when compared to the ActivPAL, which underestimates sitting time by only 2.9% (111). In addition, the ActivPAL accelerometer is said to be more accurate than the waist- and wrist-worn ActiGraph accelerometers for determining both sitting and standing activities (99). Therefore, the ActivPAL is considered a more reliable measure of SB, while the ActiGraph is considered a more reliable measure of PA intensity. Thus, wearing ActiGraph and ActivPAL accelerometers simultaneously is advantageous as it helps overcome each other's limitations and improves the accuracy and reliability of PA and SB data. Recommendations from literature suggest that sleeping time be excluded from calculations of sedentary time when recording SB (112). However, other researchers conclude that

the removal of sleep time from SB reporting possibly influences the results, thus consequently increasing uncertainties and reducing robustness of the data (113). Nonetheless, recording of sleep while assessing SB in adults using the thigh-worn ActivPAL4™ monitor has been used in previous research (114).

Various ActiGraph cut points have been proposed and used to distinguish between SB, LIPA, Mod PA, Vig PA and MVPA in adults. Table 1 below provides a selected summary of the various ActiGraph physical behaviour cut points that have been documented in scientific literature. Majority of the studies classify ActiGraph-derived SB as <100 cpm (16, 39, 80, 115-118) for adults. However, there is less consensus regarding the ActiGraph derived LIPA for adults, with some studies classifying LIPA as 100-1951 cpm (39, 116, 117), while others classified it as 100-760 cpm (118) and other as 100-2019 cpm (16). Similarly, various ActiGraph-derived cut points are reported for Mod PA for adults, with some studies classifying Mod PA as 1952-5724 cpm (80, 117, 118), while others classified it as 2020 cpm (102), 2020-2998 (16) and 2690–6166 cpm for those using a vector magnitude of three axes (100). Additionally, Vig PA is commonly classified as >5725 cpm in some studies (80, 117, 118) and 5999 cpm in others (16, 119). It is important to note that findings from a research study aimed at developing ActiGraph accelerometer tri-axial vector magnitude cut points to classify PA intensity have not classified Vig PA, but have classed this category as hard PA intensity with 6167–9642 cpm and very hard PA intensity with >9642 cpm (100). Only one study indicated ActiGraph-derived cut points for MVPA of ≥ 1952 (116). The normal trend observed in literature is the combination of moderate and vigorous intensity to derive MVPA (102).

In SA, various physical behaviour ActiGraph derived cut points have been used among adults, with most researchers classifying SB as <100 cpm (16, 39, 118) and varying cut points for LIPA ranging from 100-1951 cpm (39), 100-2019 cpm (16) and 100-760 cpm (118). Similarly, varying cut points

have been used among SA adults for moderate and vigorous intensity (16, 118). With some researchers further dividing moderate intensity to either level 1 (760-1951cpm) or level 2 (1952-5724 cpm) (118). On the other hand, another SA study among adults used a MVPA cut point of 1952–5724 cpm (39). Even though there appears to be no consensus in the MVPA cut points, these cut points are helpful in categorising PA intensity accordingly during the initialisation of the accelerometers prior to data collection and also during the data analyses. Nonetheless, there appears to be a consensus in the SB cut points being below <100cpm. However, there is an argument that cut point based analyses only makes use of limited wealth of data derived from accelerometers (109). Recent PA research reports from SA have summarised physical behaviour using the raw data from hip worn ActiGraph and thigh worn ActivPal into a combined total movement volume (ENMO), expressed in milli gravitational (107, 120, 121).

In addition, some international studies included in table 1 show that some researchers investigated the relationship between accelerometer counts and measured oxygen consumption to develop VM3 cut-points for moderate, hard and very hard intensity PA in adults (100, 122). Tri-axial vector magnitude cut-points for PA intensity classification by Sasaki and colleagues from a study conducted among young adults (± 26.9 years) was 2690-6166 cpm for Mod PA, 6167-9642 cpm for hard intensity PA and ≥ 9642 for very hard intensity PA (100). The above-mentioned study also determined the VM3 cut-points by imputing METs values for the various intensities, with 3-5.99 METs for moderate, 6-8.99 METs for hard and ≥ 9 METs for very hard (100). While another study aimed at determining VM3 cut-points in a similar age group derived different cut-points for the various intensities with 0-4572 cpm for LIPA, 4573-6786 cpm for Mod PA and ≥ 6787 cpm for Vig PA (122).

Table 1: Summary of ActivPAL and ActiGraph accelerometer cut-points for physical behaviours in adults from various research settings

Aim of the study	Population	Study design	Equipment	Testing protocol	Vector magnitude	Epochs/ Sampling frequency	Cut-points	Results	References
To assess the levels and pattern of physical activity and inactivity in an adult population	- Country: Sweden -N=1114 adults (56% women), Age: 45 ± 15 yrs	Cross-sectional study	-ActiGraph MTI Model 7164 (Manufacturing Technology Inc., Fort Walton Beach, FL)	-Free living Environment	-Uniaxial Accelerometer Measures & records vertical acceleration	-60 sec	-SB: <100cpm -Mod PA:1952-5724 -Vig PA:>5724 -Cut-off points were from the Freedson 1998	-Average intensity, MVPA was lower with higher age or BMI -Objectively obtained estimates of PA yielded lower values than self-reports.	Hagstromer M, et al., [2007]; (80)
To describe the amount of time spent in overall SB in the United States, by gender, age, and racial/ethnic group	Country: USA -N=6329 -Age: ≥6yrs	Longitudinal study (2003-2004)	-ActiGraph accelerometer	-Free living Environment	-----	-60 sec	-SB: <100 cpm	-The most sedentary (7.7 hrs /day) groups were older adolescents and adults aged ≥60 yrs.	Matthews C.E, at al., [2008]; (115)
To explore the relationships between accelerometer counts and measured oxygen consumption across a heterogeneous group of adults across a wide range of ages	- Country: not disclosed - N=90 -Age: 29yrs(N=30) 49yrs(N=30) 69yrs(N=30)	Experimental	-7164 cpm ActiGraph	-Exercise treadmill	-Uniaxial accelerometer	-60 sec	-LIPA: 0-4572 cpm - Mod PA: 4,573-6786 cpm - Vig PA: ≥ 6787 cpm	- Strong relationship (r=0.90; p<0.001) between accelerometer counts and measured VO ₂ values during walking and running across all age groups. - No differences in counts per minute across age groups across speed.	Miller N.E, et al., [2010]; (122)

<p>To compare activity counts from the ActiGraph GT3X to those from the ActiGraph GT1M during treadmill walking/running.</p> <p>To develop tri-axial vector magnitude (VM3) cut-points to classify PA intensity.</p>	<p>-Country: USA -N= 50 adults (N=28 men; N=22 women) -Age $\pm 26.9 \pm 7.7$ yrs</p>	<p>Experimental</p>	<p>-ActiGraph GT3X</p>	<p>-Exercised at 4 treadmill speeds (4.8, 6.4, 9.7, and 12kmh⁻¹). GT3X was initialized to collect data in the VT, AP& ML planes GT1M initialized to collect data in VT & AP planes</p>	<p>-----</p>	<p>- 1 sec</p>	<p>-VM3 cut-points -Mod PA: 2690–6166 cpm(4.8km/h) -Hard PA:6167–9642 cpm (6.4km/h) -V. hard PA: >9642 cpm (9.7km/h)</p>	<p>-Oxygen consumption data was conducted to develop VM3 cut-points for moderate, hard and very hard PA. -AP and VM2 activity counts from the GT1M were significantly higher (p<0.01) than those from the GT3X at 4.8, 9.7 and 12kmh⁻¹. -VM3 cut-points may be used to classify PA in future studies.</p>	<p>Sasaki J, et al., [2011]; (100)</p>
<p>To investigate the independent associations of physical activity, cardiorespiratory fitness, and sedentary time on body composition and cardiometabolic risk factors for CVD and T2D in Black South African women.</p>	<p>-Country: SA - N = 76 -Age: 18–45 yrs) - Black women</p>	<p>Cross-sectional study</p>	<p>- ActiGraph MTI 7164</p>	<p>-Free Living environment</p>	<p>-----</p>	<p>-60 sec</p>	<p>- SB:<100 cpm - LIPA: 100-1951 cpm -MVPA:1952–5724 cpm Vig PA: 5725–9498 cpm Very vig PA: ≥ 9499cpm</p>	<p>- LIPA- but not MVPA was inversely associated with trunk FM (r=-0.25, P= 0.03). - SB was associated with TG (r= 0.36, P= 0.01) and TG/ HDL-C (r= 0.34, P= 0.04), independent of body fat. - Cardiorespiratory fitness was inversely associated with body fat % (r=-0.34, P= 0.02), central FM (r=-0.31, P= 0.03), VAT (VAT, r=-0.47, P< 0.01), and (HOMA-IR; r=-0.41, P= 0.01).</p>	<p>DickieK, et al., [2015] (39)</p>

To examine the associations of four mutually exclusive categories of objectively measured physical activity and sedentary time on markers of cardiometabolic health	<ul style="list-style-type: none"> - Country: UK -2008 Health Survey for England dataset -N=2132 -Age: ≥ 81 yrs 	Cross-sectional study	-ActiGraph GT1M	-Free Living environment	-----	-60 sec	<ul style="list-style-type: none"> -SB: <100 cpm -LIPA: 100–1951 cpm -MVPA: ≥ 1952cpm -MVPA time in ≥10 min bouts, allowing for a 2 min exception in the intensity threshold 	<ul style="list-style-type: none"> - Busy Bees: Physically active (>150min/wk) & ↓ ST 51.13±1.46 min/d of MVPA; 417.2 ±3.62 min/d of SB; 394.9±3.16 min/d of LIPA. - Sedentary exercisers: Physical active (>150 MVPA) & ↑ ST 44±0.80 min/d of MVPA; 564.5 ±2.68 min/d of SB; 260.5 ±1.88 min/d of LIPA. - Light movers: Physically inactive (<150min/wk) & ↓ ST 13.2±0.39 min/d of MVPA; 435.5±3.84min/d of SB; 396.2 ±4.35 min/d of LIPA. - Couch potatoes: Physically inactive (<150min/wk) & ↑ ST 9.7±0.22 min/d of MVPA; 595.7 ±2.39 min/d of SB; 245.9±2.47 min/d of LIPA. - In comparison to Couch Potatoes, Busy Bees, Sedentary Exercisers & Light Movers had more favourable health markers. 	Bakrania A, et al., [2016]; (116)
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<p>To describe fitness, and objectively measured physical activity levels and patterns in young Black SA adults from Soweto To examine associations between physical activity, fitness and BMI.</p>	<p>-Country: SA - N= 256 -Age: 19-20yrs - N=137 men -N = 119 women</p>	<p>Observational study</p>	<p>-ActiGraph GT1M</p>	<p>-Free Living environment</p>	<p>-----</p>	<p>-60 sec</p>	<p>-SB < 100 cpm -LIPA 100-2019 cpm -Mod PA: 2020-5998 cpm, equivalent to 3 METs - Vig PA: ≥ 5999 cpm,</p>	<p>- Men had a higher VO_{2max} vs. women (41.9(41, 43) vs (32.6 (32, 33)) $mlO_2/kg/min$; $p < 0.001$). -Men spent more time in MVPA vs. women (83(80, 94) vs 43(38, 45) min/day, $p < 0.001$. - Men spent less time in SB vs. women (541(541, 567) vs 575(568, 597) min/day, $p < 0.01$.</p>	<p>Prioreschi A. et al., [2017]; (16)</p>
<p>To develop a method of combining hip and thigh accelerometry signals to quantify and describe physical behaviors in middle-age South African men and women.</p>	<p>-Country: SA - N= 357 women - N= 437 men - Age: 53.7±(6.3) yrs</p>	<p>Cross sectional study</p>	<p>- ActiGraph GT3X+ - ActivPAL</p>	<p>-Free Living environment</p>	<p>- Triaxial accelerometer</p>	<p>- 80 and 20 Hz - Dynamic range of ±6 g and ±2g for the hip and thigh worn accelerometer - Record raw triaxial acceleration</p>	<p>- Standing: thigh pitch < = 70° - Sitting/lying: thigh pitch: >70° - LIPA: $ENMO_{hip} < 70mg$ - LIPA: $ENMO_{thigh} < 105mg$ - MVPA: $ENMO_{hip} \geq 70mg$ - MVPA: $ENMO_{thigh} \geq 105mg$</p>	<p>- Movement volume was 15.0 ±6.5 mg for men and 12.2± 3.4 mg for women - Men spent more time in MVPA and sitting/lying - Women spent more time standing. - Men living with overweight or obese spent less time in MVPA compared to those who were normal weight. - Women living with overweight or obese spent less time in LIPA and more time sitting/lying compared</p>	<p>Micklesfield L, et al., [2022] (120)</p>

								to those who were normal weight.	
To investigate free-living, accelerometry derived step cadence and walking among Rural South African women	-Country: SA -N = 122 under-normal weight - N= 141 overweight-obese	Cross sectional study	- ActiGraph	-Free Living environment	-Uni-axial accelerometers	-----	-SB: 0-99 counts/min -LIPA: 100-760 counts/min moderate activity Mod intensity 1: 760-1951 counts/min - Mod intensity 2: 1952-5724 counts/min - Vig intensity: ≥ 5725 counts/min)	- Average step volume was 13.568 steps/day. - $\approx 45\%$ of daily steps was accumulated in the low-to-moderate intensity range (760–1951 counts/min). - 75% of steps were accumulated in bouts > 15 min. - > 85% of participants were classified as active-to-highly active.	Cook I, et al., [2022] (118)
Explored the associations between physical behaviours and total and regional adiposity Examined how reallocating time in different physical behaviours was associated with total	-Country: SA -N=308 women N= 384 men Age:41-72yrs	Cross sectional study	- ActiGraph GT3X+ (hip worn) - ActivPAL (mid-thigh)	-Free Living environment	- Triaxial accelerometer	- 80 and 20 Hz - Dynamic range of ± 6 g and ± 2 g for the hip and thigh worn	- Standing: thigh pitch $< = 70^\circ$ - Sitting/lying: thigh pitch: $> 70^\circ$ - LIPA: $ENMO_{hip} < 70mg$	-Reallocating 30 min of sitting/lying to 30 min of MVPA was associated with 1.0% lower FM in men. - Reallocation of 30 min of sitting/lying to MVPA and 30 min of standing to MVPA were associated with a	Mendham A, et al., [2022] (107)

body fatness in men and women from a low-income setting						accelerometer - Record raw triaxial acceleration	- LIPA: ENMO _{thigh} <105mg - MVPA: ENMO _{hip} >= 70mg - MVPA: ENMO _{thigh} >= 105mg	0.3% and 1.4% lower FM in women	
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Abbreviations and signs : Sample size (N); Hertz (Hz); Interclass correlation (ICC); Hertz (Hz); Body Mass Index (BMI); High-density lipoprotein cholesterol (HDL-C); Triglyceride (TG); Correlation (r); Years (yrs); Physical activity (PA); Waist circumference (WC); Visceral adipose tissue (VAT), Fat mass (FM); Anterior Posterior axes (AP); Euclidean Norm Minus One (ENMO); gravitational (g); Hours (hrs) Vector Magnitude of two axis (VM2); Vector Magnitude of three axis (VM3); Counts per minute (cpm); Vertical plane (VT); Maximal oxygen uptake (VO_{2max}); Millilitres of oxygen per kilogram in one minute (mlO₂/kg/min); Sedentary Behaviour (SB); Physical activity (PA); Light intensity physical activity (LIPA); Moderate intensity physical activity (Mod PA); Moderate-to-vigorous intensity physical activity; (MVPA); Milligravitational (mg); Vigorous intensity physical activity (Vig PA), United States of America (USA); United Kingdom (UK); South Africa (SA); Decrease (↓); Increase (↑); Less than (<); Greater than (>)

2.3.2 Physical behaviour patterns of adults

Globally, it is reported that more women than men (32% vs. 23%, respectively) are not meeting the PA recommendations (123). According to the 2018 technical package for increasing PA prepared by the WHO, 26% of the populations from MICs were not meeting the PA recommendations in 2016 (123). In the African region, 17.3% of men and 24.4% of women are not meeting the PA recommendations (124). Within SA, a higher percentage of women (51.6%) than men (42.2%) are reported to not be meeting the PA recommendations (124).

Research studies in both young and middle-aged Black SA women from low-resourced settings showed that the majority of women were meeting the PA guidelines according to the GPAQ (12-15, 125). Results from a longitudinal study (follow up after 5.5 years) by Dickie and colleagues including 240 apparently healthy Black SA women (26 ± 7 years) reported that 61% of women were classified as meeting the MVPA guidelines according to GPAQ (12). Most of the PA was accumulated through walking for transport, which is undertaken at a low to moderate intensity (12). The prevalence of meeting PA recommendations was also found to be high (80.5%) in middle aged Black SA women from a low-resourced setting, with majority of the PA time (54%) spent in transport-related PA and only 13.9% in leisure time PA (15). Gradidge echoed similar findings in a cross-sectional study of 977 Black SA women (mean age 41.0 ± 7.84 years) from the Bt20cohort, where 67% of the women were classified as active according to GPAQ criteria (14). The domain that contributed most to overall weekly PA was walking for transport, with only 45% of women participating in leisure time PA (14). Prioreshi and colleagues also found that most (86%) young (18-25 years) Black SA women from a low-resourced setting met the 150 min/wk PA guidelines through walking for transport, which is usually accumulated as low to moderate intensity, with less than half the women participating in leisure time PA (13).

Lastly, a cross-sectional study using GPAQ derived data in Black SA urban (n = 510) and rural (n = 509) dwelling women (18–23 years) found that MVPA was significantly lower ($p < 0.001$) in the urban (median and interquartile range: 420 (160–900) min/wk) women compared to rural women (1680 (970–2580) min/wk) (125). Women living in urban areas spent 1 hour (hr) more sitting per day (6 hours per day (hrs/d)) compared to women living in rural areas (5 hrs/d) (125). Findings from the above-mentioned studies provide a snapshot of the PA patterns of Black SA women. However, for all of the above-mentioned studies, subjective measures of PA such as the GPAQ were used and objectively measured PA using accelerometers are more accurate when quantifying time spent in physical behaviours.

ActiGraph accelerometer derived PA findings from a five country study including Africa origin populations from the USA, Ghana, Jamaica and Seychelles and SA, showed that SA women were spending more time in 10 min bouts per day (bouts/d) of SB (61.02 ± 37.70) and less time in 10 min bouts/d of LIPA (93.24 ± 51.33) when compared to women from the other countries (103). However, SA women recorded more time in 10 min bouts/d in MVPA (10.17 ± 10.14) in comparison to women from USA, Ghana, Jamaica and Seychelles, with Ghanaian women recording the highest 10 min bouts/d in MVPA (11.79 ± 12.70) (103). Furthermore, accelerometer-derived PA results by Prioreshi and colleagues showed that young Black SA women (19-20 years) from a low-resourced setting in SA spent 9.6 (9.5, 10) hrs/d in SB, 132 (126, 140) min/d in LIPA and 43 (38, 44) min/day in MVPA (16), an indication that these women are meeting the WHO PA recommendations, but are still engaging in large amounts of SB. Another SA study investigating free-living ActiGraph accelerometry-derived step cadence and walking strategy parameters in 263 adult women (19–56 years) from a low-resourced setting showed that the women achieved ~13,568 steps/day, with approximately 45% of daily steps accumulated in the low-to-moderate intensity range (118). Similar findings were reported in young and middle-age (45 years) Black SA women from a low-resourced urban setting, where over half (55.3%) of the women recorded an average of

≥10,000 accelerometer measured steps per day (steps/d) (39). However, these women spent majority of their awake time (59.4%) in SB (~8.5 hrs/d) (39). Cook and colleagues also showed that over 45% of Black SA women (30-59 years) from a rural low-resourced setting achieved more than ≥10,000 steps/d, with a high percentage (86.6%) of the women meeting and exceeding the 150 min/wk PA guidelines, achieving as high as 450 min/wk of MVPA (106). Only 13.3% of the women from the above-mentioned study were classified as not meeting the guidelines (106), three times less than that observed from urban dwelling women from another study comprising of a similar population (39). These results show that the majority of urban dwelling women living in low-resourced communities are meeting PA guidelines, with only a small percentage of rural dwelling women not meeting the guidelines.

The difference in physical behaviours among rural and urban dwelling Black SA women has been reported previously (120, 126, 127). Findings by Cook and colleagues showed that Black SA rural women were less sedentary (780 ± 10 min/d) in comparison to urban women 842 ± 40 (70.5 ± 2.3) min/d and accumulated greater amounts of daily ≥10 min bouts of MVPA (53 ± 4 min/d) in comparison to urban dwelling women (33 ± 15 min/d) within a particular count band of 760-1951 cpm (126). Similarly, physical behaviours differed in Black women aged 31-36 years from urban and rural areas in Limpopo, SA (127). Urban dwelling women spent 56 min/d in MVPA and 18 hrs/d in sedentary time, compared to rural women who spent 110 min/d in MVPA and 15 hrs/d in sedentary time (127). Recent research findings conducted among middle-aged adults from a low-resourced SA community using both the ActivPAL and ActiGraph accelerometers showed that women living with overweight and obesity spent less time in LIPA and more time in sedentary in comparison to normal weight participants (120). Even though there is an emergence of research on the importance of breaking up sedentary time, there appears to be paucity of research reporting on ActivPAL-derived SB patterns such as sit-to-stand transition in SA, particularly among Black SA women. There also appears to be limited research highlighting the importance of reducing

sedentary time as a preventative measure to curbing overweight and obesity, including reports from SA national survey.

Understanding how PA is accumulated is critical when monitoring a population's compliance with specific PA guidelines (108). This information could help researchers better link PA exposure to health outcomes such as increased overweight and obesity, which has been reported in literature. Studies reporting on the subjective and objectively derived PA behaviours among Black SA women presented in this review of the literature show that women from both rural and urban dwelling areas meet the recommended PA guidelines via high volumes of LIPA according GPAQ, but still partake in large volumes of SB. Moreover, Black SA women are less likely to participate in leisure time PA which are usually performed at higher intensities (2). On the other hand, the accelerometer derived physical behaviour findings show that urban dwelling women accumulate less PA and spent more time in SB in comparison to rural dwelling women. The difference in the physical behaviour patterns among the urban and rural dwelling women might be due to the environmental differences in the transport related PA between the urban and rural areas in SA (128). Furthermore, the selected summary of literature on the physical behaviours of Black SA women from a low-resource setting highlight the need to implement intervention opportunities for promoting leisure time PA and reducing SB among women living in low-resourced urban areas.

The promotion of PA (129, 130) has been highlighted as one of the effective preventative measures to curb the increase in overweight and obesity and help to mitigate obesity-related NCDs in SA (129, 130). The implementation of community wide campaigns for PA is one of the "best buys" intervention strategies recommended in the 2018 NCD country profile (131). Furthermore, the improvement of security and safety in communities to promote participation in PA and addressing cultural norms around normal weight and body perceptions are some of the recently published approaches to addressing the prevalence of obesity in SA (130). The above-mentioned approaches

are in line with those by the South African Department of Health (SADoH) 2023-2028 strategies for the prevention and management of obesity, which highlights the importance of empowering South Africans to make healthy choices by enabling equitable access to PA opportunities (129).

2.3.3 The association between physical behaviour patterns, overweight and obesity in adults

Several researchers from HICs have reported on the association between self-reported (54, 132) and accelerometer-derived physical behaviour patterns (55) and overweight and obesity among adults. An inverse association between accelerometer derived MVPA and BMI ($\beta = -0.215$, $p < 0.001$) and waist circumference ($\beta = -0.228$, $p < 0.001$) was found among United Kingdom (UK) adults at risk of developing T2DM (55). Similarly, findings from a 2-year longitudinal study conducted in the USA investigating the association between self-reported PA and obesity among various ethnic groups including non-Hispanic White, non-Hispanic Black, Hispanic and Asian showed a strong inverse association between MVPA and obesity among White men and women ($p < 0.001$) and non-Hispanic Black women ($p < 0.001$), but no association between BMI and self-reported PA was observed among the Asian population (54).

Researchers from HICs have also shown positive associations between SB and increased risk of obesity among adults (132-134). Sitting is the most common type of SB amongst adults (84). For example, sitting in the workplace, during transport and leisure time contributes to time spent being sedentary (135). Results from a cross-sectional study in Australian adults showed that sitting in a car for more than 1 hr/d was significantly associated with higher BMI and waist circumference (132). Similarly, findings from a longitudinal study conducted among apparently health women with a BMI of $>30 \text{ kg/m}^2$ showed that 2 hrs/day increase in television watching was associated with a 23% (95% CI: 17-30) increase risk of obesity (133). Findings from the National Health and Nutrition Examination Survey among USA adults showed that adult women (≥ 20 years) living with obesity reported more sitting time (311 min/d, 95% CI: 295–327) in comparison to both

women with a normal BMI (263 min/d, 95% CI: 251–276; $p < 0.000$) and those living with overweight (261 min/d, 95% CI: 243–281; $p = 0.000$) (134). Findings from a cross-sectional study among young women (± 29 years) concluded that accelerometer-derived non-active sitting (sitting on a chair with backrest and feet on the floor) was positively associated with ($p \leq 0.001$) BMI ($r = 0.244$), body fat percent (BF%) ($r = 0.216$), weight ($r = 0.236$), total fat mass (FM; kg) ($r = 0.241$), leptin ($r = 0.237$), and negatively associated with high-density lipoprotein cholesterol (HDL-C) ($r = -0.117$, $p = 0.031$) (105). While, active sitting (sitting on a stool without backrest and feet off the floor) was negatively associated ($p \leq 0.001$) with BMI ($r = -0.300$), BF% ($r = -0.249$), weight ($r = -0.305$), FM ($r = -0.320$), leptin ($r = -0.259$), and positively associated with HDL-C ($r = 0.115$, $p = 0.035$) (105). Even though there are no universally accepted guidelines for SB (114), 60 minutes of sedentary time has been reported to be associated with higher total abdominal fat, visceral fat and subcutaneous fat in adults (136). Notably, even though individuals may be meeting the public health PA guidelines and/or recommendations, increased levels of SB have independent adverse health effects.

Breaks in sedentary time is reported to be associated with reduced metabolic risk factors independent of total sedentary time and MVPA (137, 138). Breaks in sedentary time is defined as how often a certain amount of sedentary time is disrupted with activity when accounting for the total time spent sitting and can be quantified by number of sit-to-stand transitions or number of sedentary bouts (114, 139). Furthermore, breaks in sedentary time such as sit-to-stand transitions is associated with smaller waist circumferences (WC) in adults (140). Breaks in sedentary time have also been shown to be inversely associated with WC ($\beta = -0.215 \pm 0.051$, $p < 0.001$) and BMI ($\beta = -0.151 \pm 0.049$, $p = 0.003$) in UK adults at risk of T2DM independent of known confounders such as age (55).

2.3.4 The association between physical behaviour patterns, overweight and obesity in SA adults

Several SA researchers have reported on the association between physical behaviour patterns and body composition (12, 15, 39, 103, 106, 107, 121, 125). Findings from a cross-sectional study examining the association between SES and GPAQ derived PA and sedentary time, and how they predict adiposity among Black SA urban (n = 510) and rural (n = 509) rural dwelling women (18–23 years) found that more time spent in MVPA was directly associated with a lower BMI for the combined sample (men and women) (125). Muti and colleagues showed that meeting PA guidelines (150 min/wk) was associated with 0.68 kg/m² lower BMI among SA women in the total sample of women from a cross-sectional study investigating the association between BMI and self-reported PA among middle aged adults from four SSA countries (15). Similar findings were reported from a longitudinal study by Dickie and colleagues showing that Black SA women who were meeting WHO PA guidelines had lower body weight, body fat and WC, central and appendicular FM compared to those who were not meeting guidelines (12). However, an increase in weight (~7 kg) BF% (~3%), and BMI (~3 kg/m²) over the 5.5 year follow-up was similar between women meeting and not meeting PA guidelines (12). Cook and colleagues reported similar results from a 2-year longitudinal in a rural setting and despite the majority (90%) meeting the recommended 150 minutes per week of PA guidelines, this did not prevent weight gain among this population, with a mean increase in weight of 15.2 kg (106).

Findings from a cross sectional study comprising of urban dwelling Black SA women from a low socio-economic setting aged between 18-45 years showed that accelerometer derived LIPA was associated with lower total FM (%) ($r = -0.25$, $P = 0.03$) (39). In addition, recent findings by Kufe and colleagues showed that substituting 30 min of sitting/lying, standing or LIPA with the same amount of MVPA time was associated with increased insulin sensitivity in middle age SA women from a low socio-economic setting (121). In the same cohort, Mendham and colleagues showed

that reallocation of 30 min of sitting/lying to MVPA or 30 min of standing to MVPA in women were associated with a 0.3% and 1.4% lower FM, respectively (107). These results highlight the importance of incorporating MVPA into daily PA, especially for reducing cardiometabolic risk factors such as insulin resistance and obesity. The association between weight loss and PA has also been shown in a longitudinal study. A longitudinal study over a two-year follow-up period reported that over two years, SA women gained 2.15 ± 6.82 kg, while SA men gained 0.76 ± 4.67 kg (103). However, neither baseline MVPA nor sedentary time were associated with weight gain among all participants (103).

In summary, most of the PA accumulated by Black SA women is through walking for transport, which is undertaken at low-to-moderate intensity (12-14). Moreover, research has reported that Black SA women are less likely to participate in leisure time PA which is usually structured exercises performed at higher intensities (2). Physical activity in the form of structured exercise contributes to the creation of an energy deficit by increasing total energy expenditure, thus potentially promoting weight loss (141). Exercise is a subset of PA that is planned, structured, repetitive and has as a final or an intermediate improvement and/or maintenance of physical fitness components, which are health related fitness and skill-related fitness (5).

2.4 EXERCISE TRAINING

According to the ACSM guidelines, exercise prescription should include four main principles, namely frequency, intensity, time and type (FITT) (142). Frequency refers to the number of days per week dedicated to the exercise and is said to be an important contributor to health and fitness benefits (142). Additionally, it is recommended that the exercise sessions be spread to 3-5 days/wk to achieve the recommended PA guidelines. On the other hand, intensity refers to the volume of exercise and time referring to the duration of the exercise session (142). Exercise intensity can be prescribed in either absolute or relative terms, with absolute exercise intensity referring to a

specific value of power (e.g. watts in cycling) or speed (e.g. running speed) being the same for all participants (143). While relative exercise intensity is usually determined as a percentage of the maximal oxygen consumption derived from a test consisting of progressive increases in power output (143). Light intensity physical activity is performed at a relative intensity of <55% maximum heart rate (%HRmax), with an rate of perceived exertion (RPE) between 8-10 on the Borg 6-20 scale (144). While Mod PA is performed at a relative intensity of 55- 70% HRmax, with an RPE between 11-13 (144) and Vig PA performed at a relative intensity of 70- 90% HRmax with an RPE between 14-16 (144). The ACSM guidelines recommend that adults perform moderate and vigorous intensity exercises ranging from 20-60 min/d of MVPA comprising of aerobic and resistance exercises in a continuous and intermittent manner (142). Intermittent periods of exercise training are broadly known as interval training and consist of alternating bouts of intense exercise alternated with recovery periods (142). Some of the favourable health outcomes from high intensity interval training (HIIT) include reduced weight (21), lower fasting insulin and improved CRF (21, 145, 146). Additionally, combined exercise training has also been reported to result in reduced BF%, FM (kg), WC, weight and BMI (2, 20, 147, 148) and improved CRF (20, 148-150).

Cardiorespiratory fitness reflects the integrated ability of the cardiopulmonary system to transport oxygen from the atmosphere to the mitochondria for the purpose of performing physical work (4). This demonstrates the combined capability of the muscles, cardiopulmonary and vascular system to transport and use oxygen (3) and the ability of the muscle cells to receive and use the oxygen and nutrients delivered by the blood and to communicate these metabolic demands to the cardiovascular system (4). Cardiorespiratory fitness can be directly measured and expressed as maximum oxygen consumption (VO_{2max}) or estimated from the peak work rate achieved on a treadmill and/ or cycle ergometer (4). Directly measured VO_{2max} is more objective and precise in comparison to estimated VO_{2max} (151).

Even though sex, health status, and genetics are determinants of CRF, habitual PA levels are modifiable determinant of CRF (3). Furthermore, CRF can be used as an objective surrogate of PA patterns (3). For example, developed relative ($\% \text{VO}_{2\text{max}}$) PA intensity cut-points for young adults aged 20-29 yrs by Miller and colleagues were 0-4572 cpm for LIPA ($<44\% \text{VO}_{2\text{max}}$), 4573-6786 cpm for Mod PA ($45-59\% \text{VO}_{2\text{max}}$) and $\geq 6,787$ cpm for Vig PA ($\geq 60\% \text{VO}_{2\text{max}}$) (122). Furthermore, various studies have reported on the association between CRF and physical behaviours in adults. High levels of PA achieved through leisure time are associated with increased CRF in comparison to sedentary individuals (152). Similarly, findings from a cross sectional study conducted among young and middle aged (18-45 years) Black SA women from a low resourced setting showed that CRF was inversely associated with sedentary time ($r=-0.31$, $P= 0.03$), but not PA ($P> 0.05$) (39).

Low CRF is not only associated with higher clustered cardio-metabolic risk (153), but it is also one of the strongest predictors of all-cause mortality and NCDs (154, 155). Research has consistently shown that regular exercise increases CRF (17, 20, 149, 150), reduces cardio-metabolic risk factors such as obesity (2, 17, 20, 147, 149), abdominal obesity (17, 20, 147, 148, 156) and unfavourable lipid profile (147, 148, 156). In response, ‘exercise is medicine’ was developed with the primary goal of targeting the implementation of interventions that will prevent, slow, stop and reverse the progression of NCD (157, 158). However, the majority of training interventions to date have been conducted in high-income settings (17-19, 159-161), with little in low-resourced communities (156, 162-164).

2.4.1 The effect of the type of exercises on body composition and cardiorespiratory fitness

The type of exercise training, intensity and volume all impact on the level of changes in composition and CRF. A short term (5 weeks, 4 sessions a week) intervention among young women (18-30 years) living with overweight and obesity compared the effect of HIIT (60 x 8 seconds (s) of cycling at $\sim 90\%$ $\dot{V}O_{2\text{peak}}$ interspersed with 12 s recovery) and moderate-intensity continuous training (MICT) comprising of 40 min continuous cycling at 65% $\dot{V}O_{2\text{peak}}$ for 40 min showed improvements in $\dot{V}O_{2\text{peak}}$ (+7.9% in HIIT versus +11.7% in MICT), but no changes in body composition (21). Another study with a similar approach, showed comparable reduction in abdominal fat (HIIT [-44.7 cm^2], MICT [-37.5 cm^2], $p > 0.05$) and not total body fat mass in response to 12 weeks of HIIT or MICT in young women living with obesity (165). Findings from HIIT interventions in a real world setting where aerobic interval training, maximal volitional interval training and walking groups were compared among inactive adults living with obesity. Results showed significant increases in CRF ($\text{VO}_{2\text{max}}$; +1.01% ml/min/kg) in the aerobic interval training group when compared to the maximal volitional training (-0.06% ml/min/kg) and walking group (-1.03% ml/min/kg; $p=0.03$) (146). Other researchers have also gone as far as examining the differences in enjoyment, perceived exertion and effect between MICT and HIIT in recreationally active individuals, where higher enjoyment in response to HIIT ($103.8 \pm 9.4 \text{ AU}$) was shown in comparison to MICT ($84.2 \pm 19.1 \text{ AU}$; $p = 0.013$) (166).

Nonetheless, research has also shown that combined exercise training (aerobic and resistance) results in significant improvements in body composition when compared to aerobic training only (147). Findings from a study in premenopausal sedentary women (35-45 years) showed that combined exercise training for 8 weeks performed for 60 min/day, 3 days a week at 60-70% HRmax resulted in significantly reduced body composition in comparison to the aerobic only exercise training (147). A decrease of 4.2% FM was observed among the combined exercise training group when compared to the aerobic only exercise training group, which only achieved a

2.6% reduction in FM (147). Similar changes were observed for WC, where a 1.3% reduction was observed in the aerobic only exercise training group (147). Similar results were reported from a 12 week exercise intervention (5 d/wk) combined training (15 min aerobic and 15 min resistance) in men and women living with overweight and obesity. (20). In this study, Ho and colleagues reported a significant reduction in body fat percentage (-2.6% , $p=0.008$), abdominal fat percentage (-2.8% , $p=0.034$) and improvements in CRF ($+13.3\%$, $p=0.006$) in the combined exercise group compared to the control (20). Reduced body composition and improved CRF have also been reported among men and women (61 ± 6 years) living with and without T2DM who participated in 26 weeks of supervised combined aerobic and resistance exercise training, where overall, participants improved VO_{2peak} by 15% ($p<0.01$) and reduced weight by 2% ($p<0.01$) (149). Mendham and colleagues also reported significant reductions in body composition and improvements in CRF among inactive Indigenous Australian men who participated in a 12-week sports-based combined exercise programme (resistance and aerobic) training at 70-85% HR_{max} , 3 x/wk for 45-60 min/day (148). Significant reductions in weight ($p=0.042$), BMI ($p=0.013$), WC ($p=0.004$) and waist-to-hip ratio (WHR) ($p=0.004$), and improvements in VO_{2peak} ($p=0.0001$) were observed in the exercise group when compared to control (148). Even though there is evidence that combined exercise training is an effective approach for improving body composition and CRF, there is limited research conducted among young and premenopausal Black SA women. In addition, findings from a qualitative study conducted among Black SA women (21-55 years) from a low-resourced township (Khayelitsha) in Cape Town reported that all the women considered exercise as a strategy to improve health (46). Furthermore, the women showed interest in participating in a community based exercise intervention and suggested exercises such as dancing, aerobics and lifting weights (46).

To the best of our knowledge, we are aware of only two published exercise intervention studies that have been conducted in sedentary young (25 ± 5 years) Black SA women living with overweight

and obesity (156, 167). Both interventions were 10 weeks of Tae-Bo that were conducted in the KwaZulu-Natal (KZN) province, among University students (156) and women from the rural area of Kwadlangezwa (167). The main objective of the exercise intervention delivered among University students was to determine the effectiveness of the aerobic exercise program in decreasing cardio-metabolic-risk (156). While the main objective of the exercise intervention among the rural dwelling women was to investigate the effectiveness of a community based PA programme implemented in a low-resource setting in improving health-related and physical fitness outcomes (167). Both exercise interventions were similar in structure, they comprised of a 60 min aerobic exercise routine was performed 3 x/wk and comprised of 10 min warm up, 40 min moderate or high intensity aerobic Tae-Bo and 10 min static stretching (156, 167). Results from intervention delivered in University students concluded that the 10-weeks aerobic exercise program was effective in reducing metabolic risk factors as it significantly decreased weight (-5.9%), BMI (-6.7%), waist (-6.6%) and hip (-3.5%) circumference, sum of skinfold measured body fat percentage (-11.7%), fasting glucose (FG) (-9.5%), triglycerides (TG) (-16.7%), total cholesterol (TC) (-10.6%), resting heart rate (-11.5%), low-density lipoprotein cholesterol (LDL-C) (-20.8%) systolic (-5.4%) and DBP (-6.7%) and increased in HDL-C (+19.3%) ($p \leq 0.05$) (156). Similar findings were reported from the rural women, where the intervention resulted in significant ($p \leq 0.05$) changes in body composition and the YMCA submaximal three-minute step test derived cardiorespiratory endurance post the intervention among the treatment group when compared to the control group (167). Body composition changes included reduced body weight (-5.9%), BMI (-6.7%), WC (-6.6%) and hip circumference (HC) (-3.5%) (167). In addition, significant improvements were seen in cardiorespiratory endurance ($p = 0.011$), with a reduction of beats per minutes (bpm) during the step test (-16.6%) (167). While these results show positive health outcomes in response to exercise training in University students, the studies did not include a non-interventional control group, nor did the interventions measure changes in physical behaviours in

response to the exercise intervention. Research has reported that SB is a risk factor for mortality independent of MVPA (168). It is therefore important to investigate changes in physical behaviours in response to an exercise intervention to observe if there is an accumulation of SB (e.g. sit more) as a compensatory mechanism to the increase in structured exercise sessions at a moderate to vigorous intensity.

2.5 CHANGES IN PHYSICAL ACTIVITY PATTERNS AND SEDENTARY BEHAVIOUR IN RESPONSE TO EXERCISE INTERVENTIONS

To date, few studies (17, 19, 159-161, 169-174) have explored whether an exercise intervention can elicit changes in physical behaviours in adults; table 2 outlines the methods and results from the various intervention studies. The selection of the various studies included in table 2 was based on the objective measurement tools used to monitor changes in physical behaviours in response to an exercise intervention. This was to align with the main objective of this thesis and the objective measurement tools used to monitor changes in physical behaviours in this thesis. Furthermore, the specific countries where the research was conducted was included to highlight the gaps in research conducted in monitoring changes in physical behaviours in response to an exercise intervention within the African continent, and SA to be specific.

Some researchers have explored non-exercise physical activity (NEPA) in response to a lifestyle and moderate intensity exercise intervention (169). On the other hand, some researchers have investigated changes in non-prescribed PA energy expenditure (PAEE) (160, 161, 170, 175) from low and vigorous intensity exercise (160), aerobic, resistance and combined aerobic and resistance training (161). Furthermore, other researchers examined the long-term positive effects of exercise training on PA level months after completing the intervention (171). Findings from these studies are summarised in table 2. Some of the studies show that there were no changes in NEPA and PAEE in response to an exercise training intervention (160, 161, 169). In contrast, other studies showed trends for greater non-prescribed PAEE in the exercise group (175) and significantly

greater increase in total PAEE in response to the exercise intervention that increased with increasing exercise volume among the exercise group compared with the controls (160). The difference in the physical behaviour changes among these studies may be due differences in intervention approaches and duration.

A recent study in Sweden women aged 18-67 years showed that a decrease in ActiGraph derived sedentary time and increase in LIPA was observed in a group of adults with depression who participated in light, moderate and vigorous intensity 12-week exercise intervention (172). Additionally, the study showed that the light exercise intervention group reduced MVPA minutes (-8.22, 95% CI: -16.44, -0.01), time in MVPA bouts (-8.44, 95% CI: -14.27, -2.62), and number of activity bouts (-0.43, 95% CI: -0.77, -0.09) in response to the intervention (172). Conversely, reduced time in MVPA bouts (-6.27, 95% CI: -11.71, -0.82) and number of sedentary interruptions (-6.07, 95% CI: -9.30, -2.84) was seen among the moderate exercise intervention group and no changes were observed for the vigorous exercise intervention group (172).

It is important to note that the studies presented in table 2 only used one accelerometer, either an ActiGraph or ActivPAL, to measure both changes in PA patterns and SB in response to the exercise intervention. In addition, only a few studies collected the PA and SB data on a regular basis or at more than 3 time points during the intervention (18, 161, 170). Additionally, some of these studies only collected the PA and SB data pre and post intervention, even during 6- and 8-months interventions (160, 171). Most importantly, none of the interventions presented in table 2 were implemented in a low-resourced setting, PA patterns differ to more developed and high-income settings (12, 14). However, to the best of our knowledge, no research has been conducted among this population to examine the changes in physical behaviours and intensity of PA in response to participating in a structured exercise intervention.

Table 2: Summary of selected literature monitoring physical activity and sedentary behaviour in response to an exercise intervention						
Aim of the study	Population	Study design	Intervention components	PA and SB tools	Main findings	References
To examine the effects of three exercise training interventions on total physical activity energy expenditure (PAEE) or non-exercise PAEE	- Country: UK - N= 50 - N= 25 (men) -N = 25 (women) -Overweight & obesity - Age 40- 65 yrs	- Randomized controlled trial	- 8 months exercise intervention - Sedentary men and women were assigned to: 1. Inactive control 2. Low amount/moderate-intensity (caloric equivalent of approximately 5023 kJ. wk ⁻¹ at 40%–55% peak VO ₂) 3. low amount/vigorous intensity (caloric equivalent of approximately 5023 kJ. wk ⁻¹ At 65%–80% peak VO ₂) 4. High-amount/vigorous-intensity aerobic exercise. (caloric equivalent of approximately 8372 kJ.wk ⁻¹ at 65%–80% peak oxygen consumption VO ₂) - Participants exercised 3- 5/week. - Accelerometers were worn for 7 days at the beginning and end of an 8-month exercise intervention.	- Triaxial RT3 Accelerometer	- Post intervention, average change in total PAEE was 8.4 ± 20.9 kJ.h ⁻¹ for controls, 58.6±20.9 kJ.Ih ⁻¹ for the two low-amount groups, and 138.1 ±33.5 kJ.h ⁻¹ for the high amount group. - The high-amount group experienced a significantly greater increase in total PAEE compared with the controls (P = 0.02). - Total PAEE ↑ with ↑exercise volume. - Average change in non-exercise PAEE was 8.4 ± 20.9 kJ.h ⁻¹ for control, 25.1 ± 20.9 kJ.h ⁻¹ for the low-amount groups combined, and 62.8 ± 29.3 kJ.h ⁻¹ for the high-amount group. - No statistically significant difference in change of non-exercise PAEE between groups.	Hollowell, et al., [2008]; (160)

<p>To investigate whether there is a reduction in nonprescribed PAEE as a result of participation in a 6-mnths structured exercise intervention.</p>	<p>- Country: UK -N= 41- Sedentary men. - BMI: 28 ± 3kg/m² - Age: 54 ±6.5 yrs</p>	<p>- Randomized controlled Trial</p>	<p>- 6-months exercise intervention - Exercise group completed a 24-wk individually prescribed, progressive & monitored exercise program. - Control group asked to maintain their existing (sedentary) lifestyles - Estimates of energy expenditure and time spent participating in PA using the Actiheart -Predetermined intensity thresholds were assessed in both groups baseline & post intervention (week 24–26 during a 2-wk detraining period) & during week 2, 9, & 18 of the intervention.</p>	<p>- Synchronized accelerometry and heart rate</p>	<p>- Structured prescribed exercise ↑ total PAEE in exercise group (p=0.03) - Overall PAEE significantly higher in exercise group vs. control group (p =0.004). - Greater nonprescribed PAEE in the exercise group vs. control group (p = 0.09). - Prescribed PAEE ↑ significantly in the exercise group (p =0.001)</p>	<p>Turner J.E, et al., [2010]; (170)</p>
<p>To evaluate changes in physical activity energy expenditure in response to aerobic training, resistance training or combined aerobic and resistance training.</p>	<p>- Country: UK - N=82 - N = 32 men - N = 50 women - BMI: 25–35 kg/m² - Age: 47-51yrs</p>	<p>- Randomized controlled trial</p>	<p>- 8-months intervention - 4 months control: asked to maintain their current lifestyle. - 4 months exercise: divided into 3 groups (resistance, aerobic & combined resistance and aerobic training group 3 x/week). - Participants wore accelerometers 5- to 7-d at 3 time point of the intervention.</p>	<p>- Triaxial RT3 accelerometer.</p>	<p>- No significant change in off-exercise days PAEE in any of the exercise training groups. - significant ↑ in total PAEE in aerobic training, and both aerobic training and combined aerobic, but not in the resistance training group only.</p>	<p>Rangan VV,el al., [2011]; (161)</p>
<p>To determine if the group exercise intervention produced long-term positive effects on PA level six months post intervention</p>	<p>- Country: Norway - N= 150 - Physically inactive Pakistani immigrant men Age: 25 to 60</p>	<p>- Randomized controlled Trial</p>	<p>- 5 months intervention - N = 89 Intervention - N = 61 Control - Structured group exercise sessions led by an exercise physiologist 2x/week, two group lectures, one individual counselling session, written material and a phone call - Participants instructed to wear the accelerometer on the right hip</p>	<p>- ActiGraph accelerometer.</p>	<p>- All PA variables differed significantly between groups. - The intervention group had 84 more minutes of MVPA & 7.7 fewer hours of inactive time/ week vs. control group. - Intervention group ↑ total PA level from baseline to follow up by a mean of 36 cpm (p = 0.02),</p>	<p>Anderson E, et al., [2012]; (171)</p>

			<p>during all waking hours, except while swimming & bathing, for 7 days.</p> <ul style="list-style-type: none"> - PA data collected at 3 points (baseline, F/U 1 & F/U 2). - Participants telephonically contacted 6 months after the intervention ended for a second follow-up test (FU2) (n = 133). - PA data collect pre and post intervention 		<p>an ↑ of 10% and time spent in MVPA by an average of 7.3 min·day⁻¹ (p = 0.03), an ↑ of 21%.</p> <ul style="list-style-type: none"> - Intervention group ↓ sedentary time by a mean of 0.7 hours·day⁻¹ p = 0.001), a ↓ of 9% (95% CI = 1.5 to 16). <p>The PA variables did not change in the control group.</p>	
<p>To examine the efficacy of the group exercise intervention in increasing PA using a randomised controlled design</p>	<ul style="list-style-type: none"> - Country: Norway - N= 150 - Pakistan men - Age: 25-60 yrs 	<ul style="list-style-type: none"> - Randomized controlled Trial 	<ul style="list-style-type: none"> - 5 Months intervention - N = 89 Intervention - N = 61 Control - Structured group exercise sessions led by an exercise physiologist 2x/week, two group lectures, one individual counselling session, written material and a phone call - Participants telephonically contacted 6 months after the intervention ended for a second follow-up test (FU2) (n = 133). 	<ul style="list-style-type: none"> - ActiGraph accelerometer 	<ul style="list-style-type: none"> - The intervention group ↑ their total PA level (cpm) significantly more than the control group (p = 0.01). - Intervention group ↑ their MVPA by 6.4 min more per day vs. control group. - Both groups ↓ their inactive time, but there were no significant differences between the two groups. 	<p>Anderson E & Høstmark T [2013] (17)</p>
<p>To compare ST and NEPA during a 12-week exercise training and/or lifestyle intervention.</p>	<ul style="list-style-type: none"> - Country: USA - N= 19 Men - N = 39 Women - BMI 35.1 ± 4.6 kg/m². - Age: 20 - 60 yrs 	<ul style="list-style-type: none"> - 4 Arm quasi-experimental study 	<ul style="list-style-type: none"> - 12 weeks exercise and lifestyle intervention - Exercise group: exercise 5 days per week at a moderate intensity. - The Sedentary Time reduction group: instructed not to participate in exercise, but to accumulate non-exercise physical activity throughout the day in small bouts of activity. - Exercise & Sedentary Time Reduction group: participated in 	<ul style="list-style-type: none"> - ActivPAL accelerometer 	<ul style="list-style-type: none"> - ST did not ↓ significantly for exercise group. - No changes in NEPA at week-12 compared with baseline for the exercise group. - 50% of exercise participants ↑ ST and ↓ NEPA. - Sedentary Time reduction group ↓ ST and ↑ NEPA. - Exercise and sedentary time reduction group - 	<p>Kozey-Keadle, S [2013]; (169)</p>

			<p>supervised aerobic exercise training identical to exercise group and also received the sedentary time reduction group strategies to ↑ non-exercise physical activity & ↓ sedentary time.</p> <ul style="list-style-type: none"> - Control group: maintain habitual behaviour - Wore ActivPAL for 7 days at week 3, 6, 9, & 12. 		<p>significantly ↓ & ↑ time in NEPA at week-12 compared with baseline.</p>	
<p>To assess the impact of a 12-week multi-disciplinary lifestyle intervention on cardiometabolic risk factors in premenopausal women with abdominal obesity</p>	<ul style="list-style-type: none"> - Country: Australia - Tertiary students - Caucasian women - N= 39 - Age: 18-30 yrs 	<ul style="list-style-type: none"> - Randomised Control Trial 	<ul style="list-style-type: none"> - 12 Weeks lifestyle intervention (exercise, nutrition education & cognitive behavioural therapy) - N= 27 (intervention) - N = 12 (control) - Testing at pre, post & 24 weeks for intervention group. - Testing and pre-& post for control group - Intervention group: 2X supervised 60 min exercise sessions (progressive circuit training) and 1 unsupervised session. - Control group: Instructed to continue existing lifestyle choices & were invited to complete the lifestyle intervention after 12 weeks. 		<ul style="list-style-type: none"> - ↑ physical activity in the intervention group post intervention (p <0.001). - Significant changes in intervention groups for: <ol style="list-style-type: none"> 1. WC (-5.8 cm, -6.4%) 2. WHR (-0.02, -2.5%) 3. WHR (-0.03, -5.5%) 4. SBP (-4 mmHg, -3.4%) 5. DBP (-4.0 mmHg, -5.8%), 6. resting heart rate (-8.0 bpm, -11%), 7. predicted VO_{2max} (+4.7 ml.kg⁻¹.min⁻¹, +15%), 8. PA (+183 min. week⁻¹, +97%) 	<p>Share BL [2015] (19)</p>
<p>To determine the extent to which participation in light-, moderate- and vigorous-intensity exercise intervention influenced habitual physical activity and sedentary behaviour patterns in depressed adults.</p>	<ul style="list-style-type: none"> - Country: Sweden - Depressed patients (women) - N = - Age: 18-67 yrs 	<ul style="list-style-type: none"> - Randomised Control Trial 	<ul style="list-style-type: none"> - 12 weeks intervention - N= 21 (Light: basic yoga) - N= 25 (Moderate: intermediate level aerobic exercise training) - N= 22 (Vigorous: repetition of both static and explosive movements) 	<ul style="list-style-type: none"> -ActiGraph accelerometer 	<ul style="list-style-type: none"> - ↓ sedentary time min/d & ↑ increase in LIPA min/d across all interventions. - ↓ MVPA min/day (-8.22, 95% CI: -16.44, -0.01), time in MVPA bouts (-8.44, 95% CI: -14.27, -2.62), & number 	<p>Helgadottir B, et al [2017] (172)</p>

			- 55min/d -3x/wk		of activity bouts (-0.43, 95% CI: -0.77, -0.09) for the light intensity group. - ↓ time in MVPA bouts (-6.27, 95% CI: -11.71, -0.82) and number of sedentary interruptions (-6.07, 95% CI: -9.30, -2.84) for the moderate exercise intervention group - No changes for the vigorous exercise intervention group.	
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Abbreviations and signs: Sample size (N); Confidence interval (CI); Counts per minutes (cpm); Minutes per day (min/d); Millimetres of mercury (mmHg); Systolic blood pressure (SBP); Diastolic blood pressure (DBP); Kilojoules per hour (kJ.h⁻¹); Kilojoules per week (kJ.wk⁻¹); Light intensity physical activity (LIPA); Moderate-to-vigorous physical activity (MVPA); Waist circumference (WC); Waist-Hip-Ratio (WHR); Non-exercise physical activity (NEPA); physical activity energy expenditure (PAEE); Maximum oxygen consumption (VO_{2max}); Years (yrs); Increase (↑); Decrease (↓)

2.6 PERCEPTIONS OF BODY IMAGE

One of the most common psychological problems among people living with overweight and obesity is a defective body image (176). Body image is often defined as a degree of satisfaction with physical appearance (size, shape and general appearance) (1, 177), or how a person feels about their appearance (2). It can be argued that cultural and societal perceptions around a bigger body size and being more accepting of overweight (44, 46) and obesity (42, 46) by Black SA women is contributing to the high prevalence of overweight and obesity among this population. In addition, some women made statements such as “Our culture says that you are supposed to be fat” (178), which can make it difficult to prevent overweight and obesity through behavioural change in this population.

There is a growing area of interest in individual’s perception of their body image on an international scale (179, 180), including Africa (42-44, 46, 47, 181). Furthermore, research on perceptions of body image and/or size among Black SA women and adults has been abundant in the recent (42, 43, 46, 47, 181) and previous years (182-184). Table 3 summarises several SA studies that have reported on the perceptions of body image and/or body size from both urban (43, 44, 46-49, 183-187) and rural (43, 49, 186) dwelling Black SA women in comparison to other ethnic groups (187). These studies have used various qualitative and quantitative approaches such as Focus Group Discussions (FGDs) and Stunkard’s silhouettes (188) and/or pictorial body image models. The Stunkard’s silhouettes used by the studies summarised in table 3 have been validated in South African women previously (189).

Black SA women’s perception of obesity in rural and urban Msunduzi areas in KZN province found that the notion of obesity was perceived not to exist (43). Rather, these women preferred names like ‘fuller bodies’ or ‘rounded fuller figure’ which were adored and perceived as indicators of beauty and even a sign of affluence (43). Similar findings were echoed in a qualitative study

conducted in middle-age men and women from Soweto (Township in the city of Johannesburg) who preferred to refer themselves to being ‘fat’ and not ‘obese’ (42). Such perceptions are also observed during teenage years (183).

Findings from an exploratory qualitative study using both Stunkard’s silhouette’s and FGDs investigating beliefs regarding body size and body image among 60 Black SA girls aged 10–18 years found that even though fatness was viewed as associated with diseases such as type 2 diabetes and difficulty in finding appropriate clothing sizes, the young girls also perceived fatness as a sign of happiness and wealth (183). Similar findings were reported among Black adult SA women where thinness was associated with ill health such as Human immunodeficiency virus (HIV), Acquired immunodeficiency syndrome (AIDS) and tuberculosis (TB) (45, 184). Additionally, young and middle-age Black SA women perceived a bigger body size as an indicator of beauty, dignity and even a sign of affluence (43), whereas a thin body was viewed as not respectable and also associated with poverty (43) and sickness (45, 46). These cultural and societal perceptions around a bigger body size in Black SA women could influence whether these women engage in healthy behaviours such as physical exercise. Some of the limitations from these studies include the cross-sectional study design and a large portion (40%-75%) of the participants were unemployed, with low socio-economic status and education attainment. These factors affect views and the perceptions about obesity-related health risk as well as weight-loss intentions (48, 49).

On the contrary, some studies have also reported that Black SA women desire to be thinner (44, 45, 186). In a society that is filled with the “perfect body type” it is not surprising that many women are unhappy with their own body image (2). Findings from a study exploring the perceptions of body image among adult (40-59 years) Black SA women using the Stunkard body silhouettes showed that the women underestimated their body size compared to their derived BMI across all weight categories (45). Similar findings were reported by Okop and colleagues where Black SA

women living with overweight and obesity wanted to be a smaller size (48) and a higher proportion of women compared to men underestimated their weight (76% vs. 49%) and were dissatisfied with their body size (49). Findings from the above-mentioned studies suggest that some Black SA women are unhappy with their body size and body image. The difference in the literature reporting on the preference of bigger body size and desire to be thinner among Black SA women may be due to the difference in methodology, participant age and SES. Majority of the studies reporting on desire to be thinner among Black SA women used Stunkards's silhouettes (45, 186, 190), while some of those reporting a preference for a larger body size or satisfaction with larger body used FGDs alone (43, 46) or in conjunction with the Stunkards's silhouettes (48, 183, 184). Thus, it can be argued that the method used to assess body image perception plays a significant role in the outcomes reported.

Table 3: Summary of selected literature on the perceptions of overweight, obesity, body image and body size among SA adults (men and women)

Aim of the study	Population	Study design	Location (urban/rural)	Body image assessment	Main findings	References
To explore perceptions about factors associated with body weight and body image among Black women community of health workers living and working in Khayelitsha, Cape Town.	-Black SA women -Community Health workers N=44 -N=2: Normal weight - N= 2: Overweight - N=25: Obese -N=15 Morbidly obese -Age: 43.2 ± 7.2 yrs	-Descriptive, cross-sectional study	-Western Cape Province (Urban: Khayelitsha township)	-Body shape drawings (pictograms) - body satisfaction question	- A moderately overweight shape (BMI: 27 kg/m ²) was preferred - Moderately overweight shape was associated with dignity, respect, confidence, beauty & wealth.	Puoane T, et al., [2005]; (182)
To examine the perceptions of Black schoolgirls aged 10–18 years about body size and body image	- Black SA girls - N= 60 - Age: 10-18yrs	-Exploratory study (qualitative)	-Western Cape Province (Urban: Khayelitsha township)	-Stunkard body silhouettes - FGD	- Being fat was perceived as a sign of happiness & wealth. - Living with obesity was preferable. -Fatness was viewed as associated with diseases such as diabetes & hypertension & with increased difficulty in finding appropriate clothing sizes. - Thinness with ill health particularly HIV, AIDS & TB	Puoane T, et al., [2010]; (183)
To explore the perception among Black South African women that people who are thin are living with HIV or AIDS.	- Black SA women - N= 513 - Age: 18-65 yrs	-Exploratory study (qualitative & quantitative)	-Western Cape Province (Urban: Khayelitsha township)	- Stunkard body silhouettes - FGD	- 69% of women associated a thin figure with HIV & AIDS. - 10.2% of women associated thin figure with health. - 34.2% of women associated normal weight with health. - 50% of women preferred a normal-weight figure. - 31% of women associated being overweight with good health.	Matoti-Mvalo & Puoane [2011]; (184)

To explore urban Black women's perception of their body image	- Black SA women - N= 328 - Age: 40-59 yrs	-Cross-sectional exploratory study	- Kwa-Zulu Natal (Durban: Urban)	- Stunkard body silhouettes	- Perceived body image compared to derived BMI showed that women underestimated their body image across all weight categories. - > 40% indicated a normal to overweight preferred body image. - 99% of the women associating the underweight silhouettes with disease and HIV infection.	Devenathan R, et al., [2013]; (45)
To explore perceptions regarding body size and weight loss in a sample of Black women from a low-income community in Cape Town, SA.	- Black SA women - N= 21 - Age: 24-51 yrs	-Qualitative exploratory study	- Western Cape ((Urban: Khayelitsha township)	- FGD	- Most participants felt that living with overweight/obesity was acceptable and desirable, and agreed that they liked to be 'fat'. - Some participants disagreed and stated that they did not like to be overweight/obese.	Draper E, et al., [2015]; (46)
To determine whether lifestyle and psycho-social factors determine changes in body composition over 10 years in a population of Black African women with a high prevalence of obesity.	- Black SA women -N= 430 - ≥ 18 yrs	-Longitudinal study	-Gauteng Province (Urban: Soweto Township)	- Female body Stunkard's silhouettes	- In participants that underestimated their body size at baseline (74.0% of the study population) changes in total and peripheral levels of body fat were less than in women who correctly identified their body size. - In the group that underestimated body size, more women wanted to be leaner than in the group who knew their body size.	Gradidge P.J, et al., [2015]; (190)
- To explore the perceptions of body size, obesity risk perception, and the willingness to lose weight in men and women living in a resource-limited urban community, in order to inform appropriate community-based intervention for the prevention of obesity.	-Black SA women & men -N= 89 -N= 36 (Women) -N= 42 (Men) -Age: 35-70 years	-Descriptive qualitative study	-Western Cape Province (Urban: Langa township)	-Sex-specific validated Body Image Rating Figures (BIRF) - FGD	- Majority of women living with overweight & obesity chose the silhouettes that were smaller than the one equivalent to their weight. - Majority of obese and overweight women expressed satisfaction with their body size.	Okop K.J, et al., [2016]; (48)

<p>To identify the differences in body image satisfaction and eating attitudes between rural and urban South African young adult women and explore the interactions between BMI, physical activity, body image satisfaction and eating attitudes using site specific regressions and structural equation modelling.</p>	<ul style="list-style-type: none"> - Black SA Women - N=509 (Rural) - N= 510 (Urban) - Age: 18-23 yrs 	<p>-Cross-sectional study</p>	<ul style="list-style-type: none"> -Mpumalanga Province (Rural: Agincourt) - Gauteng Province (Urban: Soweto Township) 	<p>- Stunkard's silhouettes</p>	<ul style="list-style-type: none"> -Urban women were more likely to be overweight and obese than rural women & had a greater desire to be thinner. - In both groups, being overweight or obese was positively associated with a desire to be thinner. - Disordered eating attitude was associated with body image dissatisfaction in the urban group. - disordered eating attitude was associated with a desire to be fatter in the rural group. 	<p>Prioreschi A, et al., [2017]; (186)</p>
<p>To establish the Black South African women's perceptions of obesity in rural and urban areas in the Msunduzi District of Pietermaritzburg.</p>	<ul style="list-style-type: none"> -Black SA women -N= 73 - ≤ 35 yrs (youth) - ≥ 35 yrs (adults) 	<p>-Explorative qualitative study</p>	<p>-Kwa Zulu-Natal Province (Rural & Urban Msunduzi district)</p>	<p>-Focus group discussions</p>	<ul style="list-style-type: none"> -Obesity was perceived not to exist. - Participants referred to 'fuller bodies' and a 'rounded fuller figure'. - Rounded fuller figures were appreciated & associated with wealth and dignity. - Being thin was associated with poverty. 	<p>Dandala P, et al., [2018]; (43)</p>
<p>To assess weight discordance and body size dissatisfaction among overweight and obese South Africans, the associated factors and the implications for health promotion.</p>	<ul style="list-style-type: none"> -Black SA women & men - N= 920 - N=380 (Rural) - N= 81 (Men) - N= 299 (Women) - N= 540 (Urban) - N= 140 (Men) - N= 410 (Women) - Age:35-78 yrs 	<p>-Quantitative study</p>	<ul style="list-style-type: none"> - Eastern Cape Province (Rural: Mount Frere). -Western Cape Province (Urban: Langa Township) 	<ul style="list-style-type: none"> -Pictorial constructs (Stunkard silhouettes) - Body shape questionnaire (BSQ) -Structured questions used to describe weight perception 	<ul style="list-style-type: none"> -Higher proportion of women compared to men underestimated their weight (76% vs. 49%) & were dissatisfied with their body sizes. -Participants who perceived CVD threat, compared with those who did not, were 3 times more likely to be dissatisfied with their body sizes & 1.6 times more likely to underestimate their own weight. 	<p>Okop K.J, et al., [2019]; (49)</p>

<p>To understand the socio-cultural norms relating to weight estimation among individuals living in rapidly urbanising setting with growing disposable incomes and increasing availability of inexpensive processed or fast-food.</p>	<p>-Adult men & women -N= 57 - N= 29 (Women) - N= 28 (Men) -Age: 18-55 yrs</p>	<p>-Qualitative study</p>	<p>-Gauteng Province (Urban: Soweto Township)</p>	<p>- FGD</p>	<p>-Participants admitted to being ‘fat or overweight’, but did not view themselves as obese.</p>	<p>Bosire E.N, et al., [2019]; (42)</p>
<p>To assess body weight perceptions according to several body image dimensions in rural, employed African women.</p>	<p>- Black SA women - N= 132 - N= 72 (obese) - N= 60 (non-obese) - Age: 40 ± 10.1 yrs</p>	<p>-Cross- sectional qualitative study</p>	<p>-Limpopo Province (Rural: Venda)</p>	<p>- Stunkard silhouettes</p>	<p>- Majority (58.3%) of the women demonstrated a social value of stoutness. - Majority (63.6%) of the women were able to correctly perceive their actual body weight according to their BMI.</p>	<p>Gradidge P.J, et al., [2020]; (47)</p>
<p>To explore the perception of overweight, obesity, and health among South African adults.</p>	<p>- Black SA Adults living with overweight and obesity -Age: ≥ 18 yrs - N= 24 - N = 18 (men) - N= 6 (women)</p>	<p>-Descriptive qualitative study</p>	<p>-Gauteng, Northwest & Mpumalanga Province</p>	<p>- Semi structured interviews</p>	<p>- Believed that obesity could be caused by unhealthy habits such as eating junk food. - Identified the type of drinks, such as sugar-sweetened beverages, as the main cause of obesity. -Believed that people who were overweight were prone to weight gain due to a lack of exercise. - Women perceived that they were prone to being overweight due to pregnancy and childbirth. -Believed that older men with pot bellies (big stomachs) were wealthy. - Believed that overweight individuals were healthy and that their weight was attributable to their happiness in life.</p>	<p>Manafe M at al., [2022] (181)</p>

					<ul style="list-style-type: none"> - believed that happiness was obesogenic and thus, led to weight gain. - Perceived that growing older made the health risks related to being overweight and obese unavoidable. - believed that obesity was acceptable in their culture, although they did not embrace the belief themselves 	
<p>Abbreviations: Sample size (N); Body mass index (BMI); Kilograms per metered square (kg/m²); Years (yrs); Cardiovascular diseases (CVDs); Tuberculosis (TB); Human immunodeficiency virus (HIV), Acquired immunodeficiency syndrome (AIDS); Focus group discussions (FGD); Body shape questionnaire (BSQ).</p>						

2.7 CHANGES IN BODY IMAGE AND SELF-EFFICACY IN RESPONSE TO AN EXERCISE INTERVENTION

Exercise training can be considered as a therapeutic strategy to improve perceptions of body image (2, 22, 23) and self-efficacy (6, 191) in women living with overweight and obesity. Improvement in body image assessed using a 9 item Body Areas Satisfaction Scale and a 7-item Appearance Evaluation subscale was observed among women living with obesity in response to a 16 weeks progressive resistance exercise and dietary caloric restriction intervention (23). Similar findings were reported from a study investigating changes in body composition and body image assessed using a sub-dimension of the multidimensional body-self relations questionnaire among middle-age women in response to a 12 weeks HIIT and resistance training circuit (4x/wk at 50-60% target heart rate) (2). Furthermore, increased schedule efficacy, physical efficacy and exercise worries efficacy have also been observed in women living with overweight and obesity participating in a 12 week self-efficacy intervention (6). The intervention required participants to formulate action plans for exercise outcome expectancies, goal setting, relapse management, and exercise self-incentives (6). Perceived body image and self-efficacy have also been shown to improve in response to an exercise intervention. Findings from Vurgun and colleagues showed that a 14-week exercise intervention (60 min aerobic exercises 3 x wk) in sedentary middle-age women improved body image satisfaction and self-efficacy levels (191).

Table 4 summarises the global literature that report changes in perceived body image (2, 23, 24, 176, 191-193) and self-efficacy (6, 191) in response to exercise intervention in women. An exercise intervention study conducted amongst women college students in the USA assessed body image in response to the intervention using the body self-image questionnaire (BSIQ) (193). Results from this study concluded that combined aerobic, anaerobic and strength training was more beneficial in improving body image when compared to only aerobic exercises or no exercise at all (193). The greatest overall body image improvement was seen amongst the interval circuit training group

(193). These findings are supported by another study conducted on a mixed group (men and women) of college students (24). Body image was assessed using a Multidimensional Body Self-Relations Questionnaire (24). The circuit weight training group not only increased upper and lower body strength ($P < 0.01$), but also experienced a significant improvement in appearance, body satisfaction and physical self-efficacy with reduced social physique anxiety in comparison to the non-interventional control group (24).

All the studies listed in Table 4 were undertaken in HIC. To the best of our knowledge, there is no research reporting on the effects of exercise training on perceived body image and self-efficacy from the African continent. Further, these reported studies did not explore the women's perceptions regarding the implemented exercise intervention using qualitative approaches such as FGDs and In-depth interviews (IDIs). Focus group discussions are valuable because they provide a platform for capturing group interaction and harnessing the dynamics involved to prompt fuller and deeper group discussions (194). Further, FGDs provide a conducive environment for understanding collective social action, accessing group beliefs and understanding behaviours and attitudes that might be overlooked during IDIs (195). Furthermore, FGD and IDI might enable the researchers to collect in-depth information on PA participation barriers and facilitators through probing during the discussions and interviews. Collecting such information is not always possible through paper-based questionnaires.

Table 4: Summary of selected literature on the effect of exercise intervention on body image and self-efficacy

Aim of the study	Population	Study design	Study components	Body image tool	Self-efficacy tool	Main findings	References
To explore the effects of a 6-week circuit weight training program on multiple facets of body image.	<ul style="list-style-type: none"> - Country: USA - College students - N= 27 women -N= 12 men - 28% White - 58% African American - 13% other ethnic group - 21.7±3.8 yrs 	<ul style="list-style-type: none"> -Quasi-experimental design. - Pre-test -Post-test - N= 39 control - N= 39 exercise 	<ul style="list-style-type: none"> -6- week circuit weight training based on ACSM - 3x/week - 60 min - Individuals who had weight trained in the past year were excluded 	Multidimensional Body-Self Relations Questionnaire (MBSRQ).	- Physical Self-Efficacy Scale (PSE).	<ul style="list-style-type: none"> -Weight lifters' body images improved on all four measures - Weight trainers' aerobic exercise level & strength ↑ - The circuit weight training group ↑ in appearance, body satisfaction and physical self-efficacy. - Control participants reported no body-image changes over time. 	William, PA & Cash TF [2001]; (24)
To test a self-efficacy enhancing exercise program to achieve physical fitness among both Black and Hispanic sedentary female college students	<ul style="list-style-type: none"> - Country: USA -Black and Hispanic college-age women -N= 44 -N= 36 (Black) -N= 7 (Hispanic) -N= 1 (Mixed race) - 18-35 yrs 	- Quasi-experimental	<ul style="list-style-type: none"> - 6 weeks self-enhancing exercise intervention - Either step or dance aerobics or kick boxing class - 3x / week -50-60 minutes - 60-80% (%HR_{max}) -Health screening (history & physical examination. - Pre and post intervention testing. - Higher and lower attendance group - Digiwalker pedometer used to measure activity levels. 	- None	-Immediate self-efficacy enhancing feedback provided after each training session	<ul style="list-style-type: none"> -Women in the high attendance group showed significant improvements in exercise self-efficacy and perceived benefits & barriers to exercise. - Women in the high attendance group showed significant improvements in aerobic fitness, muscle strength, flexibility, percentage of body fat 	D' Alzono, KT, et al., [2004]; (196)

			<ul style="list-style-type: none"> - Weekly worksheets, handouts, motivational messages & homework assignments corresponding to the relevant activities and stages of behaviour. - weekly e-mail messages with feedback regarding target heart rates, personalized motivational messages & tips for maintaining exercise during stressful periods - Incentives provided based on level of participation -Focus groups 			<ul style="list-style-type: none"> & overall daily activity level. - Lack of a true control group 	
To determine the effect of aerobic and interval circuit training on fitness and body image among women	<ul style="list-style-type: none"> - Country: USA - College students - Women - N=72 -18-26 yrs 	<ul style="list-style-type: none"> - Randomized experimental design. -Pre-test -Post test 	<ul style="list-style-type: none"> - 12- week aerobic and circuit training -3 exercise programs 1. Aerobic exercise 50 min (60-90%, % HR_{max}; n= 23) 2. interval circuit 50 min (60-90%, % HR_{max}; n=28) 3. Control: no exercise (65-80%, % HR_{max}; n= 21) Volunteers excluded from study if reported to be engaging in vigorous exercise at least twice per week or individuals with self- reported eating disorders. - Physical fitness and nine body image components assessed. - Skinfold measurements taken to estimate %BF -Step test 	- Body Self-Image Questionnaire (BSIQ)	- None	<ul style="list-style-type: none"> - Significantly ↑ fitness scores for the aerobics/strength circuit training group. - Interval circuit training group experienced the greatest improvement in overall body image dependant variables 	Henry RN, et al., [2006]; (193)

			- Bench press test				
To examine correlates of body image change among overweight and obese women who participated in a 16-week diet and exercise intervention.	- Country: Canada - Women -N= 88 - 28.4±7.8 yrs - BMI: 27-40kg/m ²	- Randomized experimental design. -Pre-test -Post test	- 16 weeks exercise and dietary intervention. - 45–60 min of aerobic exercise 7x/week and progressive resistance exercise 2x/week. -Week days: exercise was performed at a supervised training center on campus. Weekends: women exercised unsupervised. - Repeated measures taken at baseline, Week 8 & Week 16 of the intervention. - Dietary intervention comprised of restricted daily caloric intake to 500 kcal below each participant’s weight maintenance energy requirements. - Participants recruited through University and community. -Body composition measured using DXA scans.	- 9-item Body Areas Satisfaction Scale (BASS) - 7-item Appearance Evaluation (AE) subscale	- Aerobic self-efficacy, participants indicated their confidence on a scale ranging from 0- 100 to run on a treadmill at a moderate intensity for up to 60 min without stopping. - Strength self-efficacy was measured by asking participants to indicate their confidence to perform the 4 1RM exercises.	- Significant improvement in body image over the study time points. - Improved perceptions of body fat.	Ginis KAM, et al., [2012]; (23)
To determine the effect of short-term aerobic exercise on depression symptoms and body image attitudes among Iranian women.	- Country: Iran -Iranian women -N=82 - 18-45 yrs	- Quasi-experimental study design. -Pre-test -Post-test - N= 41 exercise group - N= 41 control group	- 4 Week aerobic training program. - Exercise at 70%, %HR _{max} -65-70 min -Participants excluded if they were receiving depression treatment.	Multidimensional Body Self-Relation Questionnaire (MBSRQ).	-None	- Significant improvement in body image dependant variables (appearance evaluation, appearance orientation, health orientation & illness	Zarshenas, S, et al., [2013]; (192)

						orientation in exercise group. -Significant ↓ in depression symptoms in the exercise group	
To assess the effect of resistance training (RT) and flexibility training (FT) group in healthy postpartum women	- Country: USA -Postpartum women -N= 60 - 90% Caucasian - 8.3% Hispanic - 1.7% Asian - 6 weeks & 8 months postpartum, - >2.27 kg above their self-reported pre-pregnancy weight	- Randomized experimental design. - Testing at baseline, 2 months & 4 months	- 18 weeks resistance and flexibility - 2x/week - Both RT and FT protocol based on ACSM recommendations - Assessment included 1. Muscular strength 2. DEXA derived body composition 3. Depressive symptoms 4 Accelerometer derived physical activity	- None	-Exercise self-efficacy.	- RT group showed ↑ strength gains than the FT group. - Significant group x time interaction for exercise self-efficacy: 1. ↓ for RT group 2. No change for FT group. - ↑ in sedentary time in RT group compared to FT group. - ↑ light-intensity activity in RT group compared to FT group.	LeChemina nt, DJ, et al., [2014]; (197)
To examine the effects of regular aerobic exercise on physical variables, body image satisfaction and self-efficacy levels of sedentary women	- Country: Turkey -Sedentary women -Control group: 40.5±12.1yrs Exercise group: 36.3±8.5yrs	- Randomized experimental design. -Pre-test -Post test - N= 25 exercise group -N=20 control group	14- Week aerobic training program. - 3x/week - 60 minutes - Polar Heart-rate used to monitor HR. - Control group did not participate in any special kind of physical activity. - Weight and height measured to calculate BMI. - Waist and hip measured to calculate waist-to-hip ratio. - Skinfolds take to estimate % BF.	- Body Image Satisfaction Questionnaire (BISQ)	- General self-efficacy Scale.	- Significant ↓ in body mass, body fat, waist-to-hip ratio in exercise group. - Significant ↑ in body image satisfaction & self-efficacy scores in the exercise group.	Vurgun, N [2015]; (191)

<p>To compare the effects of two aerobic exercise methods (traditional based on considering the basic psychological principles) on body mass index, intrinsic motivation, sport persistence, and body image among obese women.</p>	<ul style="list-style-type: none"> - Country: Iran - Obese women -N= 36 - 30-35 yrs -BMI > 30kg/m² 	<ul style="list-style-type: none"> -Quasi-experimental - Experimental & control groups with random arrangement. -Pre-test -Post-test 	<ul style="list-style-type: none"> - Participants were divided into 2 groups. -Traditional aerobic exercises & aerobics exercises based on considering the basic needs. -Twelve weeks - 3x/ three week -60 minutes - 5 min warm-up, 35 min aerobic exercises (rubber bands, weights, sticks, fitness steps and/or gym balls), 5 min cooling and stretching & 15 minutes local movements. 	<ul style="list-style-type: none"> -Body Image Concern Inventory 	<ul style="list-style-type: none"> - None 	<ul style="list-style-type: none"> - Results indicated the superiority of the experimental group. - Aerobic exercise caused a significant ↓ in body image concern. - Superiority of the experimental group in ↓ body image concerns. 	<p>Aboutaleb, P & Badami R, [2016]; (176)</p>
<p>To investigate body composition and body image of women doing CrossFit, Pilates and Zumba exercises.</p>	<ul style="list-style-type: none"> - Country: Not specified - Women -N = 80 - 42.74±8.47 yrs 	<ul style="list-style-type: none"> -Experimental - Control group (n=35) -Experimental group (n=45) -Pre-test -Post-test 	<ul style="list-style-type: none"> - Mixed exercises (CrossFit, Plates, Zumba). -High-intensity interval training & circuit weight training. - 4 x/ week. -Twelve weeks exercise intervention. -Target heart rate of 50-60%. 	<ul style="list-style-type: none"> - “Body Areas Satisfaction Scale” sub-dimension of the Multidimensional Body-Self Relations Questionnaire 	<ul style="list-style-type: none"> - None 	<ul style="list-style-type: none"> -Significant difference observed in body weight and BMI post intervention in the experimental group (P=0.00). -↑ body areas satisfaction in the experimental group. (P=0.00) -Body areas satisfaction of women having weight loss ↑. 	<p>Baştuğ, G, et al., [2016]; (2)</p>
<p>To investigate the effects of a 12-week self-efficacy intervention to increase exercise EE by boosting scheduling, physical, and exercise-worries self-efficacy in</p>	<ul style="list-style-type: none"> - Country: New Zealand - Overweight and obese women - N= 97 - 93% European ethnicity - BMI > 25 kg/m² - 37 yrs 	<ul style="list-style-type: none"> -Experimental - Randomized control design - Control group (N=50) -Intervention group (N=47) -Pre-test -Post-test 	<ul style="list-style-type: none"> - 12-week self-efficacy intervention -Intervention derived from social cognitive theory, comprising of 6 components. -The intervention required participants to formulate action plans for exercise outcome expectancies, goal setting, 	<ul style="list-style-type: none"> -None 	<ul style="list-style-type: none"> - Three measures of exercise self-efficacy were employed. - 1: Schedule efficacy. - 2: An 8-item measure to 	<ul style="list-style-type: none"> -The intervention ↑ schedule, physical, exercise-worries efficacy, and energy expenditure in the previously inactive group. 	<p>Buckley, J [2016]; (6)</p>

overweight and obese women.			<p>relapse management, and exercise self-incentives.</p> <ul style="list-style-type: none"> -Complete study-related self-report measures of scheduling, physical, and exercise-worries self-efficacy at baseline, week 6 and week 12. - Exercise status was assessed with two items each with a yes or no rating scale. - The daily exercise log required participants to record the type, duration, and rate of perceived exertion (intensity) for all exercise they undertook during the 12-weeks. 		<p>assess exercise related worries self-efficacy.</p> <ul style="list-style-type: none"> -An 18-item for constructing self-efficacy scales to assess confidence in physical ability for exercise 		
To compare the influence of endurance and endurance strength training on stress, self-esteem, body-esteem and eating behaviour in women with obesity.	<ul style="list-style-type: none"> - Country: Poznań -Outpatient internal medicine clinic -Obese (BMI\geq30kg/m²) 	<ul style="list-style-type: none"> - Randomised control trial - Group A (N=22) - Group A (N=22) 	<ul style="list-style-type: none"> - 12 weeks exercise intervention -Anthropometric measurements Diet unchanged. - 3x/week -36 training sessions -Group A: Endurance training (60 min; 50%- 80% (%HR_{max})) -Group B:Endurance strength Training (60 min; 50%- 860% (%HR_{max})) 	<ul style="list-style-type: none"> - Figure rating scale (Stunkards) -Body shape questionnaire 	-None	<ul style="list-style-type: none"> -The only significant difference was emotional eating. -High self-esteem ↑ in both groups. - Significant changes in anthropometric parameters were observed in both groups. 	Bak-Sosnowska, M. et al., [2021] (22)
<p>Abbreviations: Sample size (N); Body mass index (BMI); Kilograms per metered square (kg/m²); Years (yrs); Maximum Heart Rate (HR_{max}); Body Image Satisfaction Questionnaire (BISQ); Resistance training (RT); Flexibility training (FT); Multidimensional Body Self-Relation Questionnaire (MBSRQ); American College of Sport Medicine (ACSM); Body Areas Satisfaction Scale (BASS); Minutes (min); Heart Rate (HR);</p>							

2.8 EXPERIENCES FROM PARTICIPATING IN AN EXERCISE INTERVENTION

There appears to be limited literature on the perceptions of participating in an exercise intervention in the African continent, particularly among low-resourced communities. Recent findings from a study exploring the influence of an exercise intervention on the perceptions and knowledge of modifiable risk factors for NCDs among women from a low-resource setting in SA showed that health exposures and cultural traditions influenced the participant's perceptions about PA (162). Furthermore, participants reported fear of injury as a barrier to PA engagement, particularly the lack of knowledge of safe activities, but enjoyed the group exercise sessions (162). Even though the above-mentioned study audio recorded the FGDs and collected the data at 3 points in time during the 12 weeks exercise intervention, it presented with some limitations, such as the lack of IDI (162). Human behaviour is influenced by collective behaviour and thought, thus conducting IDI is important for understanding the importance of an individual's behaviour (195). Semi-structured questions form an important aspect of FGDs and IDIs. Semi-structured questions combine some structured questions to obtain basic information with other questions that permit more flexible answers to convey ideas and /or perceptions in an open ended manner (195). Furthermore, it is important to thoroughly interrogate the barriers of engaging in exercise interventions during FGDs and IDIs, such information is critical for providing guidelines for future interventions and to ensure practicality and sustainability of future exercise interventions in low-resourced settings.

Perceived barriers to exercise and healthy eating among women from disadvantaged communities in HICs has been documented in literature (198, 199). Focus group discussion findings from African America women living with obesity from disadvantaged neighbourhoods in the USA highlighted that insults from strangers about their body size, feelings of intimidation and embarrassment about not being able to complete exercises due to their body size were some of the barriers to exercise (198). In addition, cost, childcare, lack of

time and low awareness of available PA and/or exercise offerings are some of the barriers to PA reported by individuals from low socioeconomic setting in the UK (199).

On the other hand, some studies have reported weight loss as the primary motivation for participation in exercise (200). Following a UK based 12-week aerobic or resistance-exercise program among men and women living with overweight and obesity (± 40.7 years) the views and attitudes was that weight loss was the primary motivation for participating in the exercise intervention (200). Additionally, the women perceived a failure to lose weight as strongly affecting their motivation to continue or re-engage in exercise and a lack of knowledge of how to perform certain exercises also emerged as a barrier (200).

Weight loss as the primary motivation for participation in exercise interventions was also reported in another study examining the experiences of youth (aged 14 to 18 years) living with obesity during their participation in the Healthy Eating, Aerobic and Resistance Exercise in Youth (HEARTY) in Canada (201). Findings from the above-mentioned study reported that exercise behaviour was influenced by a sense of achieving results and by family and peers (i.e, supportive comments) (201). On the other hand, intrinsic reasons for exercise initiation have been reported by other studies (202). Another study examining the effects of group-based high-intensity functional training compared to moderate-intensity aerobic and resistance training among physically inactive young (± 28 years) women with obesity reported mostly intrinsic reasons, such as enjoyment for exercise initiation (202). Extrinsic factors such as physical appearance have also been reported to be one of the motivating factors for young women to participate in physical activities (203).

2.9 FACTORS THAT DETERMINE ADHERENCE TO EXERCISE TRAINING

Weight loss and muscle tone are shown to be some extrinsic motivating factors for participating in exercise training (204). Extrinsic motivation is defined as participating in a behaviour for external rewards (204) and is one of the motivations found within the Self-Determination Theory (SDT) (205). According to McLachlan and colleagues (204), in Self-Determination Theory, behaviour is driven by three fundamental psychological needs, including the needs for competence, autonomy, and relatedness (204). Furthermore, within the SDT there are multiple constructs such as autonomy support, psychological needs and motivation that explain the PA behaviour change process (205). Autonomy support refers to one's perception of their social environment to the extent to which it provides choices and options, acknowledges one's opinion, and provides rationale when suggesting choices. Higher levels of autonomy are reported to positively influence one's psychological needs for autonomy, competence, and relatedness (205). Satisfaction of these three psychological needs (autonomy support, psychological needs and motivation) tend to lead to greater levels of self-determined motivation (205).

Additionally, within SDT a conceptual distinction is made between motivation and goal content, whereas motivation focuses on the "why" or reasons underlying behavioural engagement, goal content refers to the "what" or objective of goal striving (204). Sweet et al., have shown that self-determined individuals participate in exercise because they derive pleasure and satisfaction from it, while non-self-determined individuals do not have a meaningful relationship with being physically active (205). Results from a randomized controlled trial in women analysing the impact of a 1-year weight management intervention concluded that interventions grounded in the SDT can be successfully implemented in the context of weight management and facilitating exercise adherence (206). In addition, the intervention group showed significant weight loss (-7.29%,) and higher a volume of exercise

(+138 ± 26 min/d of moderate plus vigorous exercise; +2,049 ± 571 steps/d), compared to controls ($P < 0.001$) (206). Some authors argue that theory integration is essential because there is a need to move to a multi-theoretical understanding of physical activity (205). While others state that the use of theory-based intervention studies helps distinguish which components work to produce expected outcomes, and to what extent (206).

According to Sweet and colleagues, SDT is aligned to Self-Efficacy Theory (SET) as they are both based on the ideology that human beings are agents of their actions (205). Even though both these theories present with a similar metatheoretical ideology, they are said to present with differences in views (205). It is said that individuals act when they feel capable and able to attain the goal in the SET (205). On the other hand, autonomy plays a great role and that feelings of capability and competence are important in the SDT (205). A behaviour is said to be autonomous, by feeling a sense of determination and having the opportunity to choose, start or continue the behaviour (207). Additionally, from the perspective of the SDT, motivation for the persistence of an activity is retained when an individual's psychological needs are satisfied (176). The likelihood of executing and sustaining a behaviour is greater if an individual feels autonomous (205). The concept of self-efficacy in the SDT is a more distal factor to behaviour as it is assumed to have a direct relationship with self-determined motivation in place of behaviour (205). Dissimilarly, self-efficacy is said to have a direct influence on behaviour, thus making it a proximal factor in the Self-Efficacy Theory (205).

Self-efficacy refers to one's confidence to participate in exercise, overcome barriers, and organise time and responsibilities around exercise (205, 208). Self-efficacy measurement tools such as the GSE scale have been culturally adapted and validated in low-income settings such as Uganda (209). Self-efficacy comprises of the three domains, including (1) task self-efficacy; one's confidence to participate in exercise (205), (2) barrier self-efficacy; one's ability to

overcome barriers related to exercise and being physically active (205) and (3) scheduling self-efficacy; organise time and responsibilities around exercise (205). However, very little is known about the role of these factors in the context of the challenges that women from low socioeconomic settings encounter. It is said that task self-efficacy and scheduling self-efficacy may be important factors in promoting exercise behaviour because they are related to abilities integral to performing elemental dimensions of exercise and regulating schedules under challenging conditions (208).

According to the Social Cognitive Theory (SCT), self-efficacy is a focal determinant of health behaviour change, because it is the common pathway through which self-regulatory efforts influence health functioning (210). Furthermore, SCT comprises of core determinants such as knowledge of health risks and benefits of different health practices (210). It is said that knowledge of health risks and benefits creates the precondition for change (210). Whereas inadequate knowledge about the negative impact of a persons' lifestyle habits on their health may result in minimal behavioural changes (210). Beliefs of personal efficacy play a critical role in behavioural change (210). Furthermore, humans regulate their behaviour through self-evaluative reactions and engage in activities that give them self-satisfaction and self-worth (210). However, it is important to note that regulation of behaviour is not solely a personal matter, but it is also influenced by the availability of resources (210). Findings from a study that applied the SCT as a framework and reported that perceived self-efficacy and perceived social support emerged as the strongest determinants of bodyweight exercise (211). Moreover, perceived social support was shown to have a stronger direct effect on exercise behaviour for women than for men (211).

2.10 LITERATURE CONCLUSIONS

In summary, the studies presented in this dissertation demonstrate that Black SA women typically meet the recommended PA guidelines, with majority of their daily PA accumulated through walking. The research findings on the physical behaviours among this population also indicate that even though Black SA women meet the recommended PA guidelines, this does not prevent weight gain and the high prevalence of overweight or obesity among this population. Black SA women have indicated interest in group exercise sessions, but research report a low percentage of Black SA women participate in leisure time PA, which is usually achieved at MVPA. I am only aware of two exercise intervention studies that were conducted among young Black University women (156) and rural dwelling women (167), and they present with the following limitations; the intervention among the University women did not have a control group, both interventions did not objectively measures body composition such as the DXA, did monitor changes in physical behaviours, did not interrogate the changes in perceived body image and self-efficacy in response to the intervention, and did not explore the women's experiences and perceptions of the intervention (156, 167). Nonetheless, recent research by Makamu-Beteck and colleagues (162) explored the influence of an exercise intervention on the perceptions and knowledge of modifiable risk factors for NCDs among women from a low-resource setting. However, they did not thoroughly interrogate the barriers and facilitators of engaging in an exercise intervention. Furthermore, the effect of an exercise intervention on habitual physical behaviours, such as increased compensatory SB in response to the exercise intervention are not known among Black SA women from a low socio-economic setting.

CHAPTER 3

Methodology

3.1 ETHICAL APPROVAL AND CONSIDERATIONS

This study was conducted according to the Declaration of Helsinki guidelines involving human participants (212) research. Ethics approval for this study was obtained from the University of Cape Town Faculty of Health Sciences Human Ethics Committee (HREC/REF: 054/2015) for the larger (parent) study (Appendix A) and (HRE/REF: 049/2016) for the current thesis (Appendix B). The research assistants explained the purpose of the study to all participants in their preferred language. Thereafter, all participants were required to sign an informed consent form prior to screening and testing procedures (Appendix C). The trial was retrospectively registered in the Pan African Clinical Trial Registry (PACTR201711002789113).

3.2 RECRUITMENT OF PARTICIPANTS

With the assistance of two field workers, participants were recruited from Khayelitsha through advertisements on Facebook (Appendix D) and the distribution of recruitment flyers around the community and shopping malls (Appendix E). Participant recruitment and testing procedures occurred over 22-months, between July 2015 and April 2017. According to the 2015 City of Cape Town (Western Cape Province) socioeconomic profile, low socioeconomic areas are classified using average household income (213). Khayelitsha is classified as one of the low socio-economic areas in Cape Town, with only 31% of the participants earning more than 5000 South African Rands, equivalent to approximately 290 US Dollars (\$) a month (214). IsiXhosa is the most commonly spoken African language in the Western Cape Province. According to the South African 2022 census statistical release report (215), the total population in Khayelitsha township is 391,749 and 98.6% of the population is Black African.

3.3 SAMPLE SIZE DETERMINATION

The data reported in this thesis are secondary endpoints from the primary study. The main aim of the primary study was to explore the changes in insulin sensitivity in response to the 12-week exercise intervention (214). The sample size determination was based the study of Nordby et al (216) with a significance level of $p < 0.05$ and power of 80%. On the basis of the change in normalized glucose clearance (measured using a euglycemic hyperinsulinemic clamp) from pre- to postintervention (12-week aerobic training) compared with the nontrained control group (8.2 [SD 5.9] vs -1.8 [SD 6.2] mL/kg/min FFM/nmoL/L insulin, respectively), 6 participants per group would be required to detect a significant difference between groups (214), corresponding with numbers from Ortega et al (217). To account for the secondary outcomes using changes in skeletal muscle glucose transporter (GLUT)4 in response to a 12-week training program as the proxy (0.65 [SD 0.69] vs 0.01 [SD 0.69] AU for training vs control group), 18 women would be required to detect a difference between groups (217). Based on a dropout rate of 10% (2/20), 20 participants per group was selected on the basis of these calculations.

3.4 SCREENING

Inclusion criteria for the current study was : i) self-reported ancestry isiXhosa speaking (both parents) Black South African women between the ages of 20-35 years; ii) living with overweight or obesity ($BMI \geq 25$ kg/m²); iii) weight stable (weight not changed more than 5 kilograms (kg) or no change in clothes size over the past 6 months); iv) sedentary (not participating in exercise training of >1 session of >20 min per week within the last 12 months) ; v) on injectable contraceptive (depot medroxyprogesterone acetate, 400 milligrams (mg), we standardised the contraceptive method as the most commonly prescribed in a South African cohort for a minimum of 2 months (218) ; vi) no known metabolic or inflammatory diseases; vii) no hypertension ($\geq 140/90$ millimetres of mercury (mmHg)), diabetes (random plasma

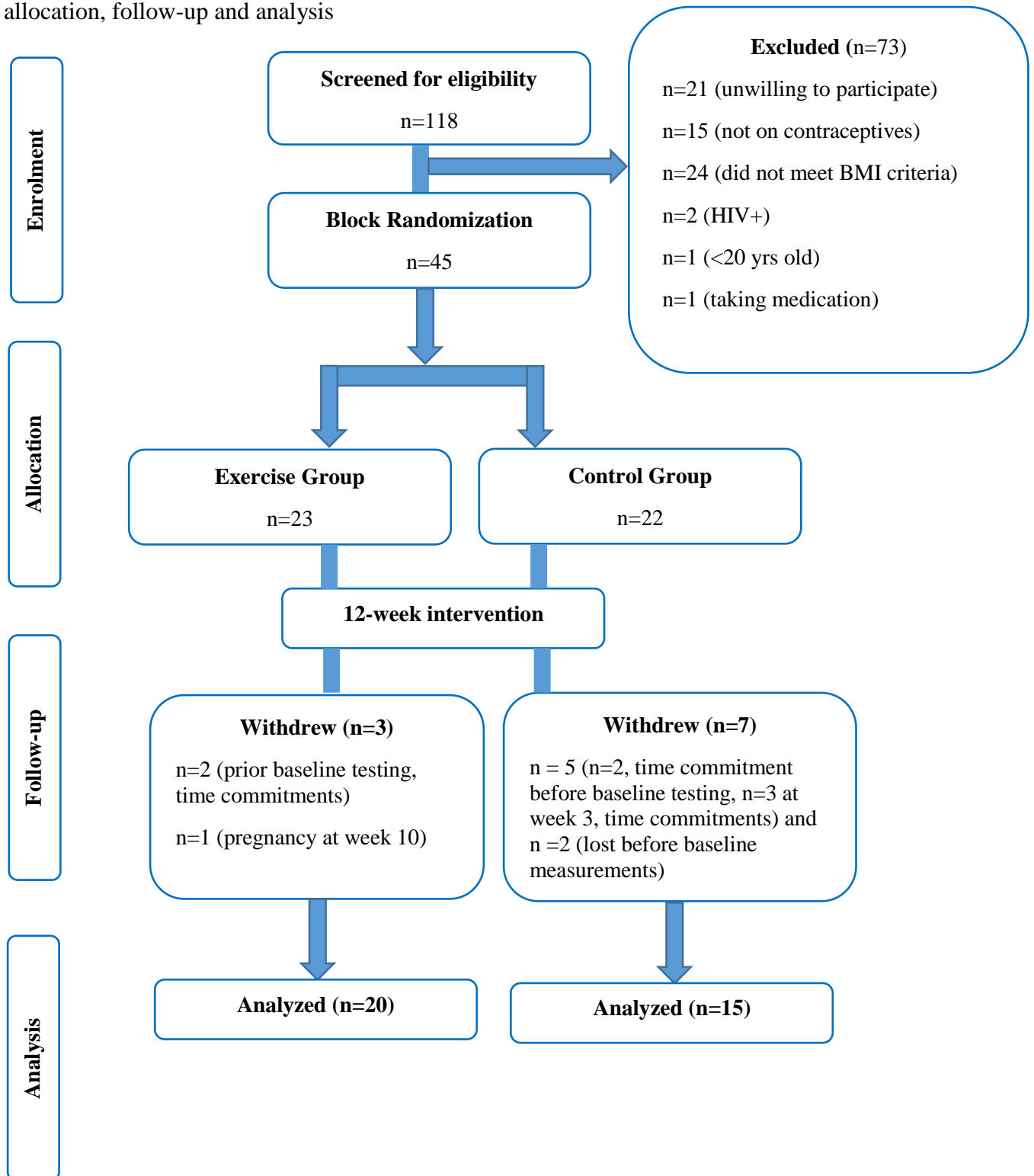
glucose concentration of >11.1 millimoles per litre (mmoL/L)), HIV or anaemia (hemoglobin (Hb) <12 g/dL) ; viii) not taking any medications; ix) non-smokers; x) not currently pregnant or lactating; xi) no orthopaedic or medical problems that may prevent exercise participation; xii) no surgical procedures within the last 6 months (214).

Participant screening took place at the David Flude Memorial Church hall in Khayelitsha (Western Cape Province, South Africa). Figure 2 below outlines the assessment of participants for eligibility, enrolment, study design, intervention, allocation, follow-up, and analysis. During the assessment of participants for eligibility, the researcher and research assistant explained the purpose of the study to all participants in their preferred language. Participants were required to complete the physical activity readiness questionnaire (142) (Appendix F). The purpose of completing this standard pre-exercise questionnaire was to assess the participants' risk for participating in an exercise programme (142). Participant who answered 'yes' to any of the questions were excluded from the study. For the HIV screening, pre- and post-test counselling was conducted by a trained counsellor fluent in English and IsiXhosa. A (rapid anti-HIV [1&2]) test, Advanced quality (InTech Product, Xiamen Chana) test kit using needle prick was used to conduct the testing. Participants presenting with a positive HIV test were excluded from the trial and referred to a local HIV clinic for management.

Body weight was measured in light weight clothing, on a portable electronic scale (BW-150, NAGATA, Tainan, Taiwan). Height was measured without shoes in a Frankfort plane using a stadiometer (3PHTROD-WM, Detecto, Missouri, USA). Both weight and height measurements were recorded to the nearest 0.1 kg and 0.1 cm, respectively. Body mass index was calculated as weight in kilograms divided by the height in meters squared (kg/m^2) (219). Furthermore, body mass index was classified according to the WHO guidelines: overweight was classified as BMI between 25-29.9 kg/m^2 and obesity $\geq 30 \text{ kg/m}^2$ (8).

Blood pressure was measured in a seated position, 3 times at 1-min intervals using an automated blood pressure monitor (Omron 711, Omron Health Care, Hamburg, Germany). The means of the final 2 measurements for systolic and diastolic blood pressure were used in statistical analyses. Hypertensive participants were excluded from the trial, hypertension was defined as SBP and/or diastolic blood pressure (DBP) $\geq 140/90$ mmHg (142). Overnight Fasting (10-12 hours) venous blood samples were drawn from all the participants' antecubital vein at baseline (pre-intervention) and after 12 weeks (post-intervention) for the analysis of glycosylated haemoglobin (HbA1c). Participants with a HbA1c $>6.5\%$ were excluded from the trial as this is an indication diabetes (220).

Figure 2: Consort diagram outlining the screening of participants for eligibility, enrolment, allocation, follow-up and analysis

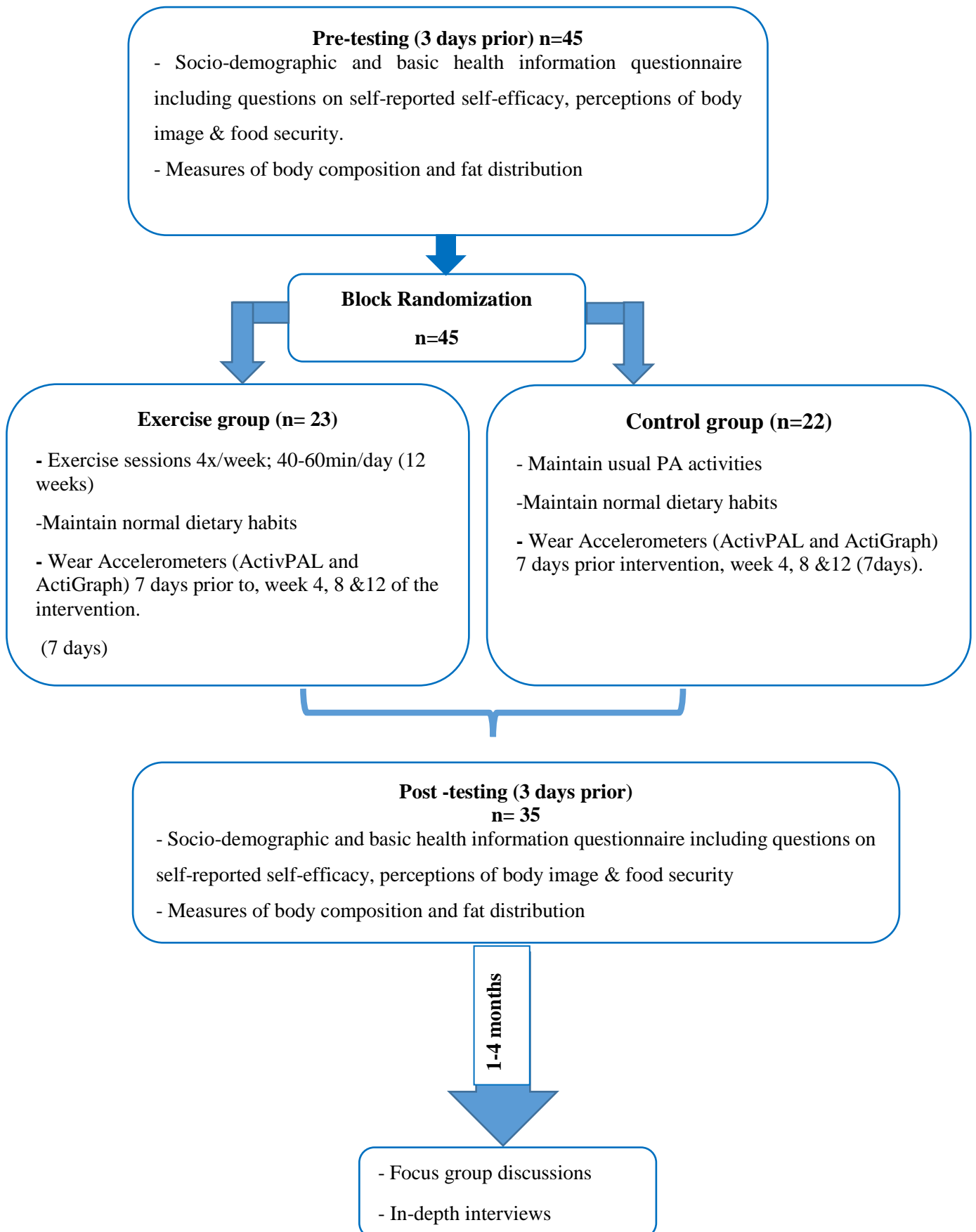


3.5 STUDY DESIGN

As shown in figure 3, this was a randomized controlled study. The randomized controlled trial design was chosen to address the main aim of the primary study, which was to explore the changes in insulin sensitivity in response to the 12-week exercise intervention. This thesis reports on the secondary outcomes. The principal investigator conducted block randomization (Microsoft Excel, 2013) after the participants completed the pre-intervention screening to ensure that researchers performing the testing were blinded to group allocation. Forty-five women met the inclusion criteria and were block randomised (2-4 participants) into either an exercise group (n=23) or a control group (n=22). Pre and post intervention quantitative measurements took place 3 days before and 3 days after the intervention. Focus group discussions and IDIs were conducted 1-4 months after the completion of the 12-week intervention to ensure that there were enough participants for each group discussion. As shown in figure 3, all participants (n=45) were invited to participate in FGDs and IDIs post intervention.

Quantitative measurements comprised of body composition and fat distribution, socio-demographic and a basic health information questionnaire including questions on self-reported self-efficacy and perceptions of body image. Participants were also issued with accelerometers to wear for seven consecutive days on week 0, 4, 8 and 12 for the purpose of monitoring habitual PA and SB. Both the control and exercise group were advised to maintain their normal dietary behaviour, while only the control group participants were asked to maintain their normal physical behaviours throughout the 12-week study period. Following the completion of the intervention, the control group were offered the opportunity to participate in 12 weeks of exercise-training.

Figure 3: Schematic overview of testing procedures



3.6 SOCIO-DEMOGRAPHIC AND BASIC HEALTH INFORMATION

QUESTIONNAIRE

An isiXhosa speaking field worker administered the socio-demographic, behavioural and basic health information questionnaire (Appendix G) at baseline and post the intervention. This questionnaire included questions on age, ancestry, exercise training, and measures on SES which includes asset index, household density, food security, educational status and current employment status. Electricity in the home, ownership of a television, radio, motor vehicle, fridge, stove/oven, washing machine, telephone, video machine, microwave, computer, cellular telephone and paid television channels (MNET or DSTV) was used to determine the individual's household wealth and resources, also referred to as the Asset Index (31). The number of persons in the household divided by the number of rooms was used to define household density (31, 39).

Education status (last standard passed) was categorised into 2 categories, 0- no higher education and 1- enrolled for higher education. The no higher education category included those participants with no formal education until grade 12. Employment status was categorised into 3 categories, 0-student; 1- formal and informal employment and 2- unemployed. Home type was categorised into either 1- house and 2- shack (informal house). Marital status was categorised into either 1-married and 0-unmarried (single, divorced and living with partner). Behavioural factors included self-reported smoking status (smoker or non-smoker). Frequency of alcohol consumption in a 4-points ordinal scale ranging from "Never", "monthly or less" to "2-4 times per week". Family history of disease and obesity was indicated by the following: "Yes", "No" and "don't know".

3.7 PERCEPTIONS OF BODY IMAGE

Body image perception was assessed pre and post the 12-week intervention using a set of nine silhouettes (Appendix G), also known as figure rating scales (FRS) (22) as presented in figure 4. These silhouettes have been validated in South African women previously (189). The participants were required to choose a silhouette that best represented the following:

- i) Their current body size (feel silhouette)
- ii) Their ideal body size (ideal silhouette)
- iii) A normal weight person
- iv) A thin person
- v) A person with obesity.

A 'Feel-Ideal' Discrepancy (FID) score, which measures body size dissatisfaction, was calculated by subtracting the 'ideal' from the 'feel' silhouette (186). A discrepancy score between perceived and actual weight (PAD) was calculated by subtracting the silhouette representing actual BMI status (Figure 4) from the 'feel' silhouette (190). A negative PAD score represents underestimation of weight status, a positive PAD score represents an overestimation of weight status, and a zero PAD score represents the accurate perception of weight status (190). In addition, participants were asked to classify their body weight status as either underweight, normal weight, overweight or obese.

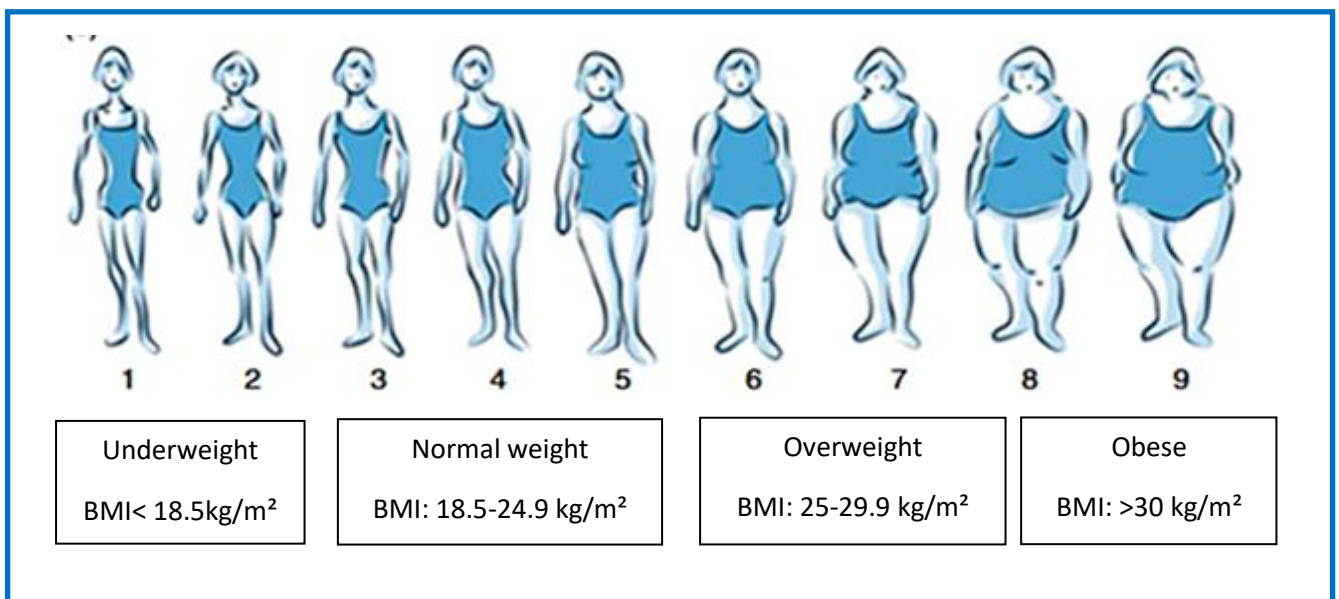


Figure 4: Stunkard's silhouettes body image rating scale for women (188)

3.8 GENERALIZED SELF-EFFICACY

Perceived self-efficacy was measured by means of the Generalized self-efficacy (GSE) scale (Appendix G) developed by Schwarzer and Jerusalem (221), comprising of 10 questions with four possible answers: (1) "Definitely not"; (2) "Disagree"; (3) "Agree slightly" and (4) "Exactly true". The scores for each of the 10 items are added to indicate a total score (221). Higher scores indicate that the individual possessed a higher GSE (221). Generalized self-efficacy is a belief of one's competency to cope with broader range of stressful or challenging demands, while self-efficacy is understood to be either task or domain specific (7). In addition, GSE is reported to reflect a generalization across various domains of functioning in which people use to judge how successful they are (7). The GSE scale has been used in other low-income settings such as Uganda where it was culturally adapted and validated (209). Findings from the above-mentioned study reported promising psychometric properties, but recommended that larger studies with repeated measures be conducted to further assess the adapted scale's factor structure, validity, reliability and stability over time (209).

3.9 DIETARY INTAKE

Dietary intake was measured by a registered dietician using a 24-hour recall (Appendix G) and a 3-day dietary record, including 2 weekdays and 1 weekend day (214) and the 4 days were averaged. In addition, a food frequency questionnaire was administered before and following the intervention (214). Nutrient intake was calculated using the South African Food Composition Database System (South African Food Composition Database, South African Medical Research Council), Cape Town, South Africa.

3.10 HOUSEHOLD FOOD INSECURITY

The current study used the household food insecurity access scale (Appendix G) for the measurement of food security (222). According to Altman and colleagues (223), food security is multidimensional in nature and changes over time, thus making accurate measurement. Furthermore, it is important to note that there is no regulated, specific or accepted ways of monitoring food security in SA (223). However, the household food insecurity access scale has been used in the South African National Health Survey (224). The household food insecurity access scale comprises of 9 generic questions on concerns around access and availability of food with a recall period of 30 days (222). Participants who answered “No” to any of the questions were required to proceed to answer the next question (222). Participants who answered “Yes” to any of the questions were requested to describe the frequency, with answers ranging from “rarely”, “sometimes” and “often” (222). The household food insecurity access scale yields 4 types of indicators that can be calculated to help understand the characteristics and changes in household food insecurity (access) in the surveyed population (222). These indicators provide information on (1) household food insecurity access-related conditions; (2) household food insecurity access-related domains; (3) household food insecurity access scale score and (4) household food insecurity access prevalence.

The household food insecurity access prevalence indicator is used to report household food insecurity (access) prevalence and make geographic targeting decisions (222). This indicator categorizes households into four levels of household food insecurity (access): 1= food secure; 2= mildly food insecure access; 3= moderately food insecure access and 4= severely food insecure access (222). In this thesis, food secure and mildly food insecure variables were grouped and moderately food insecure to severely food insecure variables were groups to report food security as a binary outcome.

3.11. MEASUREMENTS

3.11.1 Anthropometry and DXA-derived body composition

Height, weight and BMI were collected as described above. Waist circumference was measured with a tape measure at the level of umbilicus, and hip circumference at the largest protrusion of the buttocks to the nearest 0.1 centimetre (cm) (214). Baseline and post intervention sub-total body composition (whole body composition minus head) including FM and fat-free soft tissue mass (FFSTM), were measured using DXA (DXA, Discovery-W, software version 12.7.3.7; Hologic, Bedford, MA, USA) according to standard procedures. Participants whose body proportions exceeded the DXA scanning area were analysed using the arm-replacement method, which applies the replacement of data obtained for the left arm with the data obtained for the right arm (225). Abdominal subcutaneous visceral adipose tissue (SAT) and visceral adipose tissue (VAT) areas were estimated from DXA as previously used in other studies comprising of a similar population (226). The DXA measure of VAT has been shown to perform as well as a clinical read of VAT from a computerised tomography scan (227). All scans were performed by the same qualified radiographer.

3.11.2 Cardiorespiratory fitness

Cardiorespiratory fitness was determined by measuring the VO_{2peak} , the maximum amount of oxygen that an individual can utilize during intense or maximal exercise (142) using a walking treadmill-based, graded exercise test (C, Quasar LE500CE, HP Cosmos, Nussdorf-Traunstein, Germany). Prior to the exercise test, participants were familiarized to the equipment. Heart rate was monitored throughout the exercise test to determine the peak heart rate (HR_{peak}) (142) (Polar A300, Kempele, Finland). The first 6 minutes of the exercise test was based on a modified Bruce protocol (228) to obtain three stages of steady state metabolism. Subsequent minutes were designed to obtain VO_{2peak} using a ramp protocol, adapted from Takagi et al (229). The exercise test began at 3 km/hr at a 2% gradient for 2 minutes. The gradient increased by 2% for a further two 2-minute segments. The following stages increased by 2% gradient every minute until 16% gradient was achieved. Thereafter, an alternate increase in speed (0.5 km/hr) and gradient (1%) was applied until volitional exhaustion. This protocol was used as it was deemed appropriate given that at baseline, the participants were physically inactive and reported being unfamiliar with gym-based exercise equipment.

3.11.3 Accelerometry

At baseline, and weeks 4, 8, and 12 of the intervention, PA and SB were measured simultaneously using accelerometers ActiGraph (ActiGraph GT3X+, ActiGraph LLC, Pensacola, Florida) and activPAL; (activPAL 4 micro, PAL Technologies, Glasgow, UK, Figure 5) for seven consecutive days, 24 hours a day (197).



(a) GT3X+ Actigraph



(b) activPAL 4



(c): Participant wearing the GT3X+ accelerometer and ActivPal simultaneously

Figure 5: (a): Example of the GT3X+ ActiGraph; (b): ActivPAL4 and (c): participant wearing the accelerometers and simultaneously.

Participants were instructed to wear both the devices at all times, however, the ActiGraph needed to be removed during water activities such as bathing and swimming. The activPAL4 was worn on the thigh under a Tegaderm dressing to provide permanent waterproof attachment without removal. During the first visit, participants were educated on proper placement and use of the accelerometers. The GT3X+ ActiGraph accelerometer was worn around the waist on the

right mid-axillary line of the hip, attached via an elastic waist band (230). Each GT3X+ ActiGraph accelerometer was initialised at a sampling rate frequency of 60 Hz (1 min Epoch) using the ActiLife v.6.10.1 software (230). Data collected within short epoch time provides exposure information at the highest resolution and can be summed up into longer epochs (95). Even though the inclinometer feature of the GT3X+ ActiGraph is able to detect sitting, standing and lying positions (230). The GT3X+ ActiGraph also provides acceleration in three individual orthogonal planes; vertical, anterior-posterior and medio-lateral and provides activity counts as a composite vector magnitude of these three axes (100). The device was set to start collecting data on the day of fitting and was returned after seven consecutive days of wear.

The ActivPAL4TM has a sampling frequency of 10 Hz (139) was used to measure time spent sitting, standing and stepping (111), and sit to stand transitions (114). The ActivPAL4 is designed to be worn on the mid anterior thigh (99). The ActivPAL is regarded as the gold standard for measuring SB (96) and has also been shown to be more accurate than both waist- and wrist-worn ActiGraphs for determining both sitting, standing activities (231), stepping time (99) and step counts in adults (232-234). The ActivPAL is reported to be accurate in the measurement of breaking up prolonged sitting time (how often a certain amount of sedentary time is interrupted with activity) (231). This device has an inbuilt inclinometer that is able to determine posture (i.e. whether the wearer's thigh is horizontal, as in sitting or lying, or vertical as in standing or walking) (139). Differentiating between standing and sitting or lying is an important component of understanding and quantifying SB (235).

3.11.4 Accelerometry analyses

The ActiLife v.6 software (Pensacola, FL; USA) was used to analyse the GT3X+ ActiGraph PA data. Participants completed a sleep log diary to record their daily sleep and wake up times (Appendix H). This was used to exclude sleep time when quantifying daily sedentary time. Research has indicated that it is difficult to make conclusions regarding total time spent lying awake or asleep without a self-report log for sleep time (230). Each day was visually inspected together with the sleep diary for sleep and wake up times, to calculate the awake time for all the participants, as shown in figure 6. Only SB from awake time (and not sleep time) was reported in this study. Non-wear time was identified as a period of consecutive zero counts, suggesting that the device had been removed, and zeros were removed from data analyses (95). Non-wear time was subtracted from the 24 hours wear time in order to determine total wear time (119).

Where the device was given to the participants in the middle of the day and the device was set to start collecting data on that day, the first day of wear was excluded as it was deemed a familiarisation day and was not representative of a typical day. Where devices were set to start collecting data from midnight, the first day was not excluded. Participants were excluded from data analysis if they had less than three days of at least 600 minutes per day (10 hrs/d) (101, 119), following the removal of nocturnal sleep and non-wear periods. Where the devices were worn for more than 7 consecutive days and nights, the first 7 valid days (not necessarily consecutive) were used for analysis. For participants in the exercise group, a data set was included if the data set comprised a minimum of at least one non-exercise day and one exercise weekday. For participants in the control group, a data set was included if the data set comprised a minimum of two days.

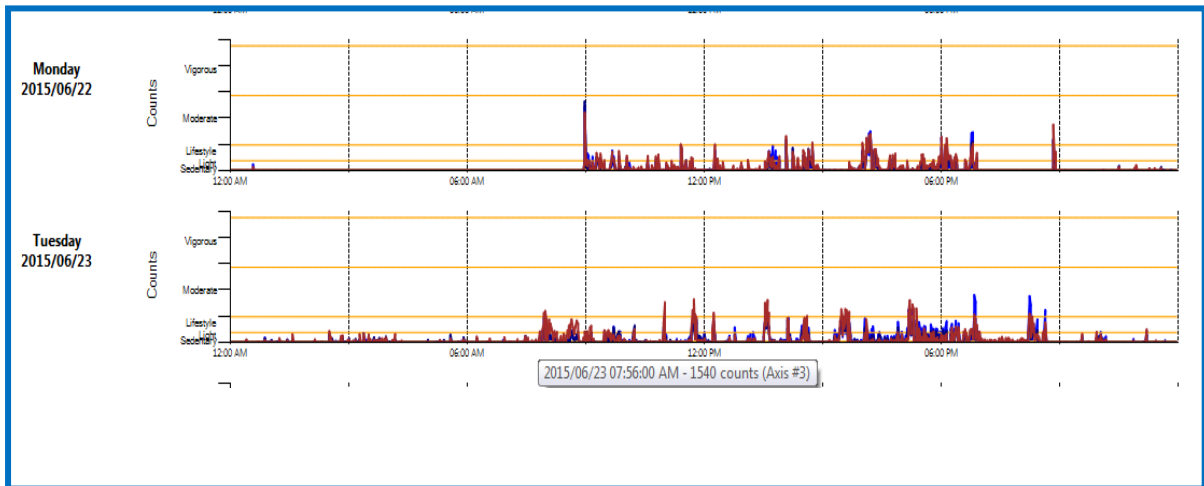


Figure 6: Example of the waist worn GT3X+ ActiGraph accelerometer output during visual inspection.

The ActivPAL analyses (v.8.11.1.49 software PAL Technologies Limited, Glasgow, UK) used CREA-enhances algorithm to analyse daily step counts, number of sit-to-stand transitions, total time spent in sedentary bouts of more than 30 and 60 min, total time spent sleeping (primary lying time), napping (secondary lying time), sedentary (sitting or lying) standing and stepping (Figure 7).

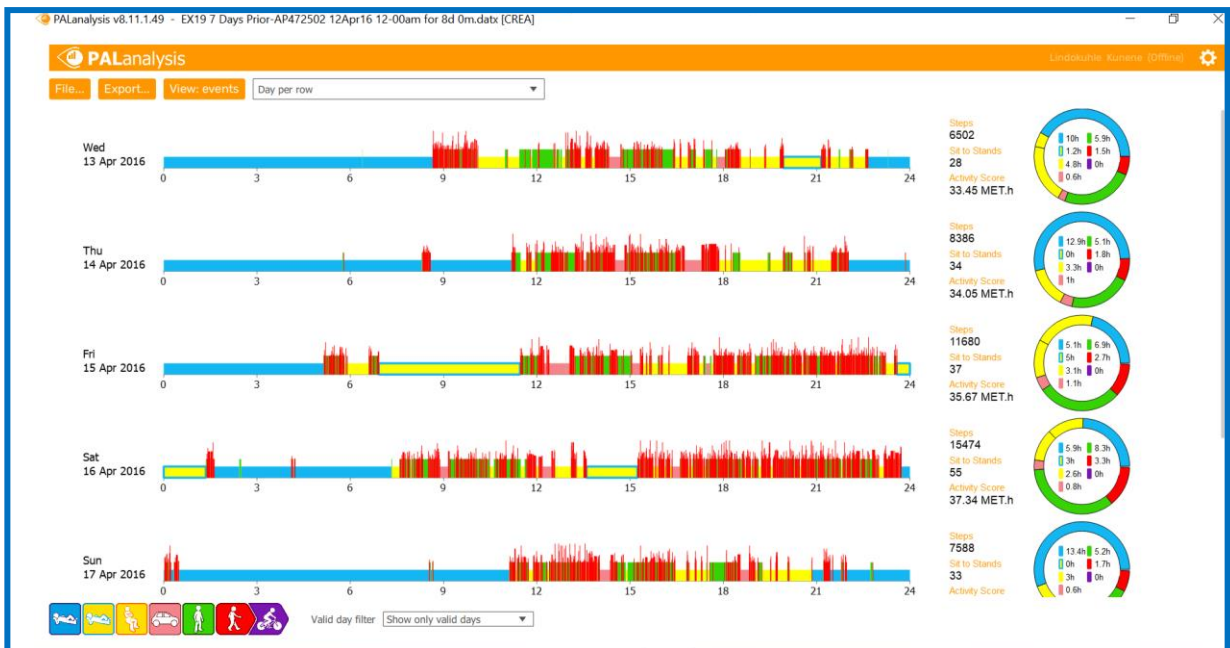


Figure 7: Example of the posture detection thigh-worn ActivPAL sedentary behaviour output.

Accelerometry data was explored as a total minute in each PA intensity and SB and reported in min/d. The current thesis also considered accelerometry data as each individual day of data (i.e., participants with seven valid days of data had all seven days considered in the model; averages were not used for the analyses).

3.11.5 Objectively Measured Physical activity and sedentary time cut off points

The Troiano cut points were used to categorise PA (119), 100-2019 cpm was categorised as LIPA, 2020-5998 cpm classified as Mod PA and >5998 cpm categorised as Vig PA (119). Moderate-to-vigorous physical activity was determined by the average of the combined Mod PA and Vig PA. While total physical activity was determined by adding LIPA and MVPA (i.e., all activity ≥ 100 cpm). Sedentary behaviour included all activity below the total physical activity threshold (< 100 cpm).

3. 12 EXERCISE TRAINING INTERVENTION PROGRAM

This 12-week exercise training intervention was structured in a staggered manner with 2-5 participants starting the intervention every week. The exercise sessions were conducted in a group setting and supervised by a Biokineticist (Exercise Physiologist) registered with the Health Professions Council of South Africa at the David Flude Memorial Church hall in Khayelitsha and Sport Science Institute of South Africa, University of Cape Town.

As shown in Table 5, the exercise intervention structure comprised of continuous aerobic training (70-85% HRmax) and resistance training (60-70% HRmax) 4 days per week. The exercise training sessions started at 40 minutes per session on the first week and progressing to 60 minutes per session on week 12 for the intervention group (Table 5). The exercise intervention design was based on the results from focus group discussions conducted in Black South African women who showed interest in participating in a community based exercise intervention and suggested exercises such as dancing, aerobics and lifting weights (46).

The group exercise sessions included 5-10 participants. The aerobic training component included dancing, running, skipping, and stepping, while the resistance exercises started with participants using their own body weight to perform exercises such as squats, lunges, push-ups. Participants then progressed to using equipment such as a 1 kg dumbbell on the last 6 weeks of the intervention to using 2.5 kg dumbbell on week 12 of the intervention. The respective exercises were altered to ensure progression and to maintain the required intensity throughout the 12-week intervention.

Heart Rate (HR) monitors (A300, Vantage NV, Polar, Finland) were used to monitor HR during every exercise session. Each HR monitor was marked with each participant's code in order to ensure that the correct HR was downloaded for each participant after every training session. The Biokineticist presenting the exercise sessions explained the purpose and function of the HR monitors to the participants. Furthermore, participants were constantly reminded to check their HR monitors during the exercise session to monitor if they were still training within the required exercise intensity. Participant were familiarised with the RPE Borg scale between 6-20 (236), which was collected from each participant 10 minutes after each training session. Exercise dose response was calculated by multiplying the percentage HR_{peak} with the number of attended exercise sessions. Participants were reimbursed for their transport costs to the training venue, their time for each completed exercise session, as well as the physiological testing. The control group participants were provided the opportunity to take part in the supervised exercise sessions post 12-weeks testing. Research has consistently shown that regular exercise increases CRF (17, 20, 149, 150), reduces cardio-metabolic risk factors such as obesity (2, 17, 20, 147, 149), abdominal obesity (17, 20, 147, 148, 156) and unfavourable lipid profile (147, 148, 156). Based on this knowledge it was deemed unethical to withhold this opportunity from the control group. Furthermore, the same re-imburement for time and inconvenience was afforded to the control group.

Table 5: The 12-week exercise training protocol, including number of repetitions, sets, duration and target intensity.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Duration (min)	40	40	40	40	45	45	50	50	55	55	60	60
Total aerobic time (min)	30	30	28	28	33	30	35	32	37	37	40	40
Total resistance training time (min)	10	10	12	12	12	15	15	18	18	18	20	20
Reps and sets	10 X 3	15 X 3	10 X 3 (1kg)	15 X 3 (1kg)	10 X 3 (1.5kg)	15 X 3 (1.5kg)	20 X 3 (1.5kg)	20 X 3 (1.5kg)	10 X 3 (2kg)	15 X 3 (2kg D)	10 X 3 (2.5kg)	15 X 3 (2.5kg DB)
Session Frequency	4 times a week											
Aerobic Intensity	70- 85% HRmax, monitored using the A300, Vantage NV, Polar Heart Rate Monitor											
Resistance Intensity	60-70 % HRmax, monitored using the A300, Vantage NV, Polar Heart Rate HR Monitor											

Min-minutes, HR_{max}- maximum heart rate, Reps- repetition, kg- weight of dumbbells in kilograms

3.13 FOCUS GROUP DISCUSSIONS AND IN-DEPTH INTERVIEWS

Focus group discussions and in-depth interviews were conducted 1-4 months after the completion of the 12-week intervention to ensure that there were enough participants for each group discussion. All recruited participants (n=45) were invited telephonically to participate in the FGDs and required to sign the focus group discussion and in-depth interview consent form (Appendix I) Participants who dropped out of the intervention (n=10) and participants in the control group who refused the opportunity to participate in the exercise training at the end of the study (n=7), were also contacted, with the intention to understand potential barriers relating to participating in the intervention. However, we were either unsuccessful in contacting these participants or they were not willing to participate. During the telephone recruitment for the FGDs, participants were informed that they would be remunerated with R50 South African Rands to cover their transport costs to the venue and R20 South African Rands to compensate for their time and inconvenience.

Participants who seemed to have the strongest opinions during the FGDs were invited to participate in the IDIs, optimising the opportunity to further explore the themes identified and adding to the richness of the information collected during the FGDs (237). The moderator and the scribe selected these participants in a debriefing session after each FGD using the notes taken by the scribe to consider the flow of the group discussion and the contribution of the various participants.

The semi-structured FGDs (Table 6) were formulated by the research team based on previous qualitative work done in a similar group of women from the study community (46). The focus group questions were aimed at investigating the participants' perceptions about the exercise intervention, and barriers and motivators that might have influenced compliance during the exercise intervention. The interviewer allowed the participant to share her experiences of the

exercise sessions, while prompting her to elaborate on salient points arising from the focus groups. The voices of most of the participants were therefore heard and additional data was collected through the IDIs to ensure that all issues raised in the FGDs were adequately explored. The IDIs contained a single open-ended question to allow the interviewer to follow topical trajectories in the conversation, as well as provide the participants freedom to express their views in their own terms (238, 239). The purpose of the IDIs was to eliminate the influence of others' opinions that could have occurred during the FGDs (237). A trained facilitator and scribe who were fluent in both English and IsiXhosa, the vernacular of the study population, conducted all the FGDs and IDIs. This ensured that no participant was excluded from the FGDs because of language barriers (240).

The FGDs and interviews were audio recorded and a scribe made notes during the FGDs. The FGDs and IDIs were conducted at the data collection site and took between 45 and 60 minutes. No time restriction was set for these discussions and the duration was deemed appropriate for the number of participants in the FGDs and the question schedules. The audio recordings were transcribed from IsiXhosa into English by an independent translator, fluent in both English and IsiXhosa. The accuracy of the transcriptions both in tone and language against the notes taken by the scribe were checked.

Table 6: Focus group discussion and in-depth interview question schedules discussion open-ended guide questions.

Number	Focus group discussion qquestions
1	Can you please briefly share with us what you have been up to since we last saw you?
2	What is the first thing that comes to mind when you hear the word ‘exercise’?
3	What are your perceptions about exercise?
4	What are some of the things that influenced you to attend the exercise sessions? This can either be barriers or motivating factors.
5	What did you like the most about the exercise sessions?
6	What did you not like about the exercise sessions?
7	How did the exercise training affect your daily life?
8	What did your friends and family have to say when they found out that you are exercising?
9	Is there anything that could be changed about the exercise training sessions to encourage you to continue exercising and for your friends and family to start exercising?
10	Of all the questions that were discussed today, is there one which you feel was the most important to you?
In-depth interview question	
1	How did you experience the exercise sessions?

Chapter 4

Changes in physical behaviour patterns in response to a 12-week exercise intervention in women living with overweight and obesity from a low- resourced setting.

4.1 INTRODUCTION

Low CRF is one of the strongest predictors of all-cause mortality and the development of NCDs (154, 155). There is indisputable evidence for the effectiveness of regular exercise for increasing CRF (17, 20, 149, 150), and reducing cardio-metabolic risk factors that include obesity (2, 17, 20, 147, 149), abdominal obesity (17, 20, 147, 148, 156) high blood pressure and an unfavourable lipid profile (147, 148, 156). Regardless, one in four adults do not engage in the recommended levels of PA (9). In response, ‘exercise is medicine’ was developed with the primary goal of targeting the implementation of interventions that will prevent, slow, stop and reverse the progression of chronic disease (157, 158). However, few exercise training studies to date have been conducted in developing countries (17-19, 160, 161, 174) and even less in low-resourced communities (156, 162-164). Women from low-resourced settings participate in low levels of leisure time PA (13, 39), which are usually performed at a moderate to vigorous intensity. Rather, women from low-resourced settings accumulate PA through walking for transport, which is undertaken at a low to moderate intensity (12-14). Cultural norms and fewer opportunities to access safe, affordable and appropriate opportunities to be active are cited as some of the contributing factors to insufficient PA amongst these communities (56). There is little data available on the changes in physical behaviour patterns in response to exercise interventions in these settings.

Studies exploring changes in PA and SB patterns in response to an exercise intervention have reported decreases in sedentary time (18, 174). This is of relevance as the recent PA guidelines by WHO have suggested that in addition to increasing PA, there should be a focus on reducing SB (83, 84). Sedentary behaviours have been associated with increased adiposity (241), risk of obesity (133, 242), T2DM (133, 243) and MetS (244-247). Despite abundant literature reporting on the adverse health effects of SB and recommendations by WHO, to date there is insufficient evidence to quantify a specific SB threshold (83, 84). Other studies exploring

changes in PA patterns in response to exercise interventions have also reported a shift in the composition of daily PA towards higher intensity activity and this occurred at the expense of a decrease in LIPA (248). A cross-sectional study of SA women from a low-resourced setting showed that reallocating 30 minutes of LIPA to 30 minutes of MVPA was associated with 1.8% lower total body FM (107). This research highlights the need for exercise interventions to target an increase in MVPA to improve CRF, reduce body FM and time spent in SB.

The primary aim of this randomised controlled trial was to evaluate the changes in PA and SB patterns in response to a 12-week aerobic and resistance exercise intervention among women living with overweight and obesity from a low- resourced setting. The secondary aim was to determine the associations between changes in PA and SB patterns with exercise dose, and changes in CRF and weight. We hypothesise that exercise training will increase TPA, particularly MVPA, which may result in less time spent in SB among the exercise intervention group compared to the non-interventional control group.

4.2 METHODS

Detailed methods on the collection of all variables reported in this chapter are outlined in the methods section (Chapter 3). Briefly, forty-five women met the inclusion criteria and were randomised into either an exercise group (EXE; n=23) or a control group (CON; n=22). The EXE group attended four weekly combined aerobic and resistance exercise training sessions over a 12-week period. Questionnaires were used to collect information on age, ancestry, exercise training, and measures on SES which includes asset index, household density, food security, educational status and current employment status. The household food insecurity access scale was used to measure food security (222).

The training load of every session was monitored with a HR monitor and RPE Borg scale (6-20) scale (236). Percentage of maximum heart rate and RPE data were recorded for each

session. Exercise dose was calculated as the mean %HRmax from all completed sessions multiplied by the number of exercise sessions completed. Heart rate is often presented as a percentage of age-predicted maximum HR (249) and the current study used the traditional formula for age-predicted HRmax of $220 - \text{age}$ (250). Pre and post intervention CRF and body composition were determined by measuring $\text{VO}_{2\text{peak}}$ and DXA scan, respectively. Accelerometers were used to measure PA (ActiGraph GT3X+) and SB (ActivPAL) and were worn simultaneously for seven days at baseline (week prior to exercise training), and again during weeks 4, 8, and 12 of the intervention. Duration (minutes) and proportion of time (%) spent in each physical behaviour are reported.

For the ActiGraph data, Troiano cut-points were used to categorise physical activity into LIPA, MVPA, and TPA (119), and the proportion of time spent in the PA intensities was quantified. Various ActiGraph cut-points are used to determine LIPA in adults, with some studies classifying LIPA as 100-1951 cpm (39, 116, 117), while others classified it as 100-760 cpm (118) and 100-2019 cpm (16). LIPA is also defined as the intensity range between SB and moderate intensity, comprising of activities with 1.5–2.9 METs (81).

The ActivPAL variables of interest included steps, total sitting time, number of sit-to-stand transitions, number of sitting bouts and time spent in sitting bouts (30-minute and 60-minute). Physical activity and SB variables were further differentiated into exercise days and non-exercise days. Exercise days only included weekdays as this is when the exercise sessions were hosted. Non-exercise days included both week and/or weekend days. Exercise adherence is presented as number and percentage of sessions attended over the 12-week intervention.

4.3 STATISTICAL ANALYSIS

Statistical analyses were performed using STATA (v.13, STATA Corp, College Station, TX). Statistical significance was set at an alpha level of $p \leq 0.05$. The Shapiro-Wilk test with visual inspection of the data distribution was used to assess normality of the continuous data. Continuous data are presented as mean \pm standard deviation if normally distributed (PA and SB data). The median (25th - 75th percentile) are presented for skewed data such as FFSTM. Fischer's exact was used to analyse the difference between groups in categorical variables such as employment status, educational status, marital status and food security at baseline.

T-test for independent samples was applied to assess the difference in normally distributed continuous variables between groups. While Mann-Whitney U test for independent variables was conducted to analyse the difference in skewed continuous variables between groups. A two-way repeated measures analyses of variance was conducted to determine main and interaction (group x time) effects of the exercise intervention on body composition and CRF. Repeated measures mixed models were used to assess the change in all PA and SB variables of interest over time (baseline, weeks 4, 8 and 12) between groups. For these analyses, averages were not used, rather to capture the variation in the data, each individual day of data was considered a single data point (i.e., all valid seven days considered in the model) in the mixed models. Mixed models were run to compare the following:

1. CON vs EXE, all days considered.
2. CON vs EXE, non-exercise days only considered for EXE group.
3. CON vs EXE, exercise days only considered for EXE group.

Mixed models for all of the above (1, 2 and 3) included all four time points (weeks 0, 4, 8 and 12). To account for the three separate analyses conducted to explore the changes in PA and SB in response to the intervention, Bonferroni correction was applied and the statistical

significance was set at an alpha level of $p \leq 0.017$ ($p < 0.05/3$) for these analyses. Associations between the change in PA (LIPA, MVPA, steps) and SB (sitting time, time in 60-minute bouts) variables with exercise dose, and changes in CRF (VO_{2peak}) and weight (kg) were explored using Pearson and Spearman's rank correlations for normally distributed and skewed data, respectively. Post hoc power analysis was conducted for all valid days to determine if the main outcomes (SB, TPA and MVPA) were sufficiently powered based on the final sample size from both the EXE group ($n=20$) and CON group ($n=15$) and significance level of $p < 0.05$.

4.4 RESULTS

4.4.1 Participants characteristics

Participants were SA women from a low-resourced setting (Khayelitsha, Western Cape Province), aged 21-27 years and living with overweight and obesity. Details of the total number of recruited participants is illustrated in figure 2 under the methods chapter (Chapter 3). Briefly, forty-five women met the inclusion criteria and were randomised into either the EXE group ($n=23$) or CON group ($n=22$). During the 12-week exercise intervention, 3 participants from the EXE group withdrew from the study, 1 due to pregnancy while the other two withdrew due to time commitments, resulting in 20 EXE group participants completing the intervention. Seven CON group participants withdrew from the study, 5 due to time commitments, and 2 were lost to follow-up, resulting in 15 CON group participants completing the intervention.

The median (IQR) age of the participants included in the analyses was 22 (21-24) years with similar mean ages between the exercise and control groups (Table 7). There were no differences in any of the sociodemographic variables between the groups at baseline (Table 7). Majority of the EXE group (65%) reported being food secure to mildly food insecure, while majority of the CON group (73%) reported being moderate to severely food insecure with a significant difference between groups ($p=0.027$). Additionally, majority of the participants were

unmarried, unemployed, with a household income of \leq R10 000 (<US\$541.21) a month and staying in a brick house (formal housing). There was no significant difference in education level between the groups ($p=0.234$). No significant differences were observed in alcohol intake between the groups ($p=0.480$).

Table 7: Sociodemographic characteristics of the participants in the exercise intervention and control group.

Variables	EXE Group (n=20)	CON Group (n=15)	P-value
Age (years)	22 (21-24)	23 (21-27)	0.764
Household density	1.1±0.4	1.4±0.7	0.176
Asset Index	7 (5-9)	7 (7-9)	0.880
Household income, n (%)			
≤R10 000	15 (75)	15 (100)	0.112
R10 000- R20 000	3 (15)	0 (0)	
≥R20 000	2 (10)	0 (0)	
Home type, n (%)			
Brick house	16 (80)	9 (60)	0.179
Informal housing	4 (20)	6 (40)	
Employment status, n (%)			
Receiving income	10 (50)	6 (40)	0.556
Educational Status, n (%)			
Completed grade 12 (high school)	15 (75)	8 (57.14)	0.234
Did not complete grade 12 (high school)	5 (25)	6 (42.9)	
Marital status, n (%)			
Married/cohabiting	3 (15)	2 (13.3)	0.640
Not married	17 (85)	13 (86.7)	
Alcohol frequency, n (%)			
Never	7 (35)	9 (60)	0.480
Monthly or less	7 (35)	3 (20)	
2-4 times a month	5 (25)	2 (13)	
2-3 times a week	1 (5)	1 (7)	
Food insecurity status, n (%)			
Food secure to mildly food insecure	13 (65)	4 (26.7)	0.027
Moderately - severely food insecure	7 (35)	11 (73.3)	

Normally distributed continuous data reported as mean ± standard deviation. Skewed and ordinal data reported as median (25th – 75th percentile). Categorical data presented as n (%); EXE (exercise); CON (control).

4.4.2 Compliance to the 12-week intervention

A total of 48 exercise training sessions were conducted, in which participants attended on average 77.2% (range: 52–100%). The heart rate responses were recorded during each exercise session with a mean intensity over the 12 weeks of 79.6 ± 4.0 %HRmax (Figure 8) and an RPE (6-20 Borg scale) of 14 ± 1 arbitrary units (AU) (Figure 9), which reflects training in the moderate intensity zone throughout the intervention. Exercise dose (sessions attended multiplied by the mean %HRmax) over the 12-week intervention report was 2572.4 ± 504.6 .

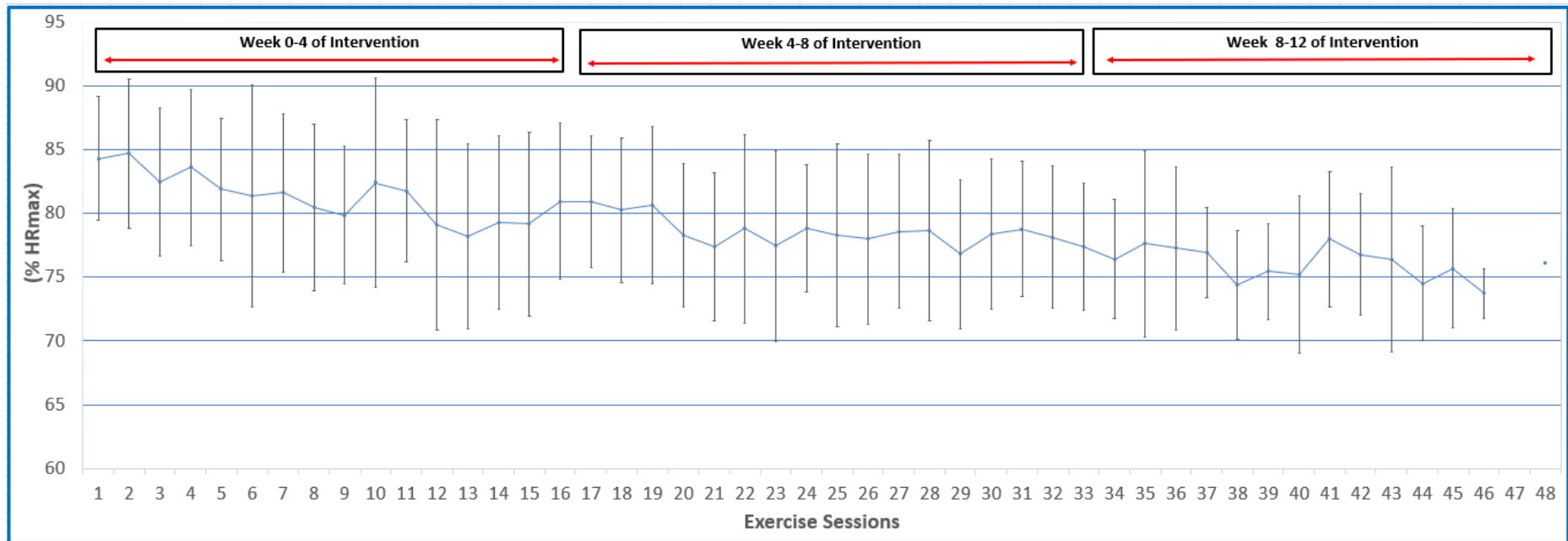


Figure 8: Training load over the 12-week intervention reported as a percentage of maximum heart rate (%HRmax) during each exercise training session. Data reported as mean \pm standard deviation.

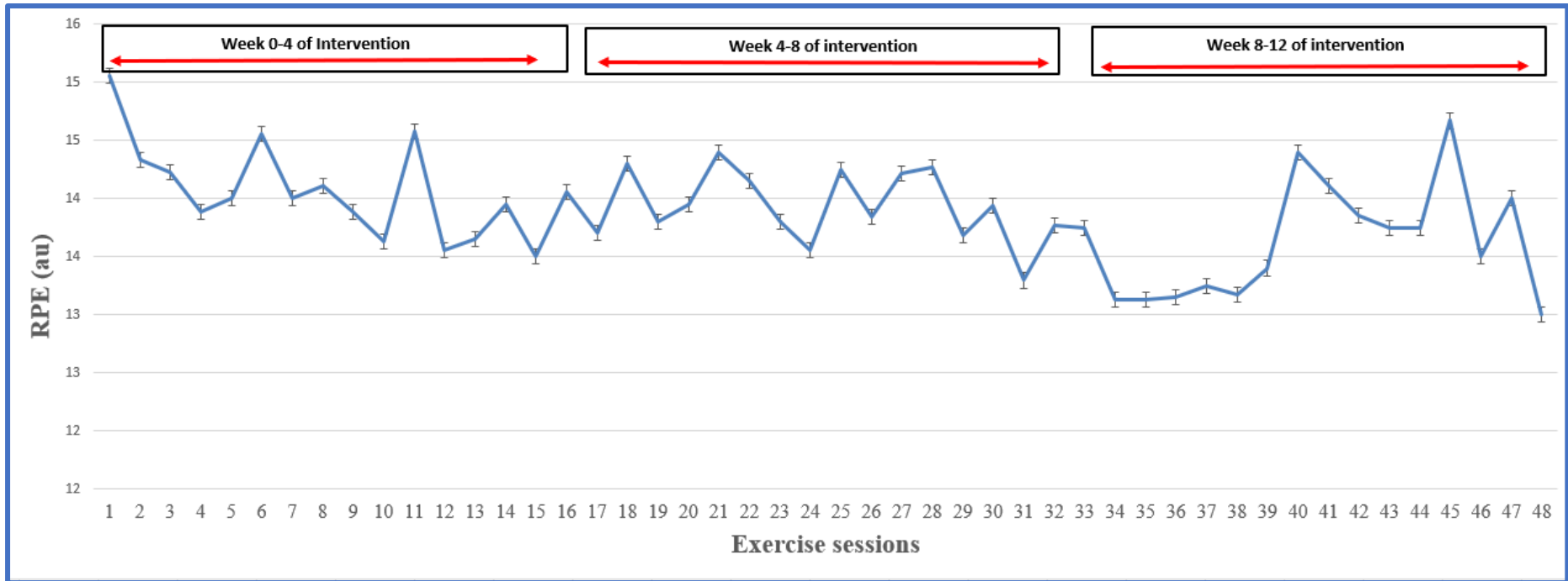


Figure 9: Training load over the 12-week intervention reported as mean rating of RPE on a 6-20 scale during each exercise training session. Data reported as mean \pm standard deviation.

4.4.3 Changes in body composition and cardiorespiratory fitness

Changes in body composition and CRF variables in response to the 12-week intervention are displayed in Table 8. There was a significant group by time interaction for weight ($p=0.007$) and BMI ($p=0.006$), such that they increased in the CON group and decreased in the EXE group. Additionally, there was a significant group x time interaction observed for gynoid fat (%FM; $p=0.002$), with a decrease observed in only the EXE group. Despite the changes in weight, no significant changes were observed for DXA-derived abdominal VAT and SAT and FFSTM between the EXE and CON group. Furthermore, VO_{2peak} , expressed in absolute terms ($ml \cdot min^{-1}$), relative to weight ($ml \cdot min^{-1} \cdot kg^{-1}$), or FFSTM ($ml \cdot min^{-1} \cdot FFSTM^{-1}$), increased in the EXE and not the CON group over the 12-week intervention ($p<0.001$ for interaction).

Table 8: Changes in body composition and cardiorespiratory fitness between the exercise intervention and control group in response to the 12-week intervention.

Variables	EXE (n=20)		CON (n=15)		Unadjusted p values		
	Pre	Post	Pre	Post	Time	Group	Group x time interaction
Body composition							
Height (m)	1.57±5.8	-----	1.62±0.1	-----	-----	-----	-----
Weight (kg)	84.1±8.7	83.3±9.7*	87.8±10.9	88.8±10.9*	0.787	0.187	0.007
BMI (kg/m ²)	34.1±2.8	33.8±3.1*	33.4±2.7	33.8±2.7	0.898	0.695	0.006
Fat-free soft tissue mass (kg)	36.6±3.5	36.6±3.6	38.3±5.6	38.8±5.8	0.405	0.239	0.347
Subtotal FM (kg)	38.6±5.5	38.6±6.7	40.3±6.9	41.2±6.2	0.179	0.366	0.199
Subtotal FM (%)	66.0±6.5	66.0±6.9	63.2±8.3	62.5±7.9	0.408	0.213	0.436
Android Fat (%)	8.3±1.0	8.1±1.0	7.9±1.4	7.9±1.5	0.092	0.544	0.402
Gynoid fat (%)	18.5±1.7	18.2±1.5*	19.4±2.3	19.6±2.3	0.190	0.084	0.002
Visceral adipose tissue (cm ²)	137.5±28.3	132.3±28.1	123.5±41.0	122.4±36.9	0.263	0.293	0.455
Subcutaneous adipose tissue (cm ²)	528.8±74.4	523.4±81.4	530±103.7	530.8±108.7	0.640	0.890	0.540
Cardiorespiratory fitness							
VO _{2peak} (ml.min ⁻¹)	2077.4±211.4	2277.8±230.7*	2099.4±281.9	2032.3±196.2	0.130	0.100	0.004
VO _{2peak} (ml.min ⁻¹ . kg ⁻¹)	24.9±2.4	27.6±3.4*	23.9±2.9	22.9±2.6	0.078	0.003	0.001
VO _{2peak} (ml.min ⁻¹ . FFSTM ⁻¹)	57.1±5.6	62.5±.3*	55.4±8.5	52.9±7.7	0.143	0.009	0.001
All data is normally distributed and reported as mean ± standard deviation. Categorical data reported as n (%). Abbreviations: VAT (visceral adipose tissue); SAT (subcutaneous adipose tissue); FM (fat mass); EXE (exercise); CON (control); (FM) fat mass; (FFSTM) fat free soft tissue mass; (VO _{2peak}) peak oxygen uptake; (ml.min ⁻¹) millilitres per minute; (ml.min ⁻¹ . kg ⁻¹) millilitres per minute per kilogram; (cm ²) square centimetre; (kg) Kilograms; (m) Meters; (kg/m ²) Kilograms per square meter; Significant within group change p<0.05*.							

4.4.4 Changes in physical activity and sedentary behaviour patterns in response to the intervention

4.4.4.1 Mixed-models analysis comparing all valid days in EXE and CON groups.

Physical activity and SB for all valid days in EXE and CON groups are reported in Table 9. Considering all valid days and compared to the CON group, MVPA increased in the EXE group from baseline to weeks 4 ($p<0.001$), and remained elevated compared to baseline at weeks 8 ($p<0.001$) and 12 ($p<0.001$), with no changes observed in the control group. In addition, the power for MVPA in min/d and % for weeks 4-12 was between 98%-99%.

This translated to only the EXE group showing a significant increase in TPA (%) from baseline to week 8 ($p=0.008$) and week 12 ($p=0.001$), but TPA (%). However, TPA in min/d and % for weeks 4-12 were not sufficiently powered, with the power between 12%-24% and 11%-41% respectively. The number of steps increased from baseline to week 4 ($p=0.008$), week 8 ($p=0.001$) and 12 ($p=0.001$) in the EXE group, whereas no change was observed in the CON group. Furthermore, daily steps were sufficiently powered for weeks 4-12, with the power between 94%-99%. In contrast, there were no changes in LIPA over time in either group.

In terms of SB variables, even though sit-to-stand was not sufficiently powered for weeks 4-12, with the power of 0.05%, a significant group x time interaction was observed for sit-to-stand transitions ($p=0.016$), with the EXE group demonstrating an increase from baseline to week 8 in comparison to the CON group. Further, a significant decline below baseline in time (%) spent in SB at week 8 ($p=0.008$ for interaction) and week 12 ($p=0.001$ for interaction) was observed in the EXE group, whereas no changes were reported in the CON group. Furthermore, the time (%) spent in SB was not sufficiently powered for weeks 4-12, with the power between 11%-40%.

Table 9: Daily physical activity and sedentary behaviour for the exercise and control groups in response to the 12-week intervention.

	EXE: All valid days				CON: All valid days				Group x time interaction
PA variables	Week 0	Week 4	Week 8	Week 12	Week 0	Week 4	Week 8	Week 12	
Days (n)	<i>N=114d</i>	<i>N=112d</i>	<i>N=119d</i>	<i>N=117d</i>	<i>N=81d</i>	<i>N=88d</i>	<i>N=84d</i>	<i>N=76d</i>	-----
LIPA (min/d)	312.0 ± 86.3	313.1 ± 76.8	315.3 ± 83.4	335.3 ± 86.5	360.6 ± 107.0	344.1 ± 100.4	332.7 ± 107.7	345.7 ± 108.5	week 0: reference week 4: p = 0.940 week 8: p = 0.187 week 12: p = 0.165
MVPA (min/d)	44.4 ± 29.2	67.3 ± 43.2 #	69.6 ± 45.0 #	69.0 ± 44.9 #	49.7 ± 37.8	42.5 ± 31.0	45.9 ± 27.5	38.9 ± 28.9	week 0: reference week 4: p < 0.001 week 8: p < 0.001 week 12: p < 0.001
TPA (min/d)	356.4 ± 91.8	380.4 ± 97.4	384.8 ± 103.0 #	404.3 ± 103.2 #	410.2 ± 124.6	386.5 ± 114.1	378.6 ± 116.7	384.6 ± 120.3	week 0: reference week 4: p = 0.176 week 8: p = 0.009 week 12: p = 0.003
LIPA (%)	35.9 ± 8.73	35.7 ± 8.1	35.4 ± 8.11	38.1 ± 8.7	41.2 ± 10.6	39.9 ± 11.1	37.7 ± 11.4	39.2 ± 12.3	week 0: reference week 4: p = 0.759 week 8: p = 0.177 week 12: p = 0.102
MVPA (%)	5.2 ± 3.4	7.7 ± 4.9#	7.9 ± 5.0#	8.0 ± 5.4#	5.6 ± 4.2	4.9 ± 3.6	5.3 ± 3.2	4.4 ± 3.1	week 0: reference week 4: p < 0.001 week 8: p < 0.001 week 12: p < 0.001
TPA (%)	41.1 ± 9.4	43.3 ± 10.6	43.3 ± 10.2 #	46.1 ± 11.1#	46.8 ± 12.2	44.9 ± 12.9	42.9 ± 12.4	43.5 ± 13.4	week 0: reference week 4: p = 0.235 week 8: p = 0.008 week 12: p = 0.001

Steps (per/d)	9429 ± 4019	11298 ± 5247 #	11114 ± 5754 #	11632 ± 5848 #	10131 ± 4561	9306 ± 4112	8954 ± 4394	9450 ± 3777	week 0: reference week 4: p = 0.008 week 8: p = 0.001 week 12: p = 0.001
Sedentary Behaviour variables									
Sedentary time (% of waking time)	58.9 ± 9.4	56.7 ± 10.6	56.7 ± 10.2#	53.9 ± 11.1#	53.2 ± 12.2	55.1 ± 12.9	57.1 ± 12.4	56.4 ± 13.4	week 0: reference week 4: p = 0.235 week 8: p = 0.008 week 12: p = 0.001
	<i>N=114d</i>	<i>N=125d</i>	<i>N=125d</i>	<i>N=112d</i>	n=98d	N=95d	N=91d	N=84d	
Nocturnal sleep time (min/d)	10.2 ± 2.6	10.3 ± 2.4	9.8 ± 2.4	9.5 ± 2.0	10.1 ± 2.7	10.3 ± 3.0	10.5 ± 2.7	10.0 ± 2.4	week 0: reference week 4: p = 0.710 week 8: p = 0.059 week 12: p = 0.213
Sitting (hours/d)	6.2 ± 2.3	6.3 ± 2.2	6.9 ± 2.8	6.2 ± 2.1	6.3 ± 2.6	6.9 ± 2.3	6.1 ± 2.2	6.8 ± 2.8	week 0: reference week 4: p = 0.641 week 8: p = 0.114 week 12: p = 0.289
Sit-to-stand (n)	31 ± 10	33 ± 11	36 ± 13#	35 ± 10	36 ± 16	35 ± 14	35 ± 14	37 ± 14	week 0: reference week 4: p = 0.164 week 8: p = 0.016 week 12: p = 0.254
Time in ≥ 60min bouts (min/d)	87.8 ± 108.2	73.6 ± 87.8	105.7 ± 117.9	63.9 ± 92.9	76.6 ± 105.1	67.8 ± 83.1	53.0 ± 68.8	74.2 ± 87.4	week 0: reference week 4: p = 0.784 week 8: p = 0.018 week 12: p = 0.225
60min bouts (n)	0.9 ± 1.1	0.8 ± 0.9	1.1 ± 1.1	0.7 ± 1.0	0.7 ± 0.9	0.8 ± 1.0	0.6 ± 0.8	0.8 ± 0.9	week 0: reference week 4: p = 0.353 week 8: p = 0.069 week 12: p = 0.099

Normally distributed data are reported as mean \pm standard deviation, skewed data is reported as median (25th – 75th percentile) and categorical data are presented as n (%). Abbreviations: LIPA (light-intensity physical activity); MVPA (moderate and vigorous intensity physical activity); TPA (total physical activity); EXE (exercise); CON (control); Day (d); A mixed-model was used to explore the effect of group, time and group x time interaction, with the interaction P value presented in the final column. After Bonferroni correction, $p \leq 0.017$; # represents a significant time effect from baseline.

4.4.4.2 Mixed-models analysis considering only exercise days in EXE group and all valid days in CON group

When comparing only exercise days in the EXE group with all valid days for the CON group (Table 10); as expected significant group x time interactions were observed for MVPA min/d (Figure 10a) and % (Figure 11a) where MVPA increased from baseline to week 4 ($p < 0.001$); week 8 ($p < 0.001$) and week 12 ($p < 0.001$) in the EXE group and not the control group. Similarly, group x time interactions were observed for TPA min/d (Figure 12a) and % (Figure 13a), such that EXE group showed increases in TPA from baseline to week 4 ($p = 0.004$), week 8 ($p < 0.001$) and week 12 ($p < 0.001$). Furthermore, daily step counts increased from baseline to week 4 ($p < 0.001$), week 8 ($p < 0.001$) and week 12 ($p < 0.001$) in the EXE group and no changes were observed in the CON group. Notably, all measures of PA changed between baseline and week 4, and then remained constant over the remaining 8 weeks.

In terms of SB behaviour measures, there was a significant group x time interaction for sit-to stand transitions ($p = 0.013$) at week 4, where increases in sit-to stand transitions from baseline were observed in the EXE group and not the CON group, and there was also a tendency for the EXE group to increase sit-to stand transitions at week 12 ($p = 0.036$). Significant group x time interactions were also seen for the % of waking time spent in sedentary behaviour (Figure 14a), which decreased from baseline to week 4 ($p = 0.001$), week 8 ($p < 0.001$) and week 12 ($p < 0.001$) in the EXE group only, with no changes observed between weeks 4 and 12 of the exercise intervention (Figure 14b). Although accumulated time spent in sedentary bouts more than 60 minutes and number of sedentary bouts > 60 minutes did not change from baseline to week 4, there was a significant change from week 4 to 8 and week 8 to 12 in the EXE group with no significant changes observed among the CON group. When compared to week 4, the EXE group showed a significant increase in accumulated time spent in sedentary bouts more than 60 minutes ($p = 0.008$) and number of sedentary bouts > 60 minutes ($p < 0.001$) at week 8.

However, at week 12, accumulated time spent in sedentary bouts more than 60 minutes ($p < 0.001$) and number of sedentary bouts > 60 minutes ($p = 0.001$) decreased significantly from week 8 towards baseline values.

Table 10: Daily physical activity and sedentary behaviour for all exercise days in the exercise group compared to all valid days in the control group.

PA variables	EXE: Exercise days only				CON: All valid days				Group X time interaction
	Week 0	Week 4	Week 8	Week 12	Week 0	Week 4	Week 8	Week 12	
Days (n)	<i>N=113d</i>	<i>N=55d</i>	<i>N=53d</i>	<i>N=43d</i>	<i>N=81d</i>	<i>N=88d</i>	<i>N=84d</i>	<i>N=76d</i>	-----
LIPA (min/d)	312.0 ± 86.3	324.3 ± 63.2	316.8 ± 71.0	330.9 ± 71.0	360.6 ± 107.0	344.1 ± 100.4	332.7 ± 107.7	345.7 ± 108.5	week 0: reference week 4: p = 0.684 week 8: p = 0.240 week 12: p = 0.417
MVPA (min/day)	44.4 ± 29.2	91.9 ± 30.5#	99.0 ± 33.6#	104.3 ± 36.3#	49.7 ± 37.8	42.5 ± 31.0	45.9 ± 27.5	38.9 ± 28.9	week 0: reference week 4: p < 0.001 week 8: p < 0.001 week 12: p < 0.001
TPA (min/d)	356.4 ± 91.8	416.2 ± 76.0#	415.8 ± 83.4#	435.2 ± 88.3#	410.2 ± 124.6	386.5 ± 114.1	378.6 ± 116.7	384.6 ± 120.3	week 0: reference week 4: p = 0.004 week 8: p < 0.001 week 12: p < 0.001
LIPA (%)	35.9 ± 8.73	37.3 ± 6.4	35.6 ± 6.3	38.7 ± 6.7	41.2 ± 10.6	39.9 ± 11.1	37.7 ± 11.4	39.2 ± 12.3	week 0: reference week 4: p = 0.569 week 8: p = 0.197 week 12: p = 0.120
MVPA (%)	5.2 ± 3.4	10.7 ± 3.6#	11.2 ± 3.7#	12.4 ± 4.4#	5.6 ± 4.2	4.9 ± 3.6	5.3 ± 3.2	4.4 ± 3.1	week 0: reference week 4: p < 0.001 week 8: p < 0.001 week 12: p < 0.001
TPA (%)	41.1 ± 9.4	48.0 ± 8.0#	46.8 ± 7.5#	51.1 ± 9.1#	46.8 ± 12.2	44.9 ± 12.9	42.9 ± 12.4	43.5 ± 13.4	week 0: reference week 4: p = 0.001 week 8: p < 0.001 week 12: p < 0.001

Steps (per/d)	9429 ± 4019	15050 ± 3167#	14780 ± 4224#	15695 ± 3550#	10131 ± 4561	9306 ± 4112	8954 ± 4394	9450 ± 3777	Week 0: reference week 4: p<0.001 week 8: p < 0.001 week 12: p < 0.001
Sedentary Behaviour variables									
Sedentary time (%waking time)	58.9 ± 9.4	52 ± 7.9#	53.2 ± 7.5#	48.9 ± 9.1#	53.2 ± 12.2	55.1 ± 12.9	57.1 ± 12.4	56.4 ± 13.4	week 0: reference week 4: p = 0.001 week 8: p < 0.001 week 12: p < 0.001
	<i>N=113 d</i>	<i>N=54d</i>	<i>N=49d</i>	<i>N=41d</i>	<i>n=98d</i>	<i>N=95d</i>	<i>N=91d</i>	<i>N=84d</i>	
Nocturnal sleep time (hours/d)	10.2 ± 2.6	10.3 ± 1.9	9.7 ± 2.3	6.4 ± 1.6	10.1 ± 2.7	10.3 ± 2.6	10.5 ± 2.7	10.0 ± 2.4	week 0: reference week 4: p = 0.851 week 8: p = 0.090 week 12: p = 0.226
Sitting (hours/d)	6.2 ± 2.3	6.8 ± 2.1	6.9 ± 2.0	6.5 ± 2.4	6.3 ± 2.6	6.9 ± 2.3	6.1 ± 2.2	6.8 ± 2.8	week 0: reference week 4: p = 0.942 week 8: p = 0.472 week 12: p = 0.758
Sit-to-stand (n)	31 ± 10	36 ± 9#	34 ± 11	37 ± 9	36 ± 16	35 ± 14	35 ± 14	37 ± 14	week 0: reference week 4: p=0.013 week 8: p = 0.102 week 12: p = 0.036
Accumulated time in > 60 min bouts (min/d)	87.8 ± 108.2	67.1 ± 85.9*	91.7 ± 103.1*	71.3 ± 88.6*	76.6 ± 105.1	67.8 ± 83.1	53.0 ± 68.8	74.2 ± 87.4	week 0: reference week 4: p=0.667 week 8: p = 0.111 week 12: p = 0.534
Sedentary bouts >60 min bouts (n)	0.9 ± 1.1	0.7 ± 0.9*	1.0 ± 1.0*	0.8 ± 0.9*	0.7 ± 0.9	0.8 ± 1.0	0.6 ± 0.8	0.8 ± 0.9	week 0: reference week 4: p = 0.225 week 8: p = 0.217 week 12: p = 0.326

Normally distributed data is reported as mean \pm standard deviation. Day (d); Abbreviations: LPA (light-intensity physical activity); MVPA (moderate- and vigorous-intensity physical activity); TPA (total physical activity); EXE (exercise); CON (control). A mixed-model was used to explore the effect of group, time and group x time interaction, with the interaction P value presented in the final column After Bonferroni correction, $p \leq 0.017$; # represents a significant time effect from baseline and * represents change over time during week 4, 8 and 12

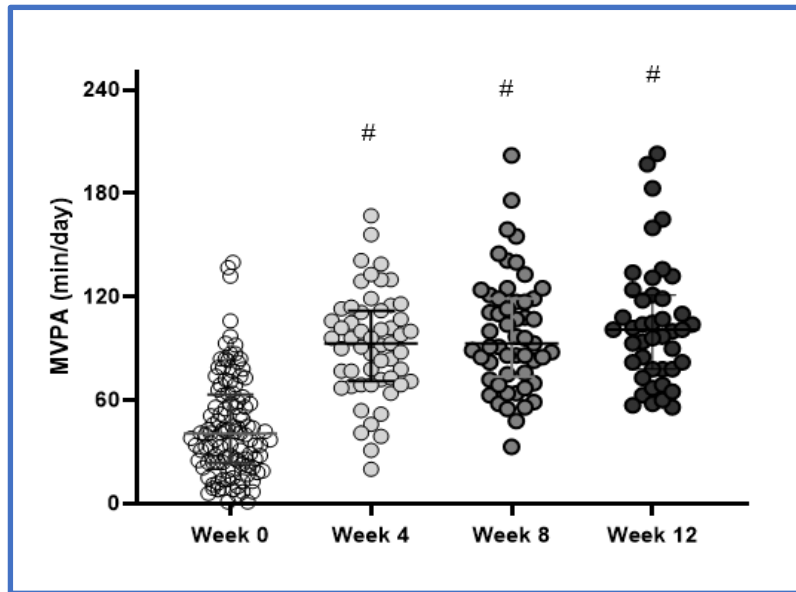


Figure 10a

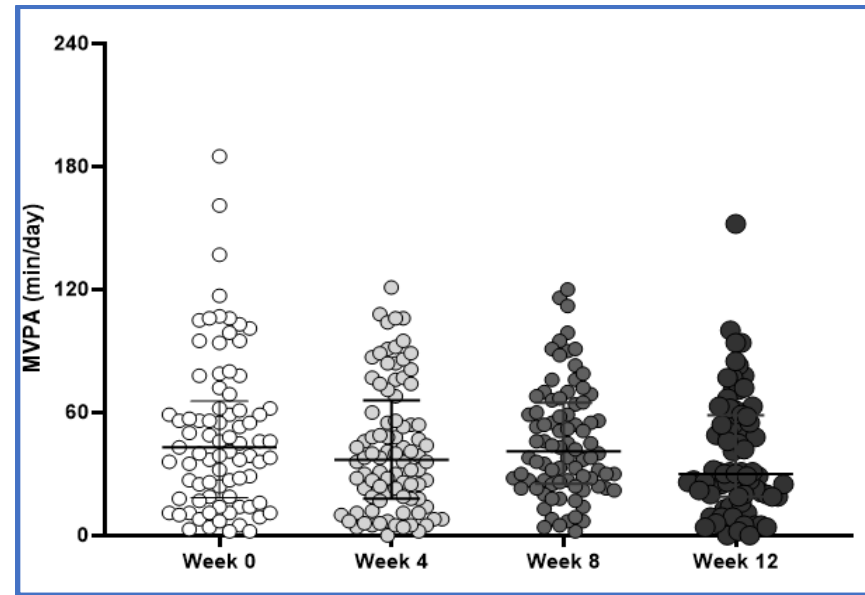


Figure 10b

Average daily MVPA (min/d) reported as all valid days and mean \pm standard deviation over the 12- week intervention with (a) representing EXE group for baseline all valid days and exercise days only at week 4, 8 and 12 and (b) CON group all valid days. There was a significant increase (#) in MVPA (min/d) from baseline, at week 4 ($p < 0.001$); week 8 ($p < 0.001$) and week 12 ($p < 0.001$) in the EXE group, with no significant changes in the CON group.

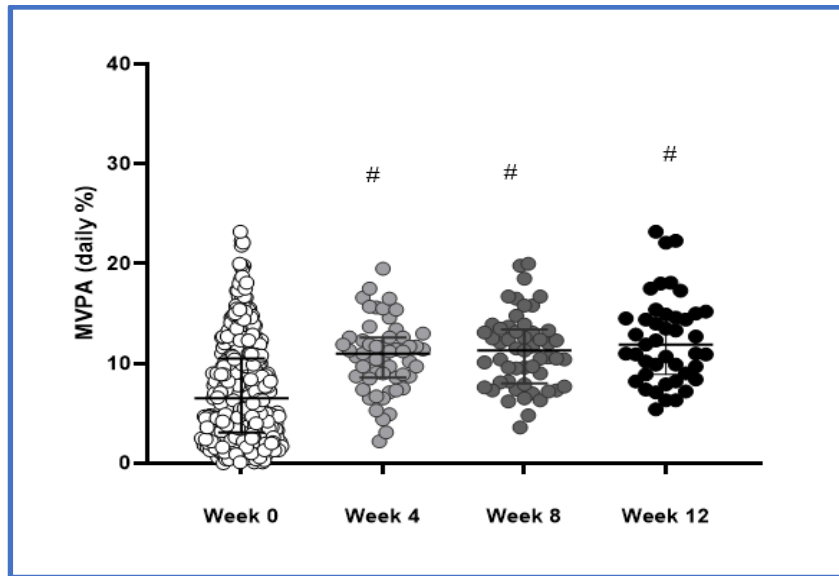


Figure 11a

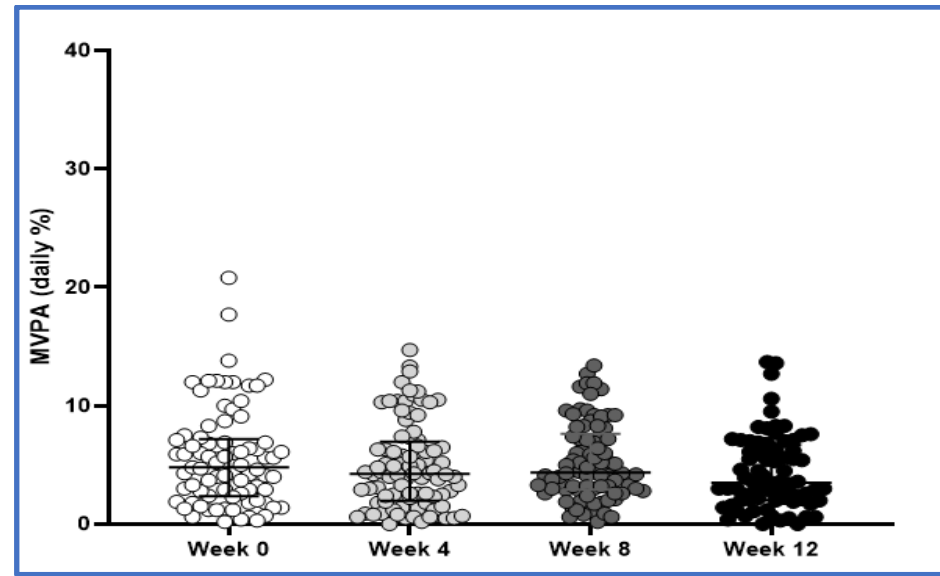


Figure 11b

Average daily MVPA (%) over the 12- week intervention with (a) representing EXE group for baseline all valid days and exercise days only at week 4, 8 and 12 and (b) CON group all valid days. There was a significant increase (#) in MVPA (%) from baseline, at week 4 ($p < 0.001$); week 8 ($p < 0.001$) and week 12 ($p < 0.001$) in the EXE group, with no significant changes in the CON group.

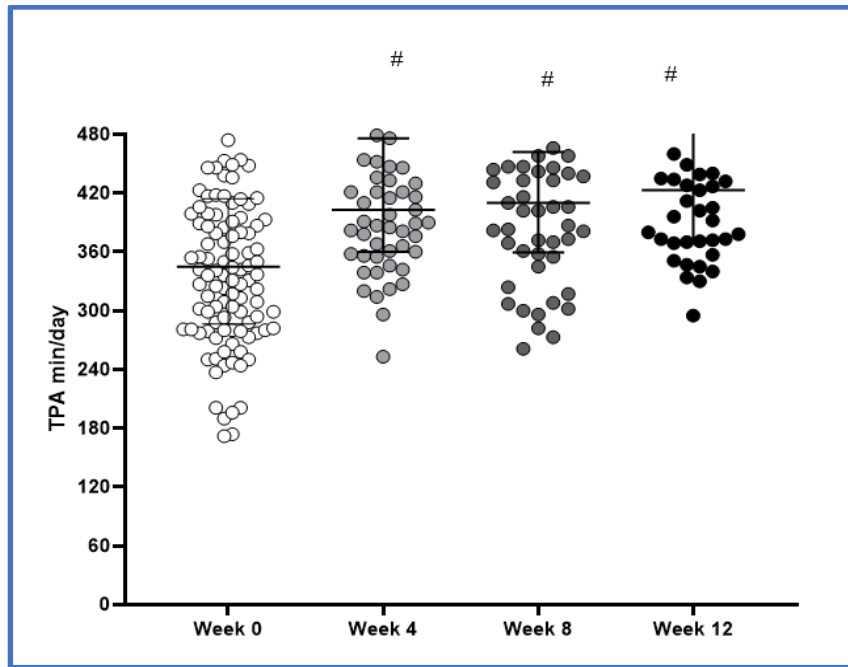


Figure 12a

Average daily TPA (min/d) reported as all valid days and mean \pm standard deviation over the 12- week intervention with (a) representing EXE group for baseline all valid days and exercise days only at week 4, 8 and 12 and (b) CON group all valid days. There was a significant increase (#) in TPA (min/d) from baseline, at week 4 ($p < 0.004$); week 8 ($p < 0.001$) and week 12 ($p < 0.001$) in the EXE group, with no significant changes in the CON group.

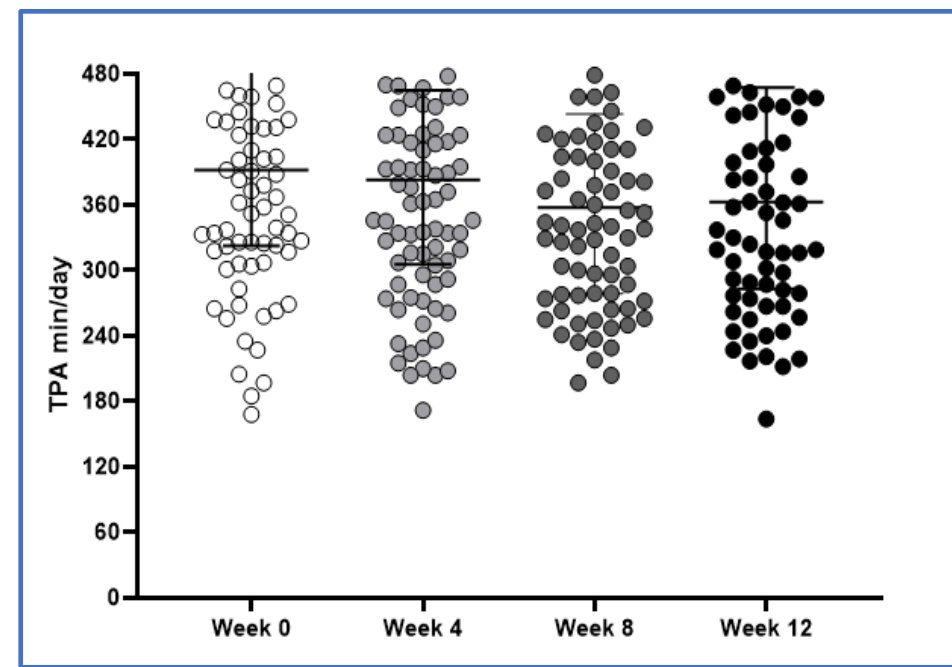


Figure 12b

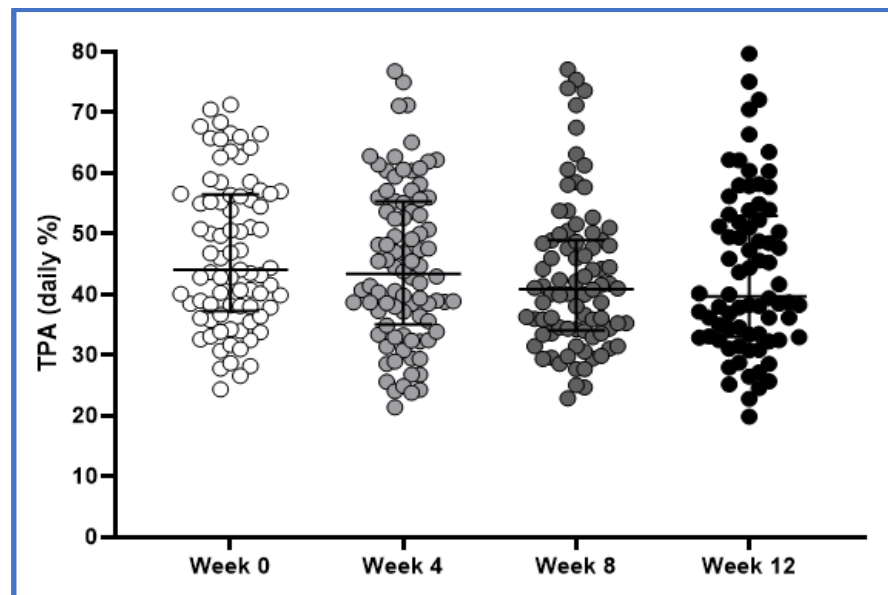
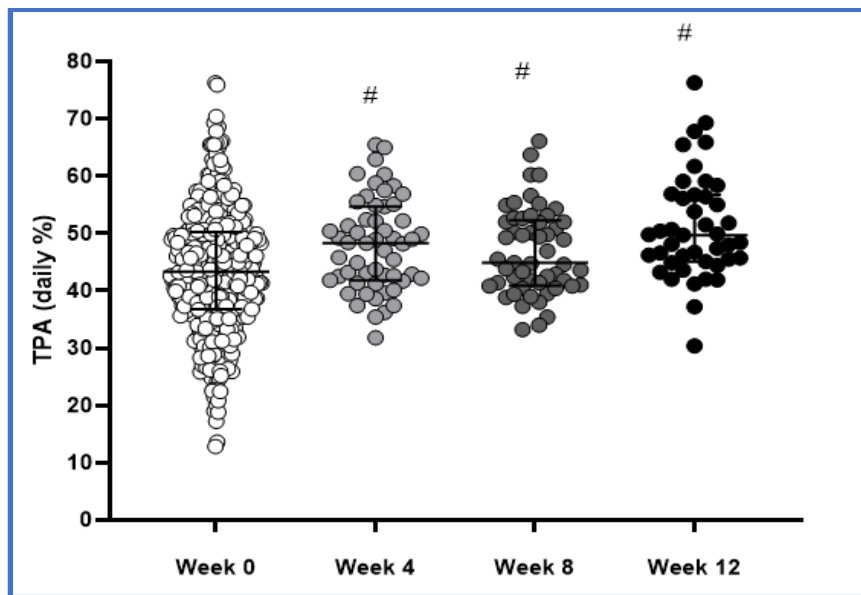


Figure 13a

Figure 13b

Average daily TPA (%) over the 12- week intervention with (a) representing EXE group for baseline all valid days and exercise days only at week 4, 8 and 12 and (b) CON group all valid days. There was a significant increase (#) in TPA (%) from baseline, at week 4 ($p = 0.001$); week 8 ($p < 0.001$) and week 12 ($p < 0.001$) in the EXE group, with no significant changes in the CON group.

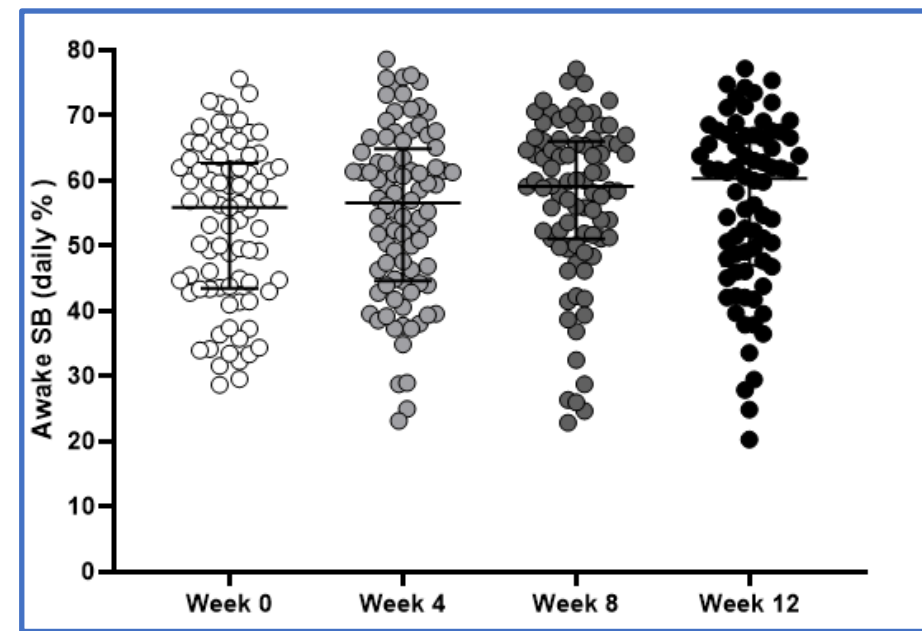
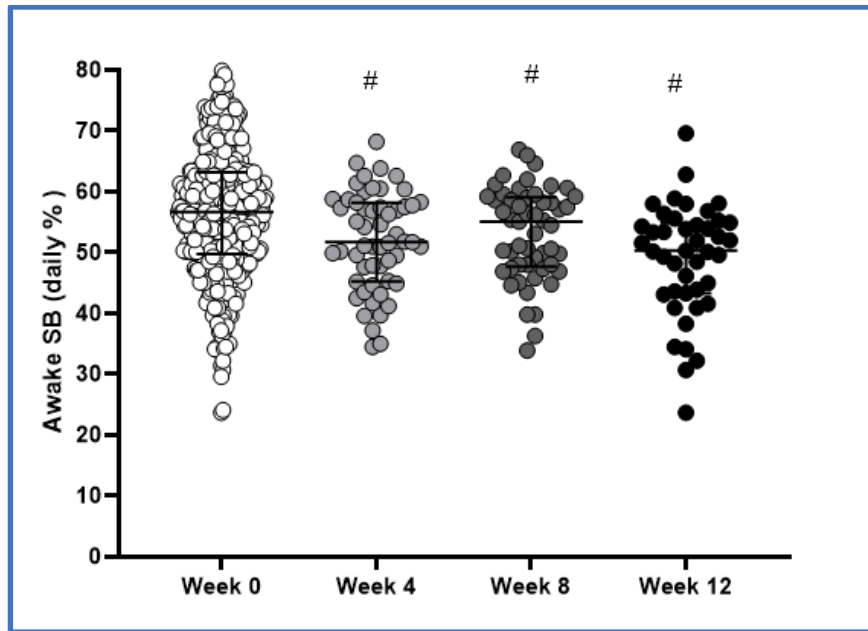


Figure 14a

Figure 14b

Average daily awake SB (%) over the 12- week intervention with (a) representing EXE group for baseline all valid days and exercise days only at week 4, 8 and 12 and (b) CON group all valid days. There was a significant decrease (#) in daily awake SB (%) from baseline, at week 4 ($p = 0.001$); week 8 ($p < 0.001$) and week 12 ($p < 0.001$) in the EXE group, with no significant changes in the CON group.

4.4.4.3 Mixed-models analysis considering only non-exercise days in EXE and all valid days in CON groups

Data comparing all non-exercise days in the EXE group compared to all valid days in the CON group are reported in Table 11. There were no significant group x time interactions for all PA variables. Nonetheless, the EXE group demonstrated the tendency to increase daily MVPA (min/d) ($p=0.036$) and TPA (min/d) ($p=0.026$) and TPA (%) ($p=0.033$) from baseline to week 12 of the intervention during non-exercise days.

In terms of the sedentary variables, accumulated time spent in >60 minutes bout of SB increased from baseline to week 8 among the EXE group ($p=0.011$) and not in the CON group. In contrast, there was tendency to increase sit-to stand transition from baseline to week 8 in the EXE group ($p=0.022$) when compared to the CON group. Furthermore, the tendency to reduce SB (% waking time) during non-exercise days ($p=0.034$) was observed in the EXE group only at week 12 of the intervention.

Table 11: Daily physical activity and sedentary behaviour including non-exercise days in the exercise group compared to all valid days in the control group

PA variables	EXE: Non-exercise days				CON: All valid days				Group x time interaction
	Week 0	Week 4	Week 8	Week 12	Week 0	Week 4	Week 8	Week 12	
Days (n)	<i>N=113d</i>	<i>N=57d</i>	<i>N=66d</i>	<i>N=74d</i>	<i>N=81d</i>	<i>N=88d</i>	<i>N=84d</i>	<i>N=76d</i>	-----
LIPA (min/d)	312.0 ± 86.3	302.4 ± 87.3	314.0 ± 92.6	337.9 ± 94.7	360.6 ± 107.0	344.1 ± 100.4	332.7 ± 107.7	345.7 ± 108.5	week 0: reference week 4: p = 0.775 week 8: p = 0.198 week 12: p = 0.086
MVPA (min/d)	44.4 ± 29.2	43.4 ± 40.4	46.0 ± 38.7	48.5 ± 35.9	49.7 ± 37.8	42.5 ± 31.0	45.9 ± 27.5	38.9 ± 28.9	week 0: reference week 4: p = 0.483 week 8: p = 0.453 week 12: p = 0.036
TPA (min/d)	356.4 ± 91.8	345.8 ± 103.8	360.0 ± 110.8	386.4 ± 107.5	410.2 ± 124.6	386.5 ± 114.1	378.6 ± 116.7	384.6 ± 120.3	week 0: reference week 4: p = 0.975 week 8: p = 0.163 week 12: p = 0.026
LIPA (%)	35.9 ± 8.7	34.1 ± 9.3	35.3 ± 9.4	37.8 ± 9.7	41.2 ± 10.6	39.9 ± 11.1	37.7 ± 11.4	39.2 ± 12.3	week 0: reference week 4: p = 0.473 week 8: p = 0.205 week 12: p = 0.108
MVPA (%)	5.2 ± 3.4	4.8 ± 4.3	5.1 ± 4.2	5.5 ± 4.2	5.6 ± 4.2	4.9 ± 3.6	5.3 ± 3.2	4.4 ± 3.1	week 0: reference week 4: p = 0.754 week 8: p = 0.681 week 12: p = 0.052
TPA (%)	41.1 ± 9.4	38.8 ± 10.9	40.5 ± 11.2	43.2 ± 11.1	46.8 ± 12.2	44.9 ± 12.9	42.9 ± 12.4	43.5 ± 13.4	week 0: reference week 4: p = 0.589 week 8: p = 0.199 week 12: p = 0.033
Steps (d)	9429 ± 4019	8444 ± 4696	8750 ± 5374	9285 ± 5636	10131 ± 4561	9306 ± 4112	8954 ± 4394	9450 ± 3777	week 0: reference week 4: p = 0.965 week 8: p = 0.252

									week 12: p = 0.319
Sedentary Behaviour variables									
Sedentary time (% of waking time)	43.5 ± 16.1	42.2 ± 17.5	48.7 ± 14.5	40.0 ± 14.7	53.2 ± 12.2	55.1 ± 12.9	57.1 ± 12.4	56.4 ± 13.4	week 0: reference week 4: p = 0.590 week 8: p = 0.200 week 12: p = 0.034
	<i>N=113d</i>	<i>N=71d</i>	<i>N=76d</i>	<i>N=71d</i>	<i>n=98d</i>	<i>N=95d</i>	<i>N=91d</i>	<i>N=84d</i>	-----
Nocturnal sleep time (min/d)	10.2 ± 2.6	10.2 ± 2.8	9.8 ± 2.4	9.5 ± 2.1	10.1 ± 2.7	10.3 ± 2.6	10.5 ± 2.7	10.0 ± 2.4	week 0: reference week 4: p = 0.667 week 8: p = 0.101 week 12: p = 0.215
Sitting (hours/d)	6.01 ± 2.6	5.9 ± 2.7	6.9 ± 2.4	6.6 ± 2.4	6.05 ± 2.5	6.0 ± 2.7	6.0 ± 2.6	6.3 ± 2.5	week 0: reference week 4: p = 0.641 week 8: p = 0.114 week 12: p = 0.289
Sit-to-stand (n)	31 ± 10	32 ± 12	37 ± 14	33 ± 11	36 ± 16	35 ± 14	35 ± 14	37 ± 14	week 0: reference week 4: p = 0.665 week 8: p = 0.022 week 12: p = 0.532
Accumulated time in > 60 min bouts (min/d)	87.8 ± 108.2	78.5 ± 89.4	114.7 ± 126.3#	59.7 ± 95.6	76.6 ± 105.1	67.8 ± 83.1	53.0 ± 68.8	74.2 ± 87.4	week 0: reference week 4: p = 0.881 week 8: p = 0.011 week 12: p = 0.187
Sedentary bout >60 min (n)	0.9 ± 1.1	0.9 ± 1.0	1.2 ± 1.1	0.7 ± 1.1	0.7 ± 0.9	0.8 ± 1.0	0.6 ± 0.8	0.8 ± 0.9	week 0: reference week 4: p = 0.533 week 8: p = 0.049 week 12: p = 0.087
Equally distributed data is reported as mean ± standard deviation. Abbreviations: LPA (light-intensity physical activity); MVPA (moderate and vigorous intensity physical activity); TPA (total physical activity); Day (d); Significant group x time interaction effect, p≤0.017#.									

4.5 Relationship between changes in body weight, cardiorespiratory fitness, physical activity, sedentary behaviour patterns and exercise dose

When considering all participants (EXE and CON), an increase in MVPA from baseline to week 12 of the intervention (all valid days) was associated with a decrease in body weight ($\rho=-0.546$, $p=0.002$) after the 12-week intervention. Increases in MVPA ($\rho=0.397$, $p=0.03$) and TPA ($\rho=0.397$, $p=0.033$) from baseline to week 12 of the intervention were associated with increases in VO_{2peak} ($ml\cdot min^{-1}$) over the 12-week intervention. Changes in LIPA, total sitting time, and accumulated time spent in >60-minute bouts were not correlated with changes in VO_{2peak} ($ml\cdot min^{-1}$) or changes in body weight ($p>0.05$). Furthermore, exercise dose was not associated with changes in CRF in the EXE group ($p>0.05$). Lastly, no significant group interactions (EXE and CON) were observed in any of the associations that were explored.

4.6 DISCUSSION

To the best of our knowledge, this is the first randomized control trial to explore the changes in habitual physical behaviour patterns in response to an aerobic and resistance exercise intervention among women living with overweight and obesity from a low socio-economic setting on the African continent. By design it was expected that the exercise intervention will increase PA, particularly MVPA on the exercise training days, which also resulted in a reduction in time spent in SB. However, this did not translate to meaningful changes in physical behaviours on non-exercise training days throughout the 12-week intervention.

Findings from the current study showed that the exercise intervention resulted in an increase in MVPA and TPA, but not LIPA. This does not come as a surprise since the EXE group engaged in supervised exercises 4 times a week over the 12-week intervention and the exercise duration progressed weekly, from 40 min to 60 min per session. Furthermore, an increase of approximately 60 min in MVPA min/d and 79 min TPA min/d was observed in the EXE group during exercise days only. Similar findings have been reported in literature where young women with abdominal obesity increased their daily physical activity in response to a 12-week exercise and nutrition intervention (19). Even 5 months exercise intervention studies conducted among middle age (\pm 37yrs) men have reported increased ActiGraph-derived MVPA and TPA as the result of the structured group exercise training (17). Notably, the increase in PA in this study were attributed to the exercise intervention itself. Although the EXE group presented with the tendency to reduce SB (% of awake time) and increase MVPA min/d ($p=0.036$), TPA min/d ($p=0.026$) and TPA (%) ($p=0.033$) during non-exercise days at week 12 of the intervention, this was not a meaningful change with an increase of only ~5 min/d of MVPA being observed on the non-exercise days. Furthermore, at baseline, women from both the CON and EXE group accumulated an average of 40 min of MVPA per day but this increased to 92-104 min/d in response to the intervention. This highlights a shift from meeting the minimum

PA guidelines by the WHO towards meeting the higher end recommendation of >300 minutes of Mod PA per week for possible weight loss. The WHO recommends at least 150-300 minutes of Mod PA or 75–150 min of Vig PA to be accumulated throughout the week (9). Not surprisingly, this study also shows that a higher MVPA was associated with increased CRF and reduced weight, both risk factors for the future development of NCD (25, 26, 154, 155).

The daily MVPA findings at baseline from the current study mirror those reported from a similar population where majority of young middle-aged Black SA women from low-resourced setting were meeting the PA guidelines according to the GPAQ (12-14). Walking for transport was the domain that contributed to the most overall weekly PA, with less than 50% of women participating in leisure time PA (12, 14). Findings from the current study showed that women from the CON group maintained the daily average of 40 min of MVPA with 10 min less MVPA recorded at week 12 of the intervention. Daily steps are an outcome of total daily PA, with 10,000–10,999 steps/d translating to 40–47 min/d of MVPA in adults (251). Accordingly, it is not surprising that at baseline most participants met the guidelines of 10,000 steps/d, which increased to more than ± 14780 steps/d during exercise days for the EXE group. However, the EXE group accumulated less daily steps during non-exercise days (± 9285 steps/d). On the other hand, the CON group was only able to achieve the recommended daily steps guidelines during week-0 of the intervention, where they recorded $\pm 10,131$ steps/d, but this declined to a maximum of ± 9450 steps/d during the course of the intervention with corresponds with their decrease in daily MVPA.

Notably, there was a compositional shift in physical behaviour patterns during the 12 weeks of the exercise intervention where a 10% reduction in % of awake time spent in was observed among the EXE group during week 12 of exercise days ($58.9 \pm 9\%$ to 48.9%). In contrast, time spent in SB (% awake time) increased from baseline to week 12 in the CON group ($53.2 \pm$

12.2% to $56.4 \pm 13.4\%$). Decreased time in spent SB has been reported in response to a short term, (3-4 weeks) (173, 174), middle term (12-weeks) (172) and more long term (6 months) exercise interventions among adults (171). Within a low socio-economic setting in SA, accelerometer derived sedentary time was associated with increased triglycerides levels (39). Furthermore, findings from the Nord-Trøndelag Health Study 3 (HUNT3) comprising of 50 817 adults aged ≥ 20 years showed that ≥ 10 hrs/d total sitting time had a 65% and 115% greater risk of all-cause and cardiometabolic disease related mortality after adjustment for sex, education, BMI, PA, smoking, self-rated general health and cardiometabolic disease status (252). Thus, it is important that health professionals not only promote the importance of participating in PA but should also raise awareness about the detrimental health effects of increased sedentary time despite being physically active.

During exercise days in the EXE group, there was a significant increase in the accumulated time spent in more than 60 minutes sedentary bouts during week 8, when compared to baseline. However, the increase was only ± 4 min, and may possibly be an indicator of compensatory behaviour characterised by intervention fatigue that coincides with a trending decrease in exercise intensity (%MHR), while maintaining a moderate to vigorous RPE. These levels returned to baseline by week 12. Furthermore, there was evidence of breaking up prolonged sitting time through increases in sit-to stand transitions among the EXE group during this period. Sedentary bouts of 60-90 minutes are not only reported to be associated with higher total abdominal fat (visceral fat and subcutaneous fat) (136), but also the increased risk of all-cause mortality in adults (253). Conversely, interrupting prolonged sitting time with frequent brief bouts of LIPA, may enhance cardiometabolic health in adults (231).

Findings from the current study also showed that the increases in MVPA was associated with reduced body weight and improved CRF among all participants. Similar findings have been

reported in literature, where moderate exercise resulted in decreased body weight (254, 255) and reduced fat around the gynoid area (256) in a cohort of young adults. Furthermore, findings from a cross-sectional study among young women from USA showed that accumulating more than 90 minutes of ActiGraph-derived daily MVPA was associated with reduced percent body fat (257). Within a SA setting, reallocating 30 minutes of sitting/lying to MVPA and 30 minutes of standing to MVPA was associated with a 0.3% and 1.4% lower FM in middle-aged women (41-72 yrs of age), respectively (107).

Exercise participants from the current study showed a small, but significant weight loss (~1kg), while the CON group gained ~1kg weight and BMI increased by 1kg/m². The decrease in weight and BMI in the EXE group is consistent with interventions with similar exercise protocols (mixed training regime, frequency of exercise sessions per week, length of intervention and no dietary intervention) (2, 258). Nonetheless, our results suggest that exercise training is appropriate for small reductions in weight and for weight maintenance, but to obtain clinically significant weight reductions, exercise training may need to be complimented with other lifestyle-related interventions, such as dietary interventions (259), nutritional and /or dietary education (19). Furthermore, research has consistently shown that regular exercise increases CRF (17, 20, 149, 150). Greater CRF is associated with improved lipid profile, and increases in insulin sensitivity before and after adjusting for fat mass (39). Even though the exercise training resulted in only small changes in body composition, the substantial improvement in CRF highlights the need for long term aerobic and resistance community-based group exercise interventions for this population to possibly reduce cardiometabolic risk factors.

4.7 STRENGTHS AND LIMITATIONS

This study presents significant strengths in methodology. In particular, hip and thigh worn accelerometry were used as objective measures for PA and SB, respectively. Further, the changes in habitual PA patterns were collected from both groups across four time points during the 12-week intervention. Moreover, weekly sleep log sheets were used to exclude sleeping time from sedentary time. Another strength of the current study was the reporting of changes in daily steps throughout the 12-week intervention period. There is paucity of literature reporting on changes in daily steps in response to an exercise intervention. The limitation of the current study is the limited statistical power of some of the main outcomes (TPA and SB) due to the fact that findings reported in this thesis are secondary outcomes from the primary study. In addition, the high dropout rate in the CON group (N=7) in comparison to the EXE group (N=3), relatively small sample size and unequal distribution between the exercise and control group can also be viewed as limitations. Also, the unequal number of days obtained from the PA and SB variables through the four times points of the intervention from both groups can be viewed as a limitation. However, we were able to obtain data for a maximum of 114 valid days and minimum of 53 valid for a specific time point during the 12-week intervention, enabling us to capture the variability of the collected data.

4.8 CONCLUSION

In conclusion, the current study showed that TPA and MVPA significantly increased, with a compensatory reduction in SB (% of awake time) from baseline to week 12 in response to the exercise intervention. Our findings provide a clear indication that the overall PA increases in the exercise group were largely due to the increased PA accumulated during exercise sessions. Although the EXE group demonstrated a tendency to reduce SB and increase sit-to-stand transitions, MVPA and TPA during non-exercise days, these changes were not meaningful. The positive changes in physical behaviour patterns and CRF experienced by the EXE group

have the potential to improve the cardiometabolic health of this population. Even though the exercise intervention did not translate to clinically meaningful changes in body weight, the improvement in CRF highlights the need for long term aerobic and resistance community-based group exercise interventions for this population. It can be argued that the significant increase in MVPA and TPA with compensatory reduction in SB (% of awake time) can be viewed as clinically meaningful as previous research has shown that reallocation of 30 min/d of sedentary behaviour with MVPA is associated with reduced fat mass and higher insulin sensitivity in middle-aged SA adults (107, 121). Furthermore, it is also important to assess the targeted populations' perceptions and experiences about the delivered health intervention for the purpose of determining the effectiveness of the intervention in a real-world setting. Moreover, the impact on body image and self-efficacy which are important determinants for sustainability in such interventions should be explored.

CHAPTER 5

The effect of a 12-week exercise intervention on perceived body image and self-efficacy in women living with overweight and obesity from a low- resourced setting.

5.1 INTRODUCTION

The high prevalence of overweight and obesity among Black SA women is a public health challenge as described in the literature review (Chapter 2). It may be argued that acceptance of living with a larger body size by Black SA women (42-44, 46, 182) is a contributing factor to the high prevalence of overweight, obesity and associated cardiometabolic diseases among this population (14, 30, 32, 260, 261).

Body image is often defined as the degree of satisfaction with physical appearance (size, shape and general appearance) (1, 262), or how a person feels about their appearance (2). Studies conducted among young and middle-aged Black SA women from rural and urban areas suggest that these women have a preference for a larger body size as it is associated with beauty, dignity, confidence (182), respect, happiness (187), wealth and the appearance of being respectable (43, 183). In contrast, a thin body was viewed as not respectable and also associated with poverty (43) and sickness (46). Despite these perceptions, other studies in young and middle-age Black SA women in rural and urban settings reported body image dissatisfaction, with some women indicating the desire to be thinner (44, 45, 47, 186). Accordingly, the concept of body image in Black SA women is complex and requires an in-depth understanding of the local cultural, community and personal perceptions to advise on target interventions aimed at reducing cardiometabolic risk.

A qualitative study exploring perceptions of body size in young and middle-aged Black SA women reported that the women considered exercise as a potential strategy to improve health and showed interest in participating in a community based exercise intervention (46). Exercise training has consistently been shown to improve cardiometabolic outcomes (19, 147, 148, 156, 263). However, there is a dearth of research reporting on the effects of exercise training on perceived body image and self-efficacy in Africa. According to the SCT, self-efficacy is a focal

determinant of health behaviour change, because it is the common pathway through which self-regulatory efforts influence physical health (210). Studies conducted in postpartum women (197) and women living with overweight and obesity in Canada (23), Iran (192), and Turkey (191) have shown improved perceptions of body image and levels of self-efficacy (197) following participation in an exercise intervention ranging from 4-16 weeks.

Therefore, we hypothesise that exercise training will improve perceptions of body image and self-efficacy in Black SA women living with overweight/obesity. This study aims to determine the effects of a 12-week combined aerobic and resistance exercise training intervention on perceived body image and self-efficacy in young Black SA women living with overweight and obesity.

5.2 METHODS

Body image perception was assessed pre and post the 12-week intervention using a set of nine silhouettes (188), also known as figure rating scales (Appendix G) (22). While perceived self-efficacy was measured by means of the Generalized self-efficacy (Appendix G) (221). Detailed methods on the collection of all variables reported in this chapter are outlined in the methods section (Chapter 3).

5.3 STATISTICAL ANALYSES

Results are reported as means \pm standard deviations ($M \pm SD$) for normally distributed data (i.e. body composition and fat distribution) and median and interquartile range (25th-75th percentile) for skewed (i.e. dietary intake) and/or ordinal data (i.e. body image and self-efficacy). Dietary intake and changes in food security were assessed as potential covariates. T-test for independent samples were applied to assess the difference in equally distributed continuous variables between groups. While Mann-Whitney U test for independent variables was conducted to analyse the difference in skewed continuous variables between groups.

A two-way repeated measure of analyses of variance was conducted to determine main and interaction (group x time) effects of the exercise intervention on dietary intake, self-efficacy and perceptions of body image. Statistical analysis was performed using Statistica (TIBCO, v13.3.0, CA, USA). Significance level was set at $P < 0.05$.

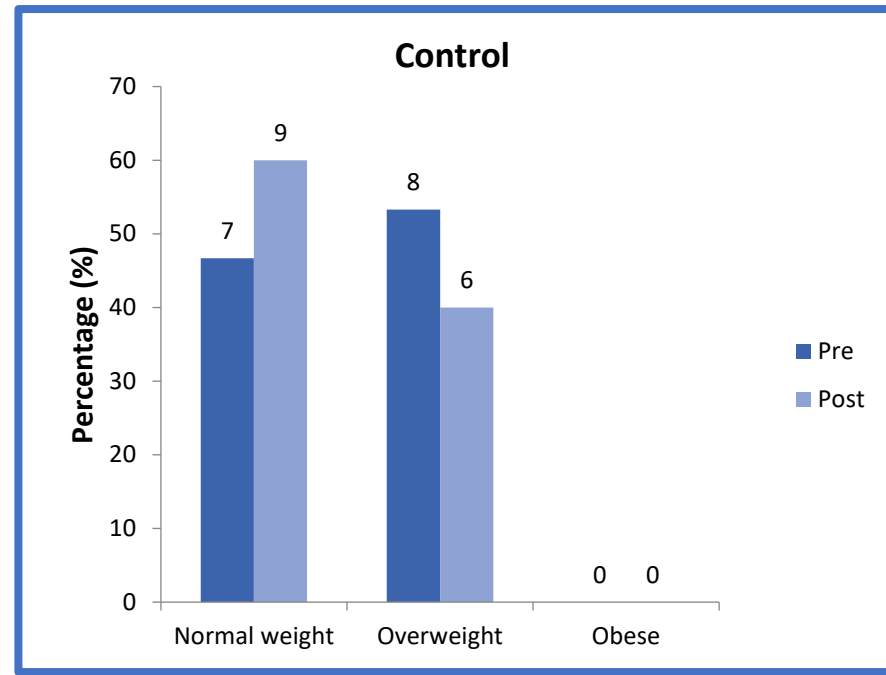
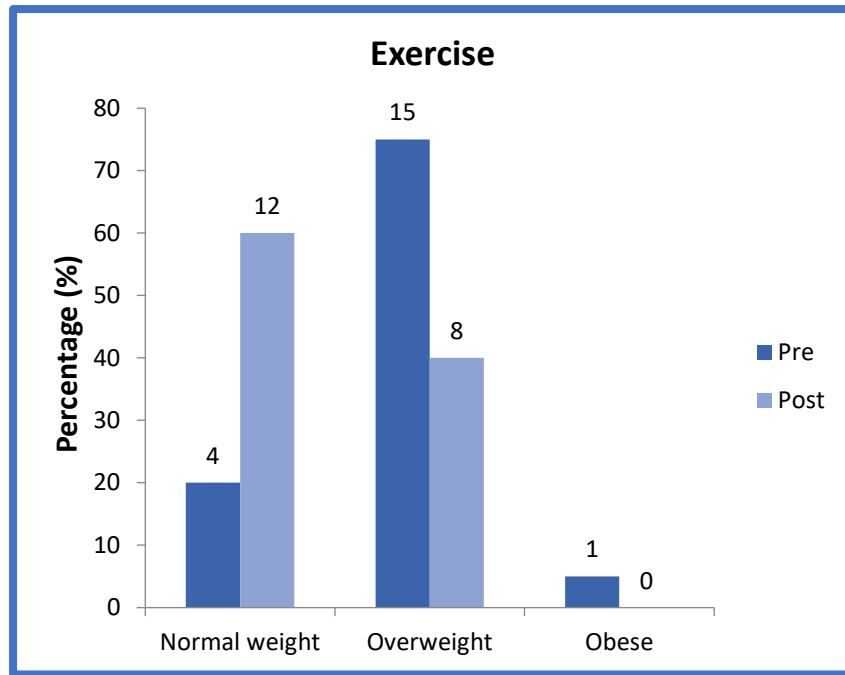
5.4 RESULTS

5.4.1 Changes in perceptions of body image and weight classification in response to the 12-week intervention

Despite 80% (n=33) of women being classified as living with obesity ($BMI \geq 30 \text{ kg/m}^2$) at baseline, when using questionnaires, 31.4% (n=11) of women classified themselves as normal weight, 65.7% (n=23) as overweight and only 2.9% (n=1) as living with obesity. In response to the intervention the CON group on average gained 1 kg and the EXE group lost 1 kg. However, following the intervention, the majority (60.0%, n=21) of participants in both groups classified themselves as normal-weight (Figure 15). In the EXE group, only one participant classified herself as living with obesity at baseline, but following the exercise intervention, she classified herself as normal weight. When provided silhouettes to classify their BMI categories (Figure 16) the women rather classified themselves as overweight (Table 12). Results also showed a FID score (body size dissatisfaction) of 1 (1-2), which suggests that most women desired a smaller body size at baseline and this did not change in response to the intervention (Table 12).

The PAD score, which represents the discrepancy between perceived and actual weight from the Stunkard's Silhouette is shown in table 13. Commensurate with the results from the perceived BMI classification, majority of participants from both EXE and CON groups (95% and 100%, respectively) under-estimated their weight status and perceived themselves to be overweight at baseline. Only one participant from the EXE group and none from the CON

group perceived themselves as living with obesity at baseline. No participants perceived themselves as living with obesity after the intervention.



A **B**

Figure 15: Change in body mass index classification in response to the 12-week intervention in EXE (A) and CON (B) groups. All data is categorical, with the (n) reported above the bars.

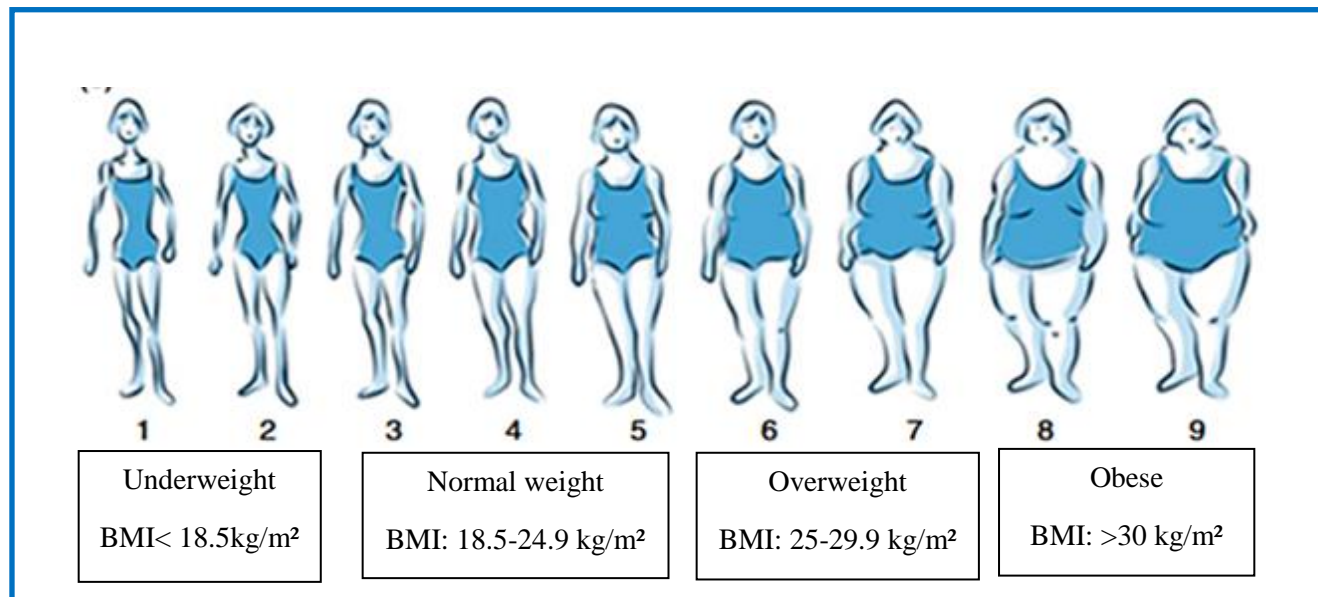


Figure 16: Stunkard's silhouettes body image rating scale for women (188)

Table 12: Changes in the perceptions of body image in response to the 12-week intervention in the exercise and control groups.							
Variables	EXE (n=20)		CON (n=15)		Time	Group	Time* Group
	Baseline	Follow-up	Baseline	Follow-up			
The feel silhouette	6 (5-7)	6 (5-6)	6 (6-6)	6 (6-7)	0.928	0.840	0.669
The Ideal silhouette	5 (4-5)	5 (4-5)	5 (4-5)	5 (4-5)	0.896	0.974	0.896
Perception of normal weight	5 (4-5)	5 (4-5)	5 (5-5)	5 (4-5)	0.872	0.997	0.723
Perception of obese	9 (9-9)	9 (9-9)	9 (9-9)	9 (9-9)	0.969	0.716	0.805
FID score	1 (1-2)	1 (1-1.5)	1 (1-2)	2 (1-2)	1.000	0.851	-----
All data is ordinal and reported as median (25 th -75 th percentile); sample size (n); FID score (calculated by subtracting the 'ideal' from the 'feel' silhouette); EXE (exercise); CON (control)							

Table 13: PAD score pre and post intervention in the exercise intervention and control groups.

PAD score category	EXE Group (n=20)				CON Group (n=15)			
	Baseline (N)	%	Follow-up (N)	%	Baseline (N)	%	Follow-up (N)	%
Underestimate weight status (negative score)	19	95	20	100	15	100	14	93
Accurate estimation of weight status (score=0)	1	5	0	0	0	0	1	7

PAD score (discrepancy score between perceived and actual weight) reported as categorical, n (%); EXE (exercise); CON (control)

5.4.2 Baseline and changes in GSE in response to the 12-week intervention

Participants that completed the intervention (n=35) presented with significantly higher GSE at baseline in comparison to the drop out participants (n=8; 24.3 ± 3.4 vs. 20.5 ± 6.4 , $p=0.002$). Changes in GSE in response to the exercise intervention are reported in Figure 17. The CON group presented with significantly higher general self-efficacy compared to the EXE group at both baseline ($p=0.003$) and post intervention ($p=0.036$). A decline in GSE was observed in both groups post intervention ($p=0.021$ for time effect), and this did not differ between groups ($p=0.801$ for interaction effect).

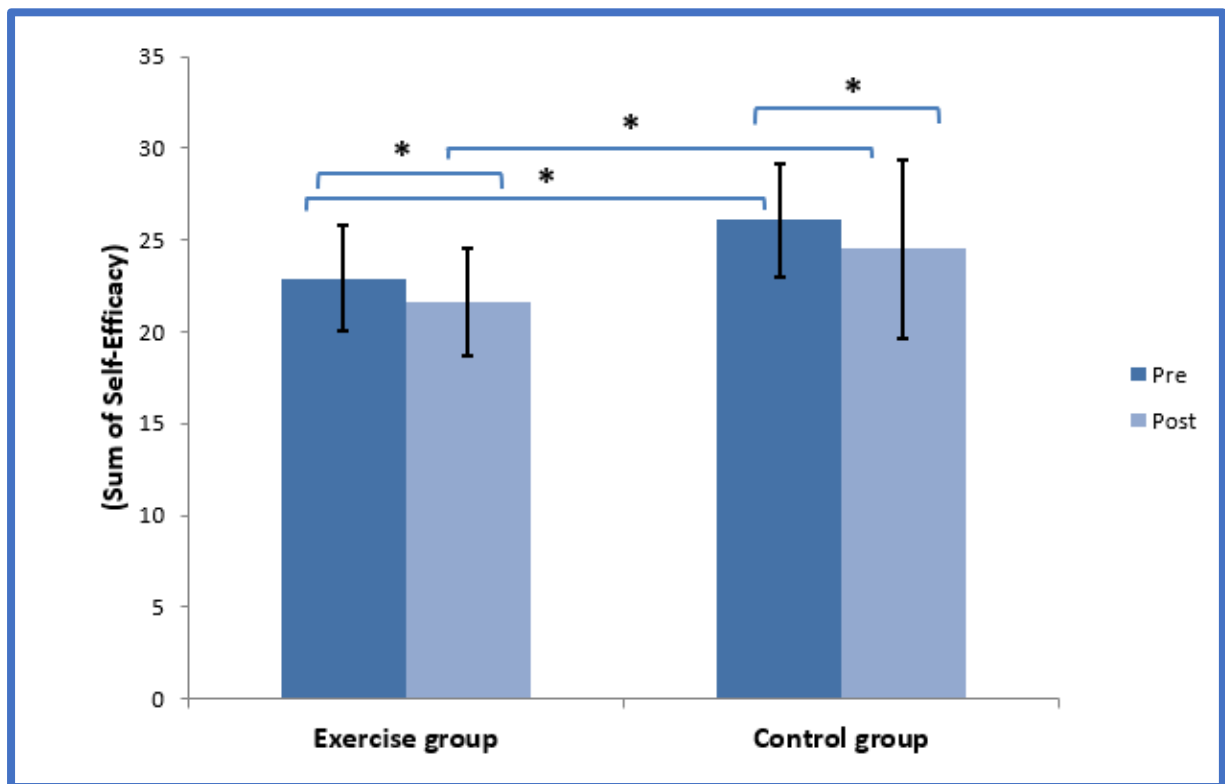


Figure 17: Differences between groups and changes in generalized self-efficacy in response to the 12-week intervention. $p < 0.05^*$

5.4.3 Changes in dietary intake and food security score between the exercise and control group in response to the 12-week exercise intervention

As shown in Table 14, there was no differences in total energy intake, macronutrient and sugar intake between the groups and over time.

Table 14: Dietary intake in exercise intervention and control groups over the 12-week intervention.

Variables	EXE (n=20)		CON (n=15)		p values		
	Pre	Post	Pre	Post	Time	Group	Time*group
Total energy intake (Kj)	8369 (7015-10566)	8443 (7595-9919)	8139 (6493-9434)	8406 (7335-9509)	0.889	0.861	0.752
Carbohydrate (%)	55.1±5.4	52.7±8.3	54±5.7	57.9±7.5	0.659	0.236	0.054
Protein (%)	13.2±2.5	13.7±3.0	14.3±1.9	13.6±2.2	0.816	0.454	0.295
Fat (%)	30.4±6.7	32.2±5.9	30.9±5.6	27.7±6.6	0.638	0.185	0.095
Sugar (%)	12.7±3.8	14.7±6.1	13.6±6.3	13.3±6.8	0.457	0.861	0.337

Normally distributed continuous data reported as mean ± standard deviation. Skewed and ordinal data reported as median (25th – 75th percentile); Kilojoules (Kj); EXE (exercise); CON (control)

5.5 DISCUSSION

This is the first study to investigate the effects of a 12-week combined (aerobic and resistance) exercise training on perceived body image and GSE in Black SA women from a low socio-economic setting and who are living with overweight and obesity. In this randomised controlled trial, we showed that the women underestimated their body size (body size discordance) and that the body size discordance was exacerbated with exercise training alongside no clinically relevant shift in body weight.

The body size discordance reported in our study resemble those of recent studies from a similar population of Black SA adults with obesity that assessed weight underestimation and body size dissatisfaction (49, 186). Okop and colleagues found that 89% of adults living with obesity and 79% with overweight underestimated their body size (49). The body weight discordance has been associated with an increased prevalence of obesity and cardiovascular diseases (49) and may have important implications for weight management and the prevention of non-communicable diseases (264).

Majority of the women wanted to be a smaller body size. The desire to have a smaller body size has been observed in other studies conducted among economically disadvantaged African American and African women with overweight and obesity (45, 48, 49, 179), urban Black SA women with and without T2DM (44), as well as in rural and urban populations (43, 186). Results from a study on lifestyle and psycho-social factors in predicting changes in body composition in Black SA women found that more women wanted to be leaner in the group that underestimated their body size when compared to those that knew their body size (60.1% vs 47.5%) (190). It may then be argued that the women in the current study underestimated their body size because they desired to be smaller, thus presenting with body size dissatisfaction.

Our findings and others emphasise that Black SA adults living with overweight and obesity present with the dichotomy of body weight discordance and dissatisfaction.

Based on the BMI classification, the current study reports that exercise training promoted the perception of a slimmer body. Indeed, half of the women in the exercise group perceived that their weight status decreased from obese/overweight to normal-weight BMI category in response to the 12-week exercise intervention. Findings by Baştuğ and colleagues report positive effects of CrossFit, Pilates, and Zumba exercises on body weight, BMI and perceived body image using the Body Areas Satisfaction Scale, a sub-dimension of the Multidimensional Body-Self Relations Questionnaire (2). This constancy may be due to similarities of exercise protocols (mixed training regime, frequency of exercise sessions per week and length of intervention). Furthermore, recent findings by Bak-Sosnowska using Stunkards Silhouette's and Body shape questionnaire reported that regular exercise over three-months in women living with obesity promoted a perception of their own body as slimmer and having less body shape concerns (22). However, the change in perceived body shape was more pronounced with endurance exercise, when compared to endurance and strength exercise training (22). Although these findings may be interpreted as an improvement in body image perception, the results were not supported by the results of the silhouettes, which did not change in response to the intervention. In low resource settings such as in this study, women do not have access to scales, and the concept of BMI and BMI categories may not be fully understood. Accordingly, the body silhouette images may provide a better representation of their body size compared to understanding the concept of BMI categories and may be a more appropriate tool for educating women from low resource settings about obesity and adverse health effects because of its visual nature.

Individuals with a positive body image have been reported to have a better sense of self-efficacy (265). According to Yoon and colleagues, self-efficacy is an individual's confidence in his or her ability to organise regular exercise, belief in ability to perform the elemental aspects of a task, confidence in successfully completing an activity and ability to perform the tasks under challenging conditions (208). This is similar to GSE, which is general beliefs in one's ability to respond, and control environmental demands and challenges (221). The 77.7% attendance rate to the exercise sessions in the current study (Chapter 4) indicates their ability to control environmental demands and challenges that might have been related to the exercise intervention. This is not surprising as the intervention participants had significantly higher GSE compared to the drop out participants. However, results from the current study showed a significant decrease in GSE in both groups after 12 weeks of exercise. The GSE findings from the current study differ from those previously reported, where exercise training resulted in enhanced physical self-efficacy among college students (24), significant improvements in GSE among sedentary women (191), and schedule, physical, exercise-worries efficacy in women living with overweight and obesity (6). Even though the GSE scale has been used in other low-income settings such as Uganda where it was culturally adapted and validated (209). The GSE questionnaire may not capture the participants response to an exercise training intervention adequately and this specific questionnaire has not been validated in this context previously, and requires further investigation among South African population. Further insight and interrogation into self-efficacy in response to exercise interventions using a qualitative approach may better capture the nuances in this population.

5.6 STRENGTHS AND LIMITATIONS

For the first time, the current study provides information on the effects of exercise training on perceptions of body image in African women with obesity, which may inform future interventions in women with overweight and obesity. A limitation of the current study was the

small sample size, unequal distribution at follow-up between the exercise and control group and the use of the GSE questionnaire, which has not, to our knowledge, been specifically validated in this population and context.

5.7 CONCLUSION

In conclusion, the current study showed that participation in a 12-week supervised aerobic and resistance exercise intervention in young Black SA women living with overweight and obesity from a low socioeconomic exacerbated body size discordance. However, the perceptions of overweight and obesity based on BMI were underestimated to a greater extent likely due to a lack of understanding of BMI categories. Rather, visual silhouettes may be a better tool for communicating body size in this setting. Despite body size discordance, the women in the study desired to be smaller in body size and may be receptive to health and weight-loss exercise interventions. Further, our findings offer informative information that should be used in future interventions about educating participants about body weight and adverse health effects a larger body size. Self-efficacy may play an important role in supporting exercise behaviour as it is the general beliefs in one's ability to respond, and control environmental demands and challenges. Therefore, should be explored in detail using qualitative research. Qualitative research strategies such as FGD and IDI may provide an in-depth understanding of the barriers and facilitators that may influence participation in an exercise intervention. Furthermore, qualitative research may provide more details on the perceptions and experiences of the implemented intervention. Such information can assist in implementing tailored community exercise interventions, which could potentially result in high adherence and adoption of an active lifestyle.

CHAPTER 6

Perceptions and experiences of young Black South African women with obesity from a low socioeconomic community after following a 12-week structured exercise intervention.

(This chapter was published in *Frontiers in Sports and Active Living*, Appendix J)

Phiri, L. P., Micklesfield, L. K., Mendham, A. E., Goedecke, J. H., & de Villiers, A. *Frontiers in Sports and Active Living*, 2022 (4) 1-11. Perceptions and experiences of young Black South African women with obesity from a low socioeconomic community after following a 12-week structured exercise intervention.

6.1 INTRODUCTION

Historically, Black SA women have not perceived obesity as a threat to their health (48), but rather associated it with wealth and beauty (43, 45, 46). As discussed in detail under the literature review (Chapter 2), studies have shown Black SA women prefer a bigger body size as it is associated with beauty, dignity, confidence (182), respect from others, happiness (187) and wealth (183), with some women commenting that “Our culture says that you are supposed to be fat” (46). African women, have been reported to perceive thinness to be associated with diseases such as HIV, AIDS and TB (45, 266), with some women mentioning comments such as “What will people think if I lose weight” (182). These cultural and societal perceptions around a bigger body size in Black SA women could influence whether these women engage in healthy behaviours such as physical exercise.

More recently, indications are that there has been a transition in the perception of obesity towards Western norms of thinness in young SA women have been reported (267, 268). However, the latest South African Demographic and Health Survey has reported that 26.5% Black adult females are living with overweight and 40.9% with obesity (11). This has occurred alongside reduced physical activity and an increase in the prevalence of NCDs (269). Accordingly, exercise interventions designed to alter physical behaviour patterns and prevent the development of NCDs in young women with obesity are warranted. Findings of previous qualitative work conducted in our study community reported that young Black SA women from a low-resource setting were interested in participating in community-based exercise interventions that incorporate dancing, aerobics and lifting weights as a strategy to lose weight and improve health (46).

When engaging groups from resource-constrained environments in exercise, there are barriers such as lack of time, cost, accessibility to facilities, other people’s perceptions and an unsafe

residential environments that must be considered (199). However, little is known about how these barriers affect the adherence and sustainability to a structured exercise programme. It is anticipated that exploring women's perceptions and experiences of 'exercise' after participating in an exercise intervention will assist in identifying barriers and enablers that can be used to design future long-term exercise interventions. Therefore, this study aimed to investigate the perceptions and experiences of a 12-week structured exercise intervention in a group of young Black SA women living with overweight and obesity from a low-resource setting.

6.2 MATERIALS AND METHODS

6.2.1 Post-intervention qualitative data collection

Focus group discussions and IDIs were conducted 1-4 months after the completion of the 12-week intervention to ensure that there were enough participants for each group discussion. All recruited participants (n=45) were invited telephonically to participate in the FGDs. Participants who dropped out of the intervention (n=10) and participants in the control group who rejected the opportunity to participate in the intervention at the end of the study (n=7), were also contacted, with the intention to understand potential barriers relating to participating in the intervention. However, we were either unsuccessful in contacting these participants or they were not willing to participate. During the telephone recruitment for the FGDs, participants were informed that they would be remunerated with R50 South African Rands to compensate for their transport to the venue and R20 South African Rands per hour for their time and inconvenience to participate in the FGDs and IDIs. Two of the eight participants in the control group who completed the post-intervention exercise training participated in the interviews.

The semi-structured focus group questions were formulated by the research group and were based on previous qualitative work done in a similar group of women from the study community (46). Following the question formulation, we sought independent input from external researchers with extensive experience in working with women from similar settings. The focus group questions were aimed at investigating the participants' perceptions about the exercise intervention, and barriers and motivators that might have influenced compliance during the exercise intervention (Table 15). The IDIs contained a single open-ended question. The interviewer allowed the participant to share her experiences of the exercise sessions (Table 15), while prompting her to elaborate on salient points arising from the focus groups.

The purpose of the IDIs was to eliminate the influence of others' opinions that could have occurred during the FGDs (270). Participants who seemed to have the strongest opinions during the FGDs were invited to participate in the IDIs, optimising the opportunity to further explore the themes identified and adding to the richness of the information collected during the FGD (271). The moderator and the scribe selected these participants in a debriefing session after each FGD, using the notes taken by the scribe to consider the flow of the group discussion and the contribution of the various participants.

Table 15: Focus group discussion and in-depth interview question schedules.

Number	Focus group discussion questions
1	Can you please briefly share with us what you have been up to since we last saw you?
2	What is the first thing that comes to mind when you hear the word ‘exercise’?
3	What are your perceptions about exercise?
4	What are some of the things that influenced you to attend the exercise sessions? This can either be barriers or motivating factors.
5	What did you like the most about the exercise sessions?
6	What did you not like about the exercise sessions?
7	How did the exercise training affect your daily life?
8	What did your friends and family have to say when they found out that you are exercising?
9	Is there anything that could be changed about the exercise training sessions to encourage you to continue exercising and for your friends and family to start exercising?
10	Of all the questions that were discussed today, is there one which you feel was the most important to you?
In-depth interview question	
1	How did you experience the exercise sessions?

A trained facilitator and scribe who were fluent in both English and IsiXhosa, the vernacular of the study population, conducted all the FGDs and IDIs. This ensured that no participant was excluded from the FGD because of language barriers. At the start of each FGD the facilitator and scribe introduced themselves and explained the purpose and reasons for doing the research. The FGDs and interviews were audio recorded and a scribe made notes during the FGDs. The FGDs and IDIs were conducted at a venue at the university and took between 45 and 60 minutes. No time restriction was set for these discussions and the duration was deemed appropriate for the number of participants in the FGDs and the question schedules. The audio

recordings were transcribed from IsiXhosa into English by an independent translator, fluent in both English and IsiXhosa. The accuracy of the transcriptions both in tone and language were checked against the notes taken by the scribe by the first author.

6.2.2 Qualitative data analysis

The first author Lindokuhle Phiri (LP) applied qualitative content analysis to analyse the transcripts (272) using the Atlasti Qualitative Data Analysis Software (Scientific Software Development GmbH, Berlin, Germany). This methodological approach allowed description and interpretation of the data using quantification of the data to develop themes. The analysis process started with reading the transcribed data in detail. Thereafter, a consensus process of drafting a coding framework was followed with another researcher Anniza de Villiers (AD) and the codes were then systematically applied to the transcripts. If relevant, applicable codes were applied more than once to the data generated from the same participant.

Main themes and sub-themes were then generated by LP and reviewed by both LP and AD after which clear definitions and names for each theme and subtheme were generated. These were checked by the rest of the research group and suggested changes were incorporated in the final document. Data saturation was achieved in the sense that all participants, intervention, control, and dropouts were invited to participate in the qualitative study and all those who agreed, took part in the FGDs. The voices of most of the participants were therefore heard and additional data was collected through the IDI to ensure that all issues raised in the FGDs were adequately explored.

6.3 RESULTS

6.3.1 Participant characteristics

From all the contacted participants, 17 participants agreed to participate in the FGDs (Exercise, n=12; Control, n=5). There were no differences in age (24 ± 4 vs. 24 ± 4 years), BMI (33.2 ± 2.4

vs. 34.3 ± 3.0 kg/m²) or socio-demographic characteristics, including education (7 vs. 5 participants with tertiary education), household income (75% vs. 72% earned >R5000/month) or housing density (1.3 ± 0.6 vs. 1.4 ± 0.9 people/room living in the household), between the participants who agreed to participate in the FGD and those who did not, respectively.

Five of the FGD participants were selected (Exercise, n=4; Control n=1) to complete IDIs. Two FGDs (FGD 1 and 2) comprised of only exercise participants who completed the intervention, and the other two FGDs (FGD 3 and 4) included a mix of participants from the exercise and control groups. Each FGD consisted of between three to five participants (Figure 18).

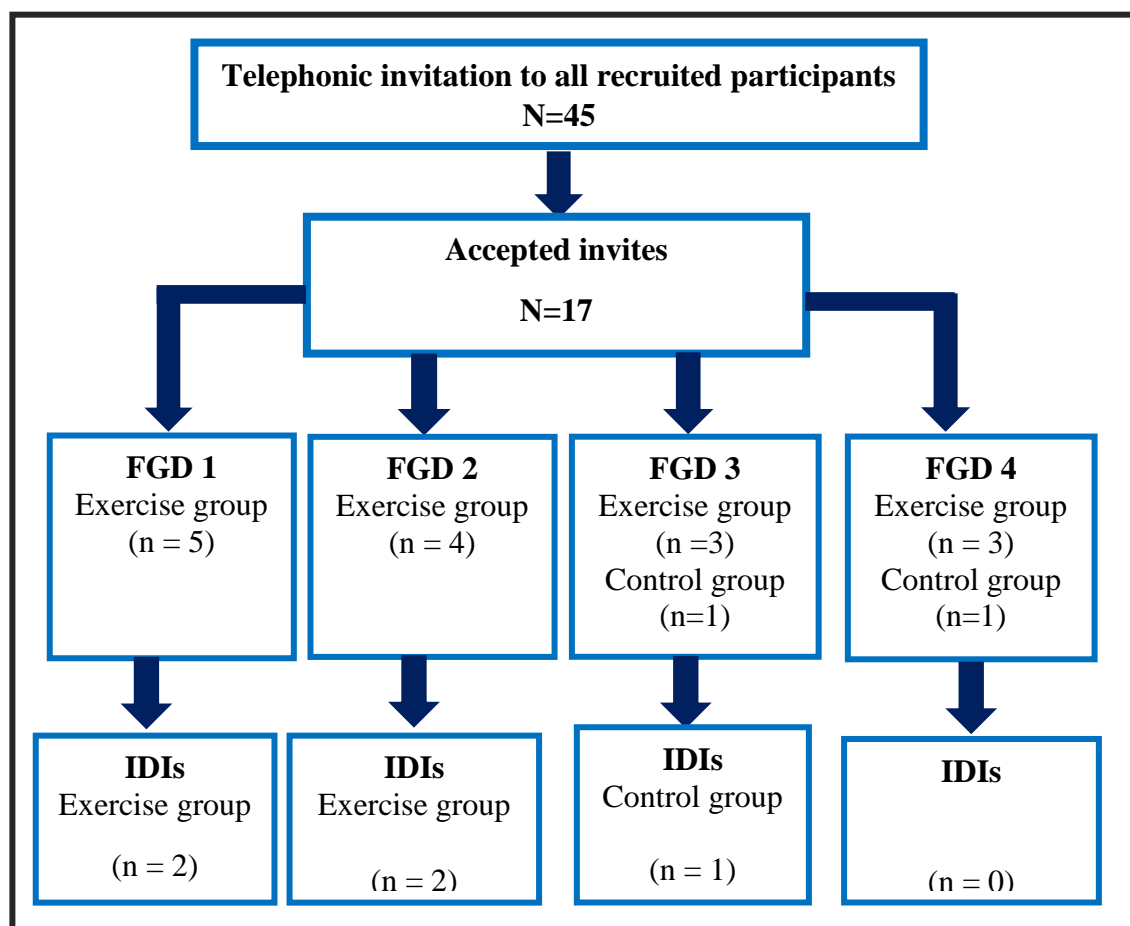


Figure 18: Participant distribution for focus group discussions (FGD) and in-depth interviews (IDI).

6.3.2 Perceptions of the exercise intervention and the perceived barriers and facilitators

Six themes (T) with 2-3 subthemes (ST) each were identified during the analysis process. These themes and subthemes are presented in Table 16. Numbers included in the table reflect the number of fragments of experiences and perceptions brought together to first form the subthemes and later the main themes. Table 16 shows that experiences relating to motivation and the acceptability of the intervention were the themes with the most quotations attached to them. These were followed by barriers experienced; sustainability and being an influencer; the perceived and experienced benefits of exercise, and lastly how the term “exercise” was perceived and defined.

Table 16: Experiences and perceptions after a 12-week structured exercise intervention

Number	Theme	Subthemes	Number of Quotations coded
1	Motivational factors	Extrinsic (financial, weight loss, training environment) and intrinsic (enjoyment and mental wellness) motivation to continue with the intervention	44
		Extrinsic motivation to enrol in the intervention (financial and anticipated weight loss)	27
		Total quotations	71
2	Exercise program acceptability	Aspects of wellness and the training environment participants liked	28
		Aspects of the training environment and exercise regime that participants disliked	26
		Total quotations	54
3	Barriers	Travel constraints	11
		Time	10
		Total quotations	21
4	Sustainability and influencing others	Serve as influencer	16
		Keep on exercising	4
		Total quotations	20
5	Benefits of being physically active	Improved self-efficacy	7
		Disease prevention and reduced stress levels	5
		Lifestyle changes	4
		Total quotations	16
6	Definitions and perceptions of “exercise”	Maintaining a healthy body	6
		Change in body composition	3
		Fit and active	1
		Total quotations	10

Theme 1: Motivational factors

During the analysis process, factors that the participants perceived to play a motivational role during the intervention were grouped together into two sub-themes namely (1) those factors that motivated the participants to enrol in the intervention, and (2) factors that kept the participants in the intervention. These identified factors are to be distinguished from the aspects that participants liked about the intervention which are included in the next theme (acceptability of the programme). Although there are overlaps, the codes informing this theme were drawn specifically from discussion points around what motivated the participants to enrol and then stay in the intervention.

Motivation to enrol: Extrinsic factors played an important role in the decision of participants to enrol in the intervention. Perceived financial advantage was mentioned by participants in all FGDs and some IDIs. This was followed by anticipated weight loss with some participants indicating that both factors played a role in their decisions.

“The money, because I was like, I saw the pamphlet, then I said okay this is so much money, then I was like I need money, and this is going to help me in many things that I need”. (IDI: Participant 36; exercise participant)

“My personal goal was basically to lose weight. I wanted to see how much weight I could lose within those three months.....” (IDI: Participant 25; exercise participant)

“This exercise sessions I was going to lose weight. I was going to be on good shape, and I was going to get money” (FGD 4: Participant 45; control participant)

The in-depth interviews revealed additional insight into why financial considerations were so important, with participants reporting that they bought basic food (often refined carbohydrates) with the money.

“The hamper. The rice, the mealie meal, the flour and the sugar, white sugar”.

(IDI: Participant 19; exercise participant)

Motivation to continue: Participants reported both extrinsic (financial, weight loss, training environment and support from others) and intrinsic (enjoyment and mental wellness) factors that motivated them to remain in the intervention. Financial considerations remained important even in the face of challenges to continue.

“My time was also affected by the exercise sessions, especially the 4 o’clock one because I would end up getting home at about 7pm. I would arrive home late and that would affect my cooking schedule, and they would shout at me at home for being late, but I didn’t give up because I would be getting money.”

(FGD1: Participant 31; exercise participant).

The participants felt toned and fitter as they could now walk long distances faster and climb stairs without becoming breathless.

But then I didn’t really care about losing weight because I actually felt fitter, I can walk from [suburb of Cape Town] to here in 10 minutes. So those were one of the things that I felt the exercise sessions really helped me with” **(IDI:**

Participant 23; exercise participant).

Influence of family and friends also served as motivators for participants from both the FGD’s and IDI’s.

“I’ve got a lot of support from my family. They actually gave me the go ahead, if it is going to work for you, do it. We are behind you all the way. There was also a point where I changed the way I eat, so they were also supporting me in that and my friends also got support from them, there was no negativity”.

(FGD2: Participant 29; exercise participant)

“My family, they motivated me to go to the exercise because it is important for the health”. **(IDI: Participant 36; exercise participant)**

Other participants however reported remaining motivated despite the negative opinions of friends and family. They persevered with the intervention even though their families expressed that their weight was “normal”; receiving remarks that they cannot see that they have lost any weight; or were warned about the negative effects of losing weight.

“My friends. My family was like no your body is okay, and we love you as you are. You don’t have to lose weight; you know how family is. They were just so supportive of you that they don’t even see that there is a problem... ..But what about me? What about what I want? So, I told myself that I am going to do it and I did it”. **(FGD2: Participant 29; exercise group)**

No, people were like, are you really exercising we see no difference. They were demotivating me and it was annoying me because they say when you exercise it’s like chemotherapy you just go and then come out very thin like thin, extremely thin. It doesn’t work like that. With exercise, it takes time to show that you are losing weight.”. **(FGD4: Participant 25; control group)**

Theme 2: Acceptability of programme

Participants shared their experiences about participating in the intervention and what they liked or disliked about the exercise programme, providing insight into the acceptability of the

programme. The disliked aspect can be distinguished from the barrier theme (theme 3) in that the barriers are mostly logistical aspects that made it difficult for the participants to attend the sessions while the disliked aspects were related to various aspects of the exercise programme. Likes and dislikes were equally distributed with many of the aspects of the programme appearing in both the “like” and “dislike” sub-themes, such as assistance from trainers and the types of exercises.

Aspects that were liked: Four main aspects came to the fore when participants discussed what they liked about the intervention. Three of these relate to the training environment. Participants liked and appreciated the support and assistance from the trainers and research team, this was followed by the type of exercises, music as part of exercise routines and lastly, wellness aspects (including friendship, feeling energized and having fun).

Positive experiences around support from the intervention team included factors such as having patience with and appreciating their challenges such as being late for the exercise classes.

“The things that I loved most about the exercise is the aerobic sessions, the fact that when we are tired, instructors would be patient with us. They would be very supportive. (FGD1: Participant 24; exercise participant).”

As highlighted in the previous quote, aerobics was the type of exercise session that was enjoyed the most. Music was used with all exercise routines and this component of the exercise programme was enjoyed by many participants. The importance of music was reiterated in the IDIs.

In addition, participants enjoyed training in a group setting and making new friends. This was reaffirmed in the IDIs.

“The one thing that I like the most is that we do it as a group, firstly. It’s not like you’re doing it alone. I can do it with someone else, with people, that is nice”

and different types of exercises that I enjoyed is that what the question was about” (FGD3: Participant 23; control group).

Aspects that were disliked: Five aspects of the intervention were identified by the participants as contributing to negative experiences. The most discussed were the training environment followed by the types of exercises, time allowed for the exercises, the physical activity monitoring equipment and lastly, the instructors.

The venue, outdoor exercises and perceived racial discrimination were factors in the training environment that contributed to negative experiences. Concerning the racial discrimination some participants indicated that they sometimes felt unwelcome in the training venue and perceived this to be because they were black.

“I feel like sometimes when we are here, other people down there, were looking at us badly because we are black, they used to say that we are disturbing them, especially when there was another class. They would want us to put our music softer but when we were outside, no one would complain”. (FGD1: Participant 19; exercise participant)

Participants identified that the heart rate monitors were uncomfortable to wear. Some of the participants also disliked certain high intensity exercises such as running up and down stairs, sit-ups, jumping jacks and running outside in the sun.

“Having to wear equipment while exercising. Not the watch. Our equipment is very irritating. I get irritated by just looking at it” (FGD 3: Participant 44; exercise participant).

Time available to complete the exercise sessions and negative experiences with the instructors were also raised as factors that negatively affected experiences, the latter were raised by a participant during the IDIs.

“I think it would be a bit more fun if the starter could maybe try to have different trainers with different experience... If there were different trainers maybe that would make things funnier or exciting. There were times when she will seem like she was not in the mood for exercise sessions”. (IDI: Participant 23; exercise participant)

Theme 3: Barriers

The most common barriers were travel constraints and lack of time. Some participants felt that the venue was not central, and they had to travel long distances to get to the venue. Three of the five participants mentioned the issue of transport as a barrier during the IDIs.

“It does not accommodate everyone, only accommodate those who are closer to the buildings.... So, the traveling is also a barrier” (FGD2: Participant 29; exercise participant)

Most of the participants identifying time as an issue were university students, some of whom worked part time in addition to their studies and had challenges finding time to attend the programme.

“It affected my daily life when I had things to do, and I had to come here to the gym.....So it was very difficult for me to manage time because I had to come here at half past four. I was always late”. (FGD1: Participant 27; exercise participant)

Theme 4: Sustainability and influencing others

Participants shared their perceived enthusiasm to continue with the exercise programme after the end of the intervention and influence others to exercise. All FGDs participants indicated that they would encourage family and friends to start exercising. Further, being more physically

active as a result of the intervention made them more aware of the benefits and importance of exercise and physical activity

“I will say yes or motivate someone to go to the gym because black people’s mentality is that- one has to have curves. We are the ones, we are Black, you understand because when you’re exercising like you are minimizing certain illness so I would say yes” (FGD4: Participant 32; control participant).

Continuing with an exercise programme came up in the FGDs and was explored further in the IDIs. Three of the five participants who participated in the IDIs continued training on their own after the intervention, one with the help of a volunteer instructor in an informal group setting.

“I jog with my friends to the certain place and then when we get there we meet like other people and there’s like [Xhosa] we have an instructor, but we don’t pay. There is an instructor, but they do it for fun, for the love of it”. (FGD1: Participant 19; exercise participant).

One participant however reported difficulty in being consistent with the exercise regime mostly because of a lack of a supportive training environment.

“Because I don’t have a personal trainer, so I don’t have someone looking after me. I do go sometimes, sometimes I don’t go”. (IDI: Participant 23; exercise participant)

Theme 5: Benefits of being physically active

Most participants acknowledged that after completing the programme they were more aware of the benefits and importance of being physically active. The perceived benefits could be grouped in three sub-themes. Improved self-efficacy was the strongest sub-theme, followed by disease prevention and reduced stress levels, and lastly, lifestyle changes.

Some participants reported improved self-efficacy in the form of coping and scheduling skills. They expressed that the exercise programme helped improve their ability to cope with busy schedules and assisted with scheduling their busy daily routines.

“Third year students have a lot of work so if I come home late, my body is tired but since I have been exercising, I have been coping. I would leave my room at 4 or 5 and I would have to come back and cook, eat and do schoolwork but what I realized was that I could cope unlike before when I used to sleep for 30 minutes. Since the gym I feel alright so that was the positive part about the gym. I could cope and be able to climb the stairs”. (FGD4: Participant 37; control participant)

“So, like the fact that I had to allocate like some of my time to the gym, like to commit some of my time to this gym thing that’s happening, it helps me to plan my daily activities”. (FGD1: Participant 24; exercise group)

Participants perceived that exercise increased their energy levels, reduced stress and may reduce risk of diseases such as high blood pressure, diabetes and heart disease.

“like I see exercising as a tool that reduces high blood pressure”. (FGD4: Participant 32; control participant)

“Exercise for me personally is a stress reliever”. (FGD3: Participant 39; exercise participant)

The participants furthermore perceived exercise to be associated with positive lifestyle changes such as changes in diet and participating in more active leisure time activities (i.e., going to the gym).

Theme 6: Definitions and perceptions of “exercise”

Several sub-themes emerged from the discussion around what the term “exercise” means. Participants defined “exercise” most often in terms of maintaining a healthy body, followed by changes in body composition such as weight loss and increased muscle mass, engaging in any physical activities, and lastly the perception that it is something that a specific group of people do.

“I think the word exercise means getting yourself to be healthy, trying to change your body, get more muscles by doing exercises”. **(FGD3: Participant 39; exercise participant)**

“I feel like exercise has to do more with physical activities than anything else. It is a physical activity. You don’t have to do a certain thing and say it’s exercising. You can walk, you can [do] anything, moving your body in general”. **(FGD3: Participant 44; exercise participant)**

A few of the participants from the FGD perceived exercise to be associated with ethnicity.

“like I’m going to be very honest, like the word exercise to me, like it has the whiteness on it, like this whiteness, like it’s for white people”. **(FGD1: Participant 24; exercise participant)**

Figure 19 presents these themes as described in the following presentation of the results and shows some of the possible associations and overlaps between the various themes and sub-themes.

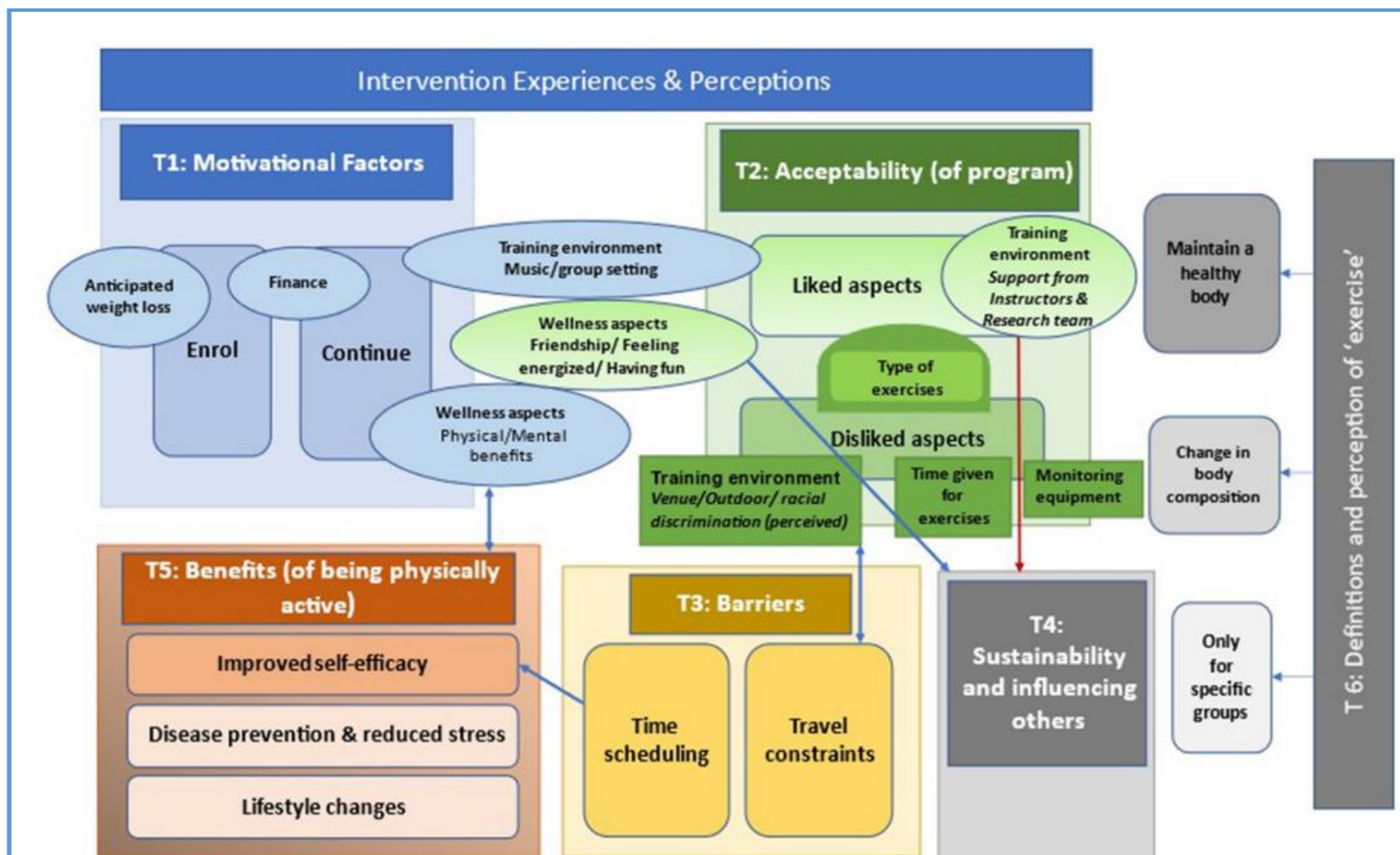


Figure 19: Themes and subthemes with possible associations and overlaps.

6.4 DISCUSSION

In this study we aimed to gain an understanding of the experiences and perceptions of young Black SA women living with obesity following their participation in a 12-week structured exercise intervention. Six themes were identified from the focus groups and in-depth interviews and included motivating factors, acceptability of the programme, barriers, sustainability and influencing others, benefits of being physically active, and perceptions of the term 'exercise'.

Financial advantage in the form of remuneration for costs relating to travel and time were identified as an important extrinsic motivator for enrolling and staying in the programme. This is not a unique finding as financial incentives have, even in high income settings, shown to be effective in behaviour change and achieving physical activity goals, as well as to moderate the effects of self-efficacy on weight-loss in adults with obesity participating in interventions (273, 274). Although there is no data on the role of financial gain on physical activity interventions within the South African context, conditional cash transfers have been used in South African high school girls to reduce HIV incidence among young women and address structural factors such as poverty (275). However, the amount of money provided to our participants as reimbursement for their travel and time was small and the perception of financial advantage gained from the project may point to the socio-economic hardships suffered in the communities from which our participants were drawn (276). This opinion is supported by the finding that participants reported using the money to buy high-energy dense staple foods such as maize-meal and sugar. These choices suggest high levels of food insecurity in the households of our participants. The consumption of high energy dense foods in low socio-economic populations and the link with obesity has been consistently reported in the literature (59, 60).

In addition to the financial incentive, participants reported weight loss (anticipated and actual) as a motivator for enrolling and staying in the intervention. Participants were reminded at

recruitment that substantial changes in body weight are not commonly shown in response to exercise only interventions (149, 277). Although only a small but significant weight loss was achieved by the intervention group (~1 kg) (278), this was experienced positively by the participants. Physical benefits such as a perceived increase in fitness levels and muscle tone could have contributed to these positive experiences. The multiple socio-cultural, environmental and behavioural factors involved in the risk for Black SA women to become obese (59) provides a further understanding for why even a small weight loss could have been considered an achievement.

Another benefit reported by participants was an improvement in psychological wellbeing (improved mood and self-esteem). These findings are supported by quantitative results previously reported from the same intervention, showing reduced symptoms of depression and improved sleep quality in response to the exercise training (277). Our findings are also consistent with previous research findings which suggested that improved psychological and physical wellbeing are related to increased exercise adherence in women with obesity (279). A study by Cleo et al. (280) reported that participants in a weight loss programme were impressed by the “indirect ripple effect” of health benefits they experienced aside from weight loss, and this seems to be true for our study as well.

Another benefit identified is the perceived increased level of self-efficacy of participants. Some indicated that participation in the programme assisted them with improving their scheduling behaviour while feelings of enhanced physical fitness, reduction of stress, and improved mood were all evident and have previously been shown to strengthen self-efficacy (208). An increase in self-efficacy is furthermore associated with persistence in exercise training even in the presence of challenging barriers (24). Barriers to attending the training sessions in our study included lack of time, distance to the training venue, and limited transport to the training venue,

all of which have been previously reported in low socioeconomic settings (199). This is different from barriers identified in similar studies such as scheduling conflicts with schoolwork, lack of motivation and social obligation to family or friends (201).

Moreover, participants reported aspects of the programme that they did not like such as the venue, some personal characteristics of the trainers, high intensity exercises and perceived racial discrimination at the venue. The latter is important as racial “everyday discrimination” were found to be positively related to distress (199) and potentially may weaken the positive experiences of participants to similar programmes. When considered together with the perception of exercise as an activity done by “white” people only, careful attention should be given to this aspect in exercise programme development. The dislike of high intensity exercise supports the results of Foster et al. (281) that in a group of relative untrained young adults the exercise regime with the highest intensity had the lowest enjoyment score.

Intrinsic and extrinsic aspects of the training programme and training environment, such as support by the instructors and group, types of exercises, friendships, fun and music were identified as well-liked aspects of the programme, which are similar to those reported by Guess (200). Participants suggested that these positively experienced factors are important when considering the sustainability of the programme, made them feel motivated to influence others to exercise and motivated them to continue with the intervention. According to Withall et al. (199) once people are active, high levels of social interaction, interest and enjoyment, are associated with improved levels of retention. Our results show that the perceived benefits (motivators) outweighed dislikes and barriers and facilitated the continuation and completion of the intervention. Not only did most participants (87%) complete the programme, but some went on to continue exercising, and all saw themselves as potentially motivating loved ones to embark on exercise programmes.

The non-attendance of some of the control participants for the FGDs and IDs can be viewed as a limitation. Another limitation of the study is that no member checking was done to explore the credibility of the findings. Various aspects of the study however contribute to the credibility of the findings. Firstly, the study was preceded by formative work in a similar group of women and the research team had insight into the lived experiences of the study participants. Although the exercise training was prescriptive and not self-selected, the mode of training was based on this formative work (46). Furthermore, extensive notes were taken by a scribe and these notes were considered during the analysis process. The current study only included participants that completed the intervention, as drop out participants were not contactable, but the aim was to describe the perceptions and experiences of those that completed the intervention.

6.5 REFLECTION ON THE TRUSTWORTHINESS OF THE DATA ANALYSIS

Even though there was no member checking conducted to explore the credibility of the findings. The current study ensured credible findings by ensuring that the FGDs and IDIs were audio recorded, IsiXhosa words translated to English and transcribed by independent service providers. The presence of the scribe during the FGDs and IDIs was to confirm the information from the audio recordings. Furthermore, the identification of themes and subthemes was applied to ensure transferable information from the audio recordings to enable us to answer our research question. In addition, the generation of themes and subthemes by one research member and reviewed by the rest of the research team ensured trustworthiness of the analysed data and reporting of dependable findings.

6.6 CONCLUSION

The current study showed that the young Black SA women from a low-resourced setting that participated in a 12-week structured exercise intervention identified perceived financial gain and perceived weight loss as motivators for exercise adherence. Furthermore, adherence to an

exercise training programme was identified to enhance mood, increase self-esteem, self-efficacy, and the development of skills to cope with perceived barriers. A targeted intervention approach that incorporates elements such as the presence of an exercise instructor, music and dancing in a group setting should be considered when developing public health programmes for sustainability in young women from low-income settings. It can be argued that the group-based exercise setting created a sense of a safe training environment for the participants. The negative influence of unsafe neighbourhood in low-resourced settings in SA as presented earlier in the literature review of this thesis suggest that safe exercise environments need to be considered for this population. Some of the practical barriers that should be taken into consideration in implementing similar interventions is the limited availability of equipment, funding, venues and trained personnel to present and supervise the exercise sessions in the communities on a regular basis. Lastly, ease and cost of access to training facilities is key to increasing and/or maintaining participation adherence in similar exercise training programmes in this population and should be considered for programme sustainability. Collectively, improved self-efficacy may play an important role in supporting exercise behaviour and should be a component that is assessed to ensure sustainability when implementing future exercise programmes. Despite the participants receiving the reimbursement for transport and compensation for their time and inconvenience, we are of the opinion that financial incentives are not likely to be a sustainable approach for long term interventions. Further research is required to address other sustainable motivators to exercise adherence such as self-selected exercise training modes and intensities, and combining diet and exercise to maximise weight loss.

CHAPTER 7

Summary discussion and conclusions

7.1 OVERVIEW OF THE RATIONALE FOR THE THESIS

Despite a high prevalence of overweight (26.5%) and obesity (40.9%) reported among Black SA women (11), majority of Black SA women meet the recommend PA guidelines and are classified as physically active (12-16). However, a large percentage of this PA is accumulated through walking for transport (12, 14), which is undertaken at a low to moderate intensity. In contrast, a few Black SA women, particularly from low-resourced settings, participate in leisure time PA (13). Leisure time PA, which is achieved through structured exercise interventions, increases MVPA (17) and has also been associated with altered physical behaviours (i.e. reduced SB) (18), improvements in body composition (19), CRF (20, 21), perceptions of body image (22-24) and self-efficacy (6, 24) in women living with overweight and obesity. However, most of these exercise interventions have been conducted in HICs (17-19, 22-24, 160, 161, 174, 191), with few studies from Africa (156, 162-164).

Formative research has shown that Black SA women living in a low resource setting consider exercise as a strategy to improve health and have demonstrated interest in participating in a community-based exercise intervention that includes exercises such as dancing, aerobics and lifting weights (46). However, it is not known how participation in a structured exercise intervention will alter habitual physical behaviours, or body image and self-efficacy. Further, little is known about the barriers and facilitators that influence participation in a structured exercise program among women living with overweight and obesity from a low-resourced setting. Therefore, this thesis adopted a randomised control study design and examined the effects of a 12-week combined (aerobic and resistance) exercise training intervention on: i) the changes in physical behaviours; and ii) body image and self-efficacy in women. Lastly, iii) this thesis explored the perceptions and experiences of the women after participating in the 12-week combined exercise training intervention. The summary of significant findings, implications and novelty of each chapter are presented in table 17.

Table 17: Summary of significant findings, implications and novelty of each chapter.

Chapter title	Summary of significant research findings	Implications	Novelty
<p>Chapter 4: Changes in physical behaviour patterns in response to a 12-week exercise intervention in women living with overweight and obesity from a low- resourced setting.</p>	<p>- ~ 1kg weight loss, decreased % gynoid fat and increased CRF were observed in the EXE group in response to the intervention, while ~ 1kg weight gain and a decline in CRF were observed in the CON group.</p> <p>- Compared to the CON group and when considering exercise days only, the following changes were observed in response to the exercise training in the EXE group from baseline:</p> <ol style="list-style-type: none"> 1. Significant increase in MVPA (min/d and %) during weeks 4, 8 and 12. 2. Significant increase in TPA (min/d and %) during week 8 and 12. 3. Accumulation of more steps during week 4, 8 and 12. 4. Decline in SB (% of awake time) during week 4, 8 and 12. 5. Increase number of sit-to-stand transitions during week 8. 	<p>- These findings showed that the overall daily increases in MVPA and TPA were largely due to the increased PA accumulated during the exercise sessions. This corresponded with the significant decrease in SB (% of awake time) from baseline to week 12 among the EXE group.</p> <p>- The increase in time spent in 60 min/d sedentary bouts by the EXE group during week 8 of non-exercise days suggest a compensatory behaviour that may be as a result of fatigue from participating in the intervention. However, the EXE group participants seem to have overcome this in week 12 as the time spent in 60 min bouts reduced by almost half, an indication of positive changes in SB as a result of the 12-week exercise intervention.</p>	<p>- This is the first study to show changes in physical behaviours (an increase in objectively measured overall PA and decrease in SB (% of awake time) in response to a combined exercise intervention among women living with overweight and obesity from low-resourced setting.</p>

	<p>6. Sit-to-stand transitions significantly increased during week 4.</p> <ul style="list-style-type: none"> - Compared to the CON group, no changes from baseline were observed in the EXE group during non-exercise days except for the increased time spent (114.7 ± 126.3 min/d) in 60 minutes bouts of SB during week 8. - Lastly, increases in MVPA and TPA were associated with increases in CRF and reduced body weight for all participants. 		
<p>Chapter 5: The effect of a 12-week exercise intervention on perceived body image and self-efficacy in women living with overweight and obesity from a low-resourced setting.</p>	<ul style="list-style-type: none"> - Majority (80%) of participants from both groups were living with obesity, but underestimated their BMI status and perceived themselves to be overweight at baseline. - Using Stunkard's silhouettes to assess perceptions of body image, women from both groups desired a smaller body size and this did not change in response to the intervention. - Majority (60.0%) of participants in both groups classified themselves as normal-weight following the intervention, despite 	<ul style="list-style-type: none"> - Findings from this study are in line with previous research in a similar setting, where women underestimated their body size. The exercise intervention might have exacerbated the underestimation of body size discordance amongst these women. - Underestimation of body size might have adverse health effects such as increased risk of developing overweight and obesity-related NCDs. - Despite presenting with body size discordance, FID score results suggested that 	<ul style="list-style-type: none"> - This is the first study to show that participation in a 12-week combined exercise intervention among young Black SA women living with overweight and obesity from a low- socioeconomic setting exacerbated body size discordance and reduced generalized self-efficacy, measured using Stunkard's

	<p>80% and 20% of the women living with obesity and overweight</p> <ul style="list-style-type: none"> - A significant decline in general self-efficacy was observed in both groups in response to the intervention 	<p>most women desired a smaller body size at baseline, and this did not change in response to the intervention,</p> <ul style="list-style-type: none"> - The decline in the generalized self-efficacy might negatively affect the women's confidence and ability to organize regular exercise. However, the sensitivity of the tool to assess GSE in this populations requires further investigation. 	<p>silhouette and Generalized - self-efficacy questionnaire.</p>
<p>Chapter 6: Exploring the perceptions and experiences of young Black women with obesity after following a 12-week structured exercise intervention.</p>	<ul style="list-style-type: none"> - Weight loss (anticipated and actual) and remuneration costs relating to travel and time were identified as important extrinsic motivators for enrolling and staying in the programme. - Improvements in psychological wellbeing (improved mood and self-esteem), increased levels of perceived self-efficacy are some of the benefits identified by the participants. - Lack of time, distance to the training venue, and limited transport to the training venue were some of the barriers identified by the women 	<ul style="list-style-type: none"> - In contrast to the self-efficacy measured using GSE, results of the FGD showed increased levels of perceived self-efficacy may have contributed to the participants overcoming barriers and being able to organise their time and responsibilities around PA, an indication that they attained multiple domains of self-efficacy including task, coping and scheduling self-efficacy. - Our results showed that the perceived benefits (motivators) outweighed dislikes and barriers and facilitated the continuation and completion of the intervention. 	<ul style="list-style-type: none"> - This is the first study to report on improvements in psychological wellbeing (improved mood and self-esteem) in response to a 12-week combined exercise intervention in young Black SA women living with overweight and obesity from a low socioeconomic. In addition, this study highlighted barriers and facilitators to attending an exercise intervention.

	<ul style="list-style-type: none"> - Programme aspects not liked by the women included some personal characteristics of the trainers, high intensity exercises and perceived racial discrimination at the venue. - Programme aspects liked by the women included support by the instructors and group, types of exercises, friendships, fun and music 		
<p>Abbreviations: BMI: body mass index; CRF: cardiorespiratory fitness; CON: control; EXE: exercise; FID score (calculated by subtracting the ‘ideal’ from the ‘feel’ silhouette); PA: physical activity; Min/d: minutes per day; MVPA: moderate and vigorous physical activity; NCDs: non-communicable diseases; SA: South Africa; SB: sedentary behaviour; %: percentage; TPA: total physical activity; ~: approximately.</p>			

7.2 MAIN FINDINGS

This is a summary of the main findings from the various chapters presented in this thesis. At baseline (non-exercise days), women from both the CON and EXE group accumulated an average of 40min of MVPA/d, suggesting that these women are accumulating ≥ 200 min/d of MVPA throughout the week, exceeding the 75–150 min of MVPA throughout the week as recommended by WHO (9). The daily MVPA findings from the current thesis mirror those reported from a similar population where majority of young and middle-aged Black SA women from low-resourced settings were reported to be meeting the PA guidelines according to the GPAQ (12-14). Notably, the participants in the EXE group accumulated an additional ≥ 45 min/d in MVPA and ≥ 50 min/d in TPA during exercise days, with no changes in LIPA reported. When considering all valid days, this translated into increases of ≥ 20 min/d and ≥ 25 min/d for MVPA and TPA respectively among the EXE group. This was accompanied by a commensurate 10% decrease in SB (% of awake time) among the EXE group during exercise days. These findings show promise of the positive impact of the exercise intervention on altering physical behaviours such as increasing MVPA and reducing SB.

The significant increase in MVPA, TPA and daily steps among the EXE group were largely due to the increased physical activity accumulated during the supervised exercise sessions presented 4 sessions x wk, which progressed from 40 min to 60 min a session over the 12-week intervention. The increase in MVPA during the exercise days was accompanied by an increase in daily steps from ± 9429 steps/d to more than ± 14780 steps/d during exercise days throughout the 12 week intervention, exceeding the recommended guidelines of accumulating 10,000 steps/d (251). In contrast, accumulated daily steps in the CON group decreased non-significantly from $\pm 10,131$ steps/d to an average of ± 9450 steps/d over the course of the intervention, corresponding with their non-significant decrease in daily MVPA and TPA, possibly reflecting variability in PA over time, possibly reflecting a variability.

Even though the exercise intervention resulted in significant improvements in physical behaviours during the non-exercise days, there was a significant increase in the time spent in 60 min/d sedentary bouts (114.7 ± 126.3) among the EXE group during week 8 of the intervention, suggesting a compensatory behaviour. This is likely due to intervention fatigue that coincided with the decrease in training load intensity (RPE and %HRmax) among the EXE group. However, during the non-exercise days, the time spent in 60 min SB reduced to 59.7 ± 95.6 min/d in week 12 of the intervention. Furthermore, findings from the current study did not find significant associations between sedentary time and body composition. This may be due to the effects of the increase in sedentary time being offset by the increase sit-to stand transitions during the same period (non-exercise days during week 8 of the intervention). Interrupted prolonged sitting time has been shown to yield positive health benefits such as decreased postprandial glucose and insulin levels not only in adults living with overweight and obesity (282), but also among healthy and normal weight adults (137). Thus, it is important that health professionals not only promote the importance of participating in exercise, but should also raise awareness about the detrimental health effects of increased sedentary time despite being physically active. Such awareness could possibly encourage individuals to break up prolonged sitting time and engage in MVPA.

Findings from the current thesis also showed that the increases in MVPA min/d were associated with reduced body weight and improved CRF among all participants. It can be argued that the significant increases in PA levels and reduced SB (% of awake time) among the EXE group was a contributing factor to the small, but significant weight loss (~1 kg) and reduced BMI (~1 kg/m²), % gynoid fat (~0.3%) and improved CRF (VO₂peak ~2.7 ml/kg/min) among the EXE group. There is indisputable evidence showing that regular exercise results in increased CRF (17, 20, 149, 150). Furthermore, greater CRF has been reported to be associated with improved lipid profile, and greater insulin sensitivity before and after adjusting for fat mass (39). In

contrast, low CRF is associated with higher cardiometabolic risk (153) and is also one of the strongest predictors of all-cause mortality and NCDs (154, 155). The reduced SB (% of awake time) among the EXE group from the current thesis is also an indication of possible improvements in cardiometabolic health. Research findings from compositional analysis of the 24 hours movement in adults living with overweight, obesity and pre-diabetes suggest replacing SB with LIPA may produce metabolic benefits that contribute to the prevention and management of NCDs such as T2DM (283). Recent findings from a cross sectional study conducted among SA women from a low-income showed that reallocation of 30 min of sitting and lying to MVPA and 30 min of standing to MVPA were associated with a 0.3% and 1.4% FM respectively (107).

It is important to note that even though large changes in body weight are not commonly shown in response to exercise training interventions (148, 149), extrinsic factors such as physical appearance (203) weight loss and a ‘toned body’ (204) have previously been shown to be motivating factors for participating in exercise training. Qualitative findings (Chapter 6) from this thesis showed that weight loss (anticipated and actual) was one of the motivators for enrolling and staying in the intervention, despite the study aims being focused on the changes in T2DM risks rather than changes in body weight. The women in the current study underestimated their body size (based on BMI and silhouettes) at baseline and perceived themselves to be overweight, as opposed to 80% being classified as living with obesity. This did not change over time but was exacerbated with exercise training as 60% of the women from both groups classified themselves as normal weight following the intervention.

It can be argued that exercise training can be considered as therapeutic strategy to improve perceptions of body image (2, 22, 23). Nonetheless, the perceptions of overweight and obesity based on BMI may have been underestimated to a greater extent due to a lack of understanding

of BMI categories. On the other hand, body silhouette images may provide a better representation of their body size compared to understanding the concept of BMI categories. For the first time, results from this thesis provide information on the effects of exercise training on perceptions of body image in Black African women living with overweight and obesity, which may inform future interventions. Being more accepting of overweight (44, 46) and obesity (42, 46) has been consistently reported among Black SA women. This may be due to the fact that a bigger body size is perceived as an indicator of beauty, dignity and even a sign of affluence (43). Whereas a thin body was viewed as not respectable and also associated with poverty (43) and sickness (45, 46).

Body size underestimation and body image (discordance) could negatively impact weight management and the prevention of NCDs. Body weight discordance has been associated with an increased prevalence of obesity and cardiovascular diseases (49) and may have important implications for weight management and the prevention of NCDs (264). Moreover, the FID score (body size dissatisfaction) of 1 (1-2) suggested that most participants desired a smaller body size at baseline, and this did not change in response to the intervention. The desire to have a smaller body size has been observed in other studies conducted among economically disadvantaged African American and African women living with overweight and obesity (45, 48, 49, 179), which may suggest that the women may be receptive to interventions that can result in more significant weight loss, such as combined diet and exercise interventions.

Community based exercise interventions comprising of dancing, aerobics and lifting weights have been identified as some of the desirable exercise activities to improve health by Black SA women from a low-resourced setting (46). These activities were incorporated into the intervention presented as part of this thesis, which were identified as well-liked aspects of the intervention in the FGDs. These well-liked intervention aspects could have possibly

contributed to the high exercise intervention adherence and retention with a recorded attendance of 77.2%. Once people are active, high levels of social interaction, interest and enjoyment, are associated with improved levels of retention (199). In addition, participants from the current study reported that financial remuneration for travelling costs and time were motivators for enrolling and staying in the intervention, which might have also contributed to the high attendance rate to the exercise sessions. Financial incentives in adults living with obesity from high-income countries have been effective in achieving PA goals and moderating the effects of self-efficacy on weight-loss (273, 274). There is a paucity of data reporting on the role of financial incentives on physical activity interventions within the SA context. Financial remuneration is not a sustainable approach for interventions in low resource settings such as SA, and further research is required to address other sustainable extrinsic motivators.

The common barriers to the intervention reported by the participants during FGDs (Chapter 6) included lack of time, distance to the training venue, and limited transport to the training venue, all of which have been previously shown in low-resourced settings (199). Nonetheless, the 77.2% attendance rate to the exercise sessions in the current study (Chapter 4) indicate the participants' ability to control environmental challenges that were related to the exercise intervention. Qualitative findings from this thesis (Chapter 6) provide evidence that participants attained multiple domains of self-efficacy including task, coping and scheduling self-efficacy. Thus suggesting that participants developed confidence to participate in physical activity, overcame barriers, and organised their time and responsibilities around physical activity (205). According to the SCT, self-efficacy is a focal determinant of health behaviour change, because it is the common pathway through which self-regulatory efforts influence health functioning (210). In addition, self-efficacy is an individual's confidence in his or her ability to organise regular exercise, belief in ability to perform the elemental aspects of a task,

confidence in successfully completing an activity and ability to perform the tasks under challenging conditions (208).

Surprisingly a significant decline in questionnaire based GSE (221), was observed in both groups post intervention. This contrasts to the reported improvement in perceived level of self-efficacy during the FGDs and IDIs (Chapter 6). The GSE findings from the current thesis (Chapter 5) differ from those previously reported, where exercise training resulted in enhanced physical self-efficacy among college students (24), significant improvements in general self-efficacy among sedentary women (191), and schedule, physical, exercise-worries efficacy in women living with overweight and obesity (6). The GSE questionnaire may not capture the participants response to an exercise training intervention adequately. This specific questionnaire has not been validated in this context previously, thus, may not have provided accurate answers and requires further investigation. Further insight into self-efficacy in response to exercise interventions using a qualitative approach may better capture the nuances in this population. Indeed, qualitative findings (Chapter 6) from the current study showed that improvement in psychological wellbeing (improved mood and self-esteem) were other reported benefits of the intervention. Feelings of elevation of mood can strengthen self-efficacy and may play an important role in supporting exercise behaviour (208).

7.3 STRENGTHS AND LIMITATIONS

Strengths from this thesis include the true experimental design through a randomised control trial with random assignment of participants to either the treatment (exercise) or control group. All the exercise sessions were conducted in a group setting and were supervised by a trained Biokineticist (Exercise Physiologist). In addition, the training intensity of each participant was captured at each session using heart rate monitors to show that the participants achieved the desired training intensity of 70-85%HRmax for continuous aerobic training and 60-70%HRmax for resistance training. Both the control and exercise groups were advised to maintain their normal dietary behaviour, while only the control group participants were asked to maintain their normal physical behaviour patterns throughout the 12-week study period. Physical behaviours and dietary intake were measured in both groups. There were no significant changes observed in dietary intake over time between the groups.

Other strengths from this thesis include the use of objective tools to measure body composition, CRF, PA and SB. The DXA was used to measure body composition and CRF was determined by measuring VO_{2peak} using a walking treadmill-based graded exercise test using direct calorimetry. Furthermore, hip worn (ActiGraph) and thigh worn (ActivPAL) accelerometers were used to measure PA and SB, respectively. Advantages of using these objective measures of PA and SB as opposed to subjective measurement tools is their high reliability and validity for quantifying physical behaviour patterns (95). Changes in PA and SB were collected from both groups across four time points during the 12-week intervention. Physical activity and SB variables were further differentiated into exercise days and non-exercise days. Averages were not used during statistical analysis, but each individual day of data was considered a single data point for the purpose of capturing variation in the data. Moreover, weekly sleep log sheets were used to exclude sleeping time from sedentary time.

A valid and reliable instrument was used for assessing perception of body image previously used in this population (188). In addition, FGDs and IDIs were used to gather information on self-efficacy, and the experiences and perceptions of the exercise intervention. The semi-structured FGD questions were formulated based on previous qualitative work done in a similar group of women from the study community (46). FGDs provide a conducive environment for understanding collective social action, accessing group beliefs and understanding behaviours and attitudes that might be overlooked during IDIs (195). Nonetheless, IDIs comprising of a single open-ended question allow the interviewer to follow topical trajectories in the conversation, as well as provide the interviewees freedom to express their views in their own terms (238, 239). The advantage of IDIs is that it eliminates the influence of others' opinions that could have occurred during the FGDs (237). Both the FGDs and IDIs were audio recorded and a trained facilitator and scribe who were fluent in both English and IsiXhosa, the vernacular of the study population, conducted all the FGDs and IDIs. This was to ensure that no participant was excluded from the FGD and IDIs because of language barriers. Familiarity with the language commonly used by research participants is important both for effective communication and development of an adequate understanding of their experiences and beliefs (240). Furthermore, extensive notes were taken by the scribe and these notes were considered during the analysis process. The audio recordings were transcribed from IsiXhosa into English by an independent translator, fluent in both English and IsiXhosa. The accuracy of the transcriptions was checked by the researcher against the notes taken by the scribe.

This thesis reports on secondary outcomes from the primary study and this can be viewed as a limitation. Two main outcomes of physical behaviours (daily steps and MVPA in min/d and %) were sufficiently powered (power >80%). However, TPA and %SB were not sufficiently powered (power <80%). Even though the ActiGraph accelerometer was used to quantify PA intensity, the various cut points used have not been validated in a South African population and

this can be viewed as a limitation. Further, the unequal number of days obtained from the PA and SB variables through the four times points of the intervention from both groups is another limitation observed in this thesis. Nonetheless, we were able to obtain data for a maximum of 114 valid days and minimum of 112 valid days for the EXE group, while a maximum of 98 valid days and a minimum of 76 valid days were obtained from the CON group for a specific time point during the 12-week intervention, providing robust data from both groups. Another limitation observed in this thesis was the higher dropout rate in the CON group (n=7) in comparison to the EXE group (n=3). The use of the GSE questionnaire for assessing self-efficacy was another limitation from this thesis as it has never been validated in SA. Nonetheless, this tool was used in the current study as it is reported to reflect a generalisation across various domains of functioning in which people use to judge how successful they are (7). To the best of our knowledge, this tool has not been validated in this population. Furthermore, the selection of the most vocal participants from the focus groups in the inclusion of the IDIs may have introduced bias to the results. Possibly, limiting the themes identified in the current study and needs to be considered when interpreting the outcomes. Furthermore, only participants that completed the intervention were included in the FGDs and IDs as drop out participants were not contactable, thus the reasons for dropping out could not be accurately assessed. Nonetheless, the aim of this thesis was to describe the perceptions and experiences of those that completed the intervention. Other limitations of the current thesis are the relatively small sample size and unequal distribution between the treatment and control group. Data on socioeconomic position were also self-reported, thus may be subject to recall bias. It is also important to note that findings from this study cannot be generalisable to all populations as it was only conducted in young Black SA women living with overweight and obesity from a low resourced setting. Nonetheless, this is an understudied and underserved population that presents with a high prevalence of overweight, obesity and NCDs risk.

7.4 CONCLUSION

Findings from this thesis showed an increase of approximately 60 min/d in MVPA and 79 min/d in TPA with a reduction of 9.7% in SB (% of awake time) among the EXE group during exercise days only at week 12 of the intervention. In addition, an average increase of 25min/d in MVPA and 48min/d in TPA with a reduction of 5% in SB (% of awake time) was observed in the EXE group during all valid days. These results indicate the practical significance of potential positive health outcomes from increased MVPA and reduced SB. Our findings provide a clear indication that the overall PA increases with exercise training were largely due to the increased PA accumulated during exercise sessions. These findings suggest that the exercise intervention may support positive changes in physical behaviours. Even though the exercise intervention did not translate to clinically meaningful changes in body weight, the improvement in CRF highlights the need for long term aerobic and resistance community-based group exercise interventions for this population. We hypothesize that long term exercise interventions, beyond 12-weeks may result in long term positive health outcomes. Furthermore, the positive changes in CRF and PA patterns experienced with exercise training may have the potential to positively impact the cardiometabolic health of this population and also possibly reduce the prevalence of NCD's and MetS among this population.

Substituting SB with 30 min/d of MVPA has been reported to result in positive clinical outcomes among middle-aged South African adults (107, 121). Kufe and colleagues showed that substituting 30 min/d of sitting/lying, standing or LIPA with the same amount of MVPA time was associated with increased insulin sensitivity in middle age SA women from a low socio-economic setting (121). In the same cohort, Mendham and colleagues showed that reallocation of 30 min/d of sitting/lying to MVPA or 30 min of standing to MVPA in women were associated with a 0.3% and 1.4% lower FM, respectively (107). Finding from this thesis

highlight the importance of incorporating MVPA into daily PA, especially for reducing cardiometabolic risk factors such as insulin resistance and obesity.

Findings from the qualitative interviews (chapter 6) highlighted that following the 12 -week exercise intervention, participants felt fitter and more toned. Furthermore, the fact that majority of the participants in the study desired to be smaller in body size suggests that these women may be receptive to health and weight-loss exercise interventions. On the other hand, the underestimation of body size which was exacerbated by the intervention might have adverse health effects as the women age and are at greater risk of developing NCDs. The perceptions of overweight and obesity based on BMI were underestimated to a greater extent likely due to a lack of understanding of BMI categories. Rather, visual silhouettes may be a better tool for communicating body size in this setting. Furthermore, a targeted intervention approach that incorporates elements such as the presence of an exercise instructor, music and dancing in a group setting should be considered when developing lifestyle intervention programmes for sustainability in young women from low-resourced settings. In addition, accessibility to training facilities is key to increasing and/or maintaining participation adherence in exercise training in this population and should be considered for program sustainability.

7.5 FUTURE RECOMMENDATIONS

The primary study was a mechanistic study aimed at exploring the changes in insulin sensitivity among African women living with overweight and obesity in response to a 12-week exercise intervention. However, FGDs and IDIs were conducted to gain an understanding of the perceptions and experiences of a 12-week structured exercise intervention for the purpose of identifying barriers and enablers that can be used to design future long-term exercise interventions. In addition, explore the effectiveness of the exercise intervention in changing PA, SB, perceptions of body image and general self-efficacy. Findings from this thesis can be used to inform implementation of future exercise intervention studies in this population.

In order to obtain a clinically meaningful weight loss, moderate to vigorous intensity exercise training needs to be complimented with other lifestyle related interventions such as dietary interventions (foods to avoid and/or limit) and nutritional and /or dietary education on consuming healthy foods considering the individuals' budget. For example, an intervention study as long as 12-weeks among middle age adults with obesity (18-45 years old) have shown that combined dietary restriction and exercise yield greater weight loss (-12kg) compared to exercise only intervention, which only yielded -3.5kg weight loss (284). Being physically active even outside the structured exercise session (i.e moving more and sitting less) should also be promoted as it may lead to positive health outcomes.

Future exercise interventions in this population should include educating the women about the health risks associated with a bigger body size. It can be argued that most women from low-resourced settings do not have access to body weight scales and the concept of BMI categories may not be fully understood. However, the body silhouette images may provide a better representation of their body size and shape and due to its visual nature, may be a more appropriate tool for educating women from low-resource settings about living with overweight and obesity and adverse health effects. There seems to be limited research reporting on the validation of the GSE rating scale among this population and this requires further investigation. It is also important to assess the targeted populations' perceptions and experiences about the delivered health intervention for the purpose of determining the effectiveness of the intervention in a real-world setting among young and older women and men residing in a low-resourced setting. Findings from such assessments can provide guidelines on the sustainability of public health community interventions that are not constantly supervised by the research and/or health care team. The ease and cost of access to training facilities is key to possibly increasing and/or maintaining participation adherence in similar exercise training programmes among this population. Thus, future interventions should ensure easy access to training venues

and/or facilities. Lastly, similar studies need to be replicated in older men and women as these populations are not excluded from the risk of NCD's, posing an additional burden on the health system.

Contributions to the thesis

The findings presented in this thesis were part of a larger study that aimed to examine the mechanisms underlying the changes in insulin sensitivity and secretion in response to a 12-week exercise intervention in Black South African women living with overweight and obesity.

Chapter 1: I drafted the introduction chapter.

Chapter 2: I conducted literature search and drafted the literature review.

Chapter 3: I conducted literature search and drafted the methods for the current study. In addition, I compiled ethical application for the study and was responsible to the annual ethics renewal application.

Chapter 4: I was responsible for the initialisation, issuing and collection of the accelerometers from the participants every four weeks. I also delivered the daily supervised exercise training sessions with the help of the student assistance. Furthermore, I was responsible for downloading the accelerometers and HR monitors after every exercise training session. In addition, I analysed all the data with the assistance of Dr Simone Tomaz for the accelerometer data.

Chapter 5: I collected and analysed the data. In addition, I drafted the entire chapter.

Chapter 6: I formulated the FGD and IDI questions. In addition, I coded and analysed all the FGD and IDI qualitative data. Thereafter, formulated the main themes and subthemes. Furthermore, I drafted the published manuscript with the collaboration of the co-authors.

Chapter 7: I drafted the discussion drawing the main findings from the research chapters presented in this thesis.

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APPENDICES

APPENDIX A: ORIGINAL ETHICS APPROVAL LETTER



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee



Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6338 • Facsimile [021] 406 6411
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

11 June 2015

HREC REF: 054/2015

A/Prof J Goedecke
Sport Science Institute

Dear A/Prof Goedecke

**PROJECT TITLE: MECHANISMS UNDERLYING INSULIN RESISTANCE IN BLACK SA WOMEN:
LESSONS FROM AN INTERVENTION STUDY**

Thank you for your response to the Faculty of Health Sciences Human Research Ethics Committee dated 11 June 2015.

The HREC has **noted and approved** the protocol amendment including the following documentation:

- Informed Consent, Amendment Version 1 dated 5 May 2015.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC REF in all your correspondence.

Yours sincerely

Signed by candidate

PROFESSOR MARC BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS

APPENDIX B: ETHICS APPROVAL FOR THE CURRENT STUDY



FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee



FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938)			
This serves as notification of annual approval, including any documentation described below.			
<input checked="" type="checkbox"/> Approved	Annual progress report	Approved until next renewal date	30.11.2025
<input type="checkbox"/> Not approved	See attached comments		
Signature Chairperson of the HREC/ Designee	Signed by candidate		Date Signed 13/11/2024

Note: Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za.

Please use the latest form found on our website: <http://www.health.uct.ac.za/fhs/research/humanethics/forms>

Comments to PI from the HREC
<i>Thank you for the deviation request</i>

Principal Investigator to complete the following:

1. Protocol information

Date (when submitting this form)	13 November 2024		
HREC REF Number	049/2016	Current Ethics Approval was granted until	30/09/2024
Protocol title	The effect of a 12-week exercise training intervention on physical behaviour patterns and perceptions of body image in Black South African women living with overweight and obesity		
Protocol number (if applicable)	Not applicable		
Are there any sub-studies linked to this study?			No
If yes, could you please provide the HREC Reference number for all sub-studies? Note: A separate FHS016 must be submitted for each sub-study.			

13 June 2024

Page 1 of 7





Principal Investigator	Professor Julia Goedecke and Dr Amy Mendham
Department and email address	Division of Physiological Sciences; Department of Human Biology Ayesha.hendricks@uct.ac.za

1.1 Does this protocol receive US Federal funding?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
1.2 If the study receives US Federal Funding, does the annual report require full committee approval? Note: Any annual approvals for Full Committee review MUST be submitted on the monthly HREC submission dates. (Please send electronic combined copy if for full committee review to hrec-submission@uct.ac.za)	<input type="checkbox"/> Yes	No (Not applicable)

If yes in 1.2 please complete section 1.3 below for invoicing purposes

1.3 Ethics Renewal Fee

Please (tick ✓) appropriate box for billing purposes:

<i>Submission Type</i>	<i>Description</i>	<i>New fee (Vat Incl.)</i>	<i>tick ✓</i>
<i>Research funded solely from UCT departmental/divisional/group budget/self-initiated research</i>	Annual evaluation of research progress report for re-certification	R0,00	<input checked="" type="checkbox"/>
<i>Non-sponsored student research for degree purposes at UCT/Other Universities & Colleges</i>	Annual evaluation of research progress report for re-certification	R0,00	<input type="checkbox"/>
<i>Annual re-certification / Progress report (FHS016 Form)</i>	Clinical Trial & International Grant Funded Research - Annual evaluation of research progress report for re-certification for Full Committee Approval	R7700,00	<input type="checkbox"/>
<i>Annual re-certification / Progress report (FHS016 Form)</i>	Clinical Trial & International Grant Funded Research - Annual evaluation of research progress report for re-certification for Expedited review	R3800,00	<input type="checkbox"/>
<i>Annual re-certification / Progress report (FHS016 Form)</i>	National grant funded research - Annual evaluation of research progress report for re-certification for Full Committee Approval	R5000,00	<input type="checkbox"/>
<i>Annual re-certification / Progress report (FHS016 Form)</i>	National Grant funded research for Annual evaluation of research progress report for re-certification for Expedited review	R1650,00	<input type="checkbox"/>

NB: Protocols funded by UCT (e.g. departmental funding / student research) and by certain grant funding organizations (e.g. MRC, NRF, CANSA,) are exempt from these charges.

Please provide details for invoicing, either complete section 1 or 2 :

1. Invoice billing – Directly to Sponsor

Sponsor's name	Not applicable
----------------	----------------



Billing Address of Sponsor:	
Vat Number:	
Contact person	
Telephone number	
Email Address	
2. Internal Journal Billing:	
Fund Number:	
Cost Centre Number:	
Account Holder Name:	
Division of Account Holder:	

2. List of documentation included to support this approval where applicable

Not applicable

3. Protocol status (tick ✓)

<input type="checkbox"/>	Open Enrolment
<input type="checkbox"/>	Closed to enrolment (tick ✓)
<input type="checkbox"/>	Research-related activities are ongoing
<input type="checkbox"/>	Research-related activities are complete, long-term follow-up only
<input checked="" type="checkbox"/>	Research-related activities are complete, data analysis only
<input type="checkbox"/>	Main study is complete but sub-study research-related activities are ongoing
<input type="checkbox"/>	Publication or thesis submitted and final completion?
<input type="checkbox"/>	Study is closed → Please submit a Study Closure Form (FHS010)

4. Enrolment

Number of participants enrolled to date	45
Number of participants enrolled, since last HREC Progress report (continuing review)	0
Additional number of participants still required	0



5. Refusals

Total number of refusals (participants invited to join the study, but refused to take part)	10
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6. Cumulative summary of participants

Total number of participants who provided consent	45
Number of participants determined to be ineligible (i.e. after screening)	200
Number of participants currently active on the study	0
Number of participants completed study (without events leading to withdrawal)	35
Number of participants withdrawn at participants' request (i.e. changed their mind)	9
Number of participants withdrawn by PI due to toxicity or adverse events	0
Number of participants withdrawn by PI for other reasons (e.g. pregnancy, poor compliance)	1
Number of participants lost to follow-up. Please comment below on reasons for loss of follow-up.	9
The research team could no longer get hold of the participants on their provided contact details	
Number of participants no longer taking part for reasons not listed above. Please provide reasons below:	0
Participants indicated that they were no longer interested and did not have time to participate in the study as the intervention required 4 months commitment (including pre-testing, 12 weeks exercise intervention and post intervention testing)	

7. Progress of study

<p>Please provide a brief summary of the research to date including the overall progress and the progress since the last annual report as well as any relevant comments/issues you would like to report to the HREC:</p> <p>Thesis abstract and notice of intention to submit PhD thesis forms (DDB09) were completed, signed and submitted in January 2024</p> <p>PhD IP assessment form (DDB10) was also completed, signed and submitted in January 2024.</p> <p>The confidentiality on the nomination of examiners (DDB14) was also completed, signed and submitted by the supervisors.</p> <p>Three results chapters emanated from this work, one of which was published in the <i>Frontiers in Sports and Active Living Journal</i> in October 2022.</p>



The thesis has been drafted is ready to be submitted on 10 December 2024.

8. Protocol violations and exceptions (tick ✓ all that apply)

<input checked="" type="checkbox"/>	No prior violations or exceptions have occurred since the original approval
<input type="checkbox"/>	Prior violations or exceptions have been reported since the original approval and have already been acknowledged or approved If so, did these occur in the last review period
<input type="checkbox"/>	Unreported minor violations that have occurred since the last review, as well as significant deviations not yet reported, are attached for review

9. Amendments (tick ✓ all that apply)

<input checked="" type="checkbox"/>	No Prior amendments have been made since the original approval
<input type="checkbox"/>	Prior amendments have been reported since the last review and have already been approved
<input type="checkbox"/>	New protocol changes/ amendments are requested as part of this continuing review (See note below)

Note: If new protocol changes are being requested in this review, please complete an amendment form (FHS006).

Specific changes in the amended protocol and consent/assent forms must be **bolded**, *italicised* or tracked and all changes must include a rationale.

10. Adverse events

10.1 Please provide below or attach a narrative summary of serious adverse events and/ or unanticipated problems since the last progress report. Please indicate changes made to the protocol and informed consent document(s) as a result (if not already reported to the HREC). Please comment on whether causality to any study procedure or intervention could be established.

None.

10.2 Have participants received appropriate treatment/ follow-up/ referral when indicated (e.g. in the case of abnormal or incidental clinical findings, distress or anxiety)?

<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Not applicable
If yes, please describe:		
Not Applicable		

11. Summary of Monitoring and Audit Activities (tick ✓)

11.1 Was this study monitored or audited by an external agency (e.g. SAHPRA, FDA)?



<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Not applicable
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11.2 Did a Data and Safety Monitoring Board publish a report?

<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Not applicable
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11.3 If yes, please identify the agency and attach a summary of the findings.

Agency Name		Report attached	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Not applicable
		DSMB report attached	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Not applicable

11.4 Has there been any agency, institutional or other inquiry into non-compliance in this study, or any finding of non-compliance concerning a member of the research team?

<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
------------------------------	---

If yes, please explain:

Not Applicable

12. Level of risk (tick ✓)

12.1 In light of your experience of this research, please indicate whether the level of risk to participants has:

<input type="checkbox"/>	Increased
<input type="checkbox"/>	Decreased
<input checked="" type="checkbox"/>	Shown no change

If there has been a change, please explain:

12.2 Please provide a narrative summary of recent relevant literature that may have a bearing on the level of risk.

Not Applicable



13. Insurance

Please confirm that valid no fault insurance is still in place? (tick ✓)			
<input type="checkbox"/> Yes		<input checked="" type="checkbox"/> No (Not applicable)	
If yes, please complete the following:			
Insurer's name:			
Policy no.		*Coverage Period:	
<i>For UCT sponsored studies please liaise the Insurance office via fhs.sponsorship@uct.ac.za regarding the required documentation and information required obtain a renewed UCT No-fault Insurance Certificate.</i>			

14. Statement of conflict of interest

Has there been any change in the conflict of interest status of this protocol since the original approval? (tick ✓)	
<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
If yes, please explain and if necessary, attach a revised conflict of interest statement (Section #7 in the New Protocol Application Form FHS013):	

15. Signature

My required signature certifies that the above is complete and correct.			
Signature of PI	Signed by candidate	Date	13 November 2024

APPENDIX C: INFORMED CONSENT

MECHANISMS UNDERLYING INSULIN RESISTANCE IN BLACK SA WOMEN: LESSONS FROM AN EXERCISE INTERVENTION.

Why is the study being done?

Within South Africa, there are many people living with diabetes (sugar disease), with black women being the most affected, especially those who are carrying extra body weight (obese). Many studies in other countries have shown that exercise training reduces the risk for diabetes. However, there are no studies in South Africa that have studied this. This study will help us understand the various factors that may cause diabetes in obese black women, including factors within the muscle, fat and blood, as well as lifestyle factors including food intake, activity levels and family history. Therefore, the aim of the study is to measure changes in the risk for diabetes in response to a 12-week exercise-training programme in obese black South African women, and to examine specific factors linked to the changes in diabetes risk. This study is important, as it will help us understand if exercise training does reduce the risk of diabetes in obese black South African women, and help us understand how this is done.

Who can participate?

If you fulfil the following criteria you will be able to take part in the study:

- I. Aged 20-35 years;
- II. Obese (weight in kg divided by height in metres squared: $30-35 \text{ kg/m}^2$)
- III. No known diseases or not taking medication for any diseases;
- IV. Not smoking or taking recreational drugs;
- V. Not currently pregnant or breast feeding;
- VI. Black South African (both parents are Xhosa);
- VII. No muscle or joint pains or medical problems that prevent you from exercising;
- VIII. Able to attend four exercise sessions per week for the 12 week study period;
- IX. Weight stable (weight not changed more than 5 kg or no change in your clothes size over the past 6 months);
- X. Are using injectable contraceptives;
- XI. Not currently taking part in organized physical activity (exercise training);
- XII. No previous adverse reactions to an anaesthetic (e.g. at the dentist).

XIII. No surgical procedures in the last 6 months.

How do we decide if you are eligible to take part in the study?

If you meet all the criteria listed above, you will then be asked to complete some tests on one day at David Flude Memorial Church hall in Khayelitsha to check that you meet the inclusion criteria of the study. You will be asked to complete the following tests/measurements:

- **Complete a questionnaire** including information on your age, medication use, ancestry, medical history, exercise and diet history, physical activity readiness;
- **Weight and height** will be measured using a scale and a height measure;
- **Blood pressure:** After a 5 minute relaxation period, blood pressure will be measured 3 times in a row, separated by 5 minutes between readings using a standard blood pressure monitor.
- **Blood glucose (sugar)** by using a finger prick and **HbA1c** by venous blood sample;
- **HIV screening** will be performed. You will receive pre- and post-test counselling from a trained counsellor and a referral will be made to an appropriate HIV clinic if you are found to be HIV positive. If you test negative, you will be able to participate in the trial;
- **8-minute step test** to measure your physical fitness: A heart rate monitor will be placed on your chest to record heart rate and movement counts during the test, and you will be required to step up and down a step at a certain speed that will get quicker as the test progresses. When you have completed the test you will be required to sit for a recovery period of 2 minutes. Only if you are able to complete the 8-minute step test will you be able to take part in the study.

How many people will take part in the study?

Forty (40) obese women, who meet all the criteria above, can take part in the study.

How long will the study last?

The study will last 14 weeks in total. The first week (week 1) and last week (week 14) will include testing at the Sports Science Institute in Newlands. Weeks 2-13 (12 weeks) will include exercise training (4 times per week) in Khayelitsha.

What will happen if you decide to take part in the study?

If you meet all the criteria listed above and decide to take part in the study, you will be asked to complete all the testing and training procedures outlined below.

Please note that if you decide to take part in this study, we will need you to give two stool (toilet) samples before and after the 12-week study. These stool samples are a requirement for taking part in the study. If you are unhappy or uncomfortable about giving stool (toilet) samples, you should not take part in this study.

You will be randomly assigned to either an exercise group or a control group. Neither you nor the investigators will be able to choose which group you will be assigned to. If you are assigned to the exercise group, you will be required to complete 12 weeks of supervised aerobic training (training that increases your heart rate and breathing rate) for 1 hour on 4 days/week by a trained facilitator David Flude Memorial Church hall in Khayelitsha. We request that you do not participate in any new additional training outside of this study. If you are assigned to the control group, you can continue with your normal life activities, and we request that you do not start a new exercise-training programme somewhere else for the 12 weeks.

You are under no obligation to take part in the study and are not required to give a reason if you do not wish to participate. If you decide to take part in the study, you are free to withdraw at any time and without giving a reason and without prejudice. If you decide to withdraw from the study, we will discuss with you what will happen to any information or samples that you have provided. If the incomplete samples and information can usefully contribute to the study, we will ask your permission to store them and use them in our analysis. Alternatively, on your request all your information and samples will be destroyed.

Procedures:

If you meet all the criteria above and are in the control OR experimental group, you will be required to complete 3 testing sessions before and another 3 sessions at the end of the 12-week study, as summarised in Table 1 and explained in detail below. All testing will be undertaken either at the Division of Exercise Science and Sports Medicine, based at the Sports Science Institute of South Africa (SSISA) in Newlands, at the Academy of Plastic Surgery, Claremont, or CUBIC at Groote Schuur Hospital. Appropriately trained medical personnel will carry out all procedures.

Table 1. Summary of testing schedule the week before and after the 12-week exercise/control intervention

		Testing Week		
Testing session:	Screening session	Testing session 1	Testing session 2	Testing session 3
Location:	David Flude Memorial Church hall, Khayelitsha	SSISA	SSISA & CUBIC, GSH	Academy of Plastic Surgery
Time of day:	Any	8am	8 am	8 am
Preparation:	None	Overnight fast and no exercise training for 72 hrs prior	Overnight fast and no exercise for 3 days prior	Overnight fast and no exercise for 3 days prior
Duration:	2 hrs	4 hrs	2 hrs	1 hr
Procedure:	<ul style="list-style-type: none"> Trial information -Informed consent -Weight and height -Blood pressure -HIV screening -Random glucose and HbA1C -8-min step test -Demographic & health questionnaire -Accelerometer and Actipal fitted -3-day dietary record forms -pedometer fitted 	<ul style="list-style-type: none"> -FSIGT -DXA scan -Blood pressure VO_{2peak} test -Stool sample collection 	<ul style="list-style-type: none"> -Fasted resting & exercising fuel use -MRS scan -Blood pressure -VO_{2peak} test -stool sample collection 	<ul style="list-style-type: none"> -Fat biopsy -Muscle biopsy -Stool sample collection

Testing Session 1: Early morning before breakfast - At SSISA - 4 hours

You will be requested to come to the laboratory at the Sports Science Institute in the morning after an overnight fast. In other words, you must not eat or drink anything, except water, from 10pm the night before (at least 10 hours). You cannot take part in any exercise training for 72 (3 days) hours before this test.

Insulin test – a measure of insulin secretion and insulin sensitivity:

A small plastic tube will be placed into a vein in each arm. You will then be required to undergo a test that will measure how much insulin your body produces and how sensitive your body is to insulin. We will inject a concentrated glucose solution (~ 30-100 ml, depending on your weight) into one vein over a 1-minute period. Small amounts of blood (1 teaspoon) will be withdrawn from the other arm at regular intervals (1-2 minutes) for 20 min. After 20 min, insulin will be infused into your arm, which will assist your body to take up the glucose into the cells. Further blood samples (1 teaspoon each) will be drawn from your other arm for a further 3.5 hrs. During this test, a maximum of 200 ml of blood will be drawn (1/3rd of the amount drawn when you donate blood). During the tests, you will be required to sit or lie quietly and DVDs will be provided for entertainment.

Questionnaires:

You will be asked questions on various measures of social and economic status (including your education, where you live and how many people share your home, the work that you do, how you spend your spare time), as well as questions on food security (access to food), family history, your personal health and reproductive history, including the number of children you have, medications that you use and how much physical activity you do. You will also be interviewed by a dietician who will ask you questions about your diet and the foods that you normally eat. You will be given a form to record the foods that you eat at home for a period of three days.

Body composition:

After your insulin test, we will take measurements of your body, including weight, height, waist and hip circumference. In addition, you will be asked to undergo a scan, which will accurately measure your fat and muscle mass, as well as your bone density. This is called a

dual x-ray absorptiometry (DXA) scan. The scan will take approximately 20 minutes to perform during which you will lie quietly on the scanning table in a medical gown provided.

VO_{2peak} test and Physical activity:

You will be required to complete an exercise test to exhaustion on a treadmill, which has been used in similar studies in the past. A mask attached to a sampling tube will be placed over your face to measure your oxygen uptake during the test. You will then begin walking on the treadmill at 3.5 km/hr (slow walk), and then every 3 minutes, the speed will be increased by 1 km/hr until you reach a speed of 6.5 km/hr (fast walking pace). If you are still able to manage this intensity, the gradient of the treadmill will increase by 2% every 3 minutes thereafter (in other words, you will begin walking uphill) until we instruct you to stop or when you are exhausted. Your heart rate will be monitored continuously throughout the test. Before you start the test, you will be given the opportunity to familiarise yourself with walking on the treadmill so that you are comfortable when you start. The mask will not affect your breathing in any way, or the quality of the air that you breathe in.

You will be given a pedometer to wear every day for the whole 12-week study period. This is a device that measures the number of steps you take every day. In addition, we will also ask you to wear other motion sensors (accelerometer, which measures how fast you move and an Actipal that measures how little you move) for 7 days. Both devices are the size of a small matchbox and will be attached to your waist with a lightweight belt. You should wear the monitors at all times, except when swimming, bathing, showering and sleeping.

Testing Session 2: Early morning before breakfast - At SSISA and CUBIC at Groote Schuur Hospital - 2 hours

You will be requested to come to the laboratory at the Sports Science Institute in the morning after an overnight fast. In other words, you must not eat or drink anything, except water from 10 pm the night before (at least 10 hours). You may not take part in any exercise training for 72 hours (3 days) before this test.

Fasting and exercising fuel use – respiratory exchange measure – during rest and exercise

After you have rested for 30 minutes, we will take measures of the air that you breathe in and out while resting quietly in a chair or on a bed for 15 minutes, and during 15 minutes of

moderate intensity walking exercise on a treadmill ($\pm 50\%$ of maximum oxygen uptake; $VO_{2\text{peak}}$). These measurements will be used to calculate the fuels (fat and carbohydrate) that you are burning. In order to perform these measures, a mask attached to a sampling tube will be placed over your face. While wearing the mask you will be able to breathe normally and the mask will not affect your breathing or the quality of the air that you breathe in.

Stool sample collection

You will be asked to provide 2 stool samples on separate days at baseline and after the 12-week intervention. For the stool collection, you will be provided with a specific stool collection kit. You will be asked to pass a stool sample onto the sample collection paper, and using the provided sample collection scoops, place a 10 ml (± 2 teaspoons) stool sample into the sample collection vial provided. You will then place this sample vial in a second container and this is then placed in a sample collection bag, which you will hand to the researcher.

Magnetic resonance spectroscopy (MRS) scan

The MRS scans will be performed at CUBIC at Groote Schuur Hospital, and will take approximately 1 hour.

The MRS scan will be used to measure the fat content of your calf muscle, liver and pancreas. MRS uses magnetic and radio waves, and will be used to generate a picture of your calf, liver and pancreas. You will be required to lie on a bed, which is moved into a wide-bore tubular structure. This is open at both ends. You will be required to lie still for 15 minutes while being in constant voice contact with the Radiographer.

If you have any of the following conditions, you may not have an MRS scan: implanted medical devices such as aneurysm clips in the brain, heart pacemakers, and cochlear (inner ear) implants; lead-based tattoos; or pieces of metal close to or in an important organ (such as the eye); claustrophobia or fear of being confined in a small space.

Session 3: Early morning before breakfast – at the Academy of Plastic Surgery - 1 hour

You will be requested to come to the Academy of Plastic Surgery in Claremont in the morning after an overnight fast. In other words, you must not eat or drink anything, except water from

10 pm the night before (at least 10 hours). You may not take part in any exercise training for 72 hours (3 days) before this test.

Fat and muscle biopsies:

You will be requested to undergo a fat biopsy from your buttocks (bum) and your abdominal area (tummy), and a muscle biopsy from your thigh muscle. The samples will be used to analyse the proteins and hormones produced by the fat cells, and the metabolic functioning of your muscle, both of which may influence your disease risk. A medical doctor (plastic surgeon) will perform the biopsies. A local anaesthetic will be administered prior to the procedure. Please inform us if you have had any previous reactions to any other anaesthetics, for example at the dentist.

For the fat biopsies, after the anaesthetic has taken effect, a small incision (0.5-1 cm) will be made in the skin, and fat samples (1.5 cm³) will be removed using a needle connected to a syringe. After this procedure, a waterproof sterile dressing will be applied. For the muscle biopsy, after the anaesthetic has taken effect, the doctor will then make a ~6-8 mm cut through the skin. A biopsy needle will then be inserted through the incision and a small piece of muscle (~4 mm x 4 mm) will be snipped from the muscle under the skin and removed through the small incision. The incision will be closed with “Steristrips” (plasters that act like stitches) and covered with a waterproof dressing and a pressure bandage.

12-week exercise/control intervention

If you are assigned to the **control group** we will request that you do not start any new exercise training programs during the 12-week study period, and continue with your daily activities and diet as usual. When you have completed the 14-week trial, you will be offered the opportunity to undergo the same exercise training as the exercise group, as described below. This is totally voluntary.

If you are assigned to the **exercise group**, you will be required to perform 12-weeks of supervised aerobic training at a moderate-vigorous intensity for one hour, four times per week. The exercise training will include cardiovascular exercises in the form of aerobic dance, boxing, running, skipping, stepping, and strengthening exercises using your own body weight or minimal equipment for resistance training (e.g. bands and weights). The frequency, duration and intensity of the exercise intervention are based on the recommendations from the British

Association of Sport and Exercise Sciences (BASES), to ensure the prevention of injuries. The 60 min classes will include moderate exercise (70-75% of your maximum heart rate) and at least 30 min of vigorous activity (75-85% of your maximum heart rate), which will be monitored using heart rate monitors. The exercise classes will be supervised by a trained biokineticist, who will monitor your progress (using heart rate data) and adjust the classes accordingly to ensure adequate improvement in cardiorespiratory fitness throughout the 12-week programme. We request that you do not participate in any new additional training outside of this study and maintain your normal diet during the 12-week trial.

Monitoring in the control and exercise groups:

If you are in the control or the exercise group, you will be asked to wear a pedometer every day for the duration of the 12-week study. You will be required to come to the community facility to download your pedometer every two weeks. This will take 10 min of your time. You will also be asked to wear the accelerometer and Actipal for 7 days at the beginning and every 4 weeks during the 12-week trial (week -1, 4, 8 and 12) (as described above). Accelerometers will be used in addition to pedometers as they provide a more accurate assessment of the intensity of your activity, and Actipals provide more information on sedentary time. You should wear the monitors at all times, except when swimming, bathing, showering and sleeping. At the same time that you wear the monitors (week -1, 4, 8 and 12), we will request that you record your dietary intake for three days, as explained in the first session. Attendance at each session, and the compliance to the exercise training will be monitored by the biokineticist.

What are the risks and discomforts of this study?

Insulin test – a measure of insulin secretion and insulin sensitivity:

There are no appreciable risks for this test, other than those associated with routine blood sampling, including discomfort, bruising, swelling and local infection. All procedures will be supervised and carried out by a medical doctor and appropriately trained medical personnel using sterile techniques to minimise any risks of infection. These tests are used routinely in research to accurately determine insulin secretion and insulin sensitivity. A maximum of 200 ml of blood will be drawn during the entire study, which is less than half that drawn during standard blood donation.

Body composition:

The only risk associated with the DXA scan is exposure to radiation. However, the radiation exposure with a DXA scan is less than half that of a chest x-ray (11.3 microSieverts).

Physical activity monitors:

There are no risks or side-effects from wearing the physical activity monitors.

Fitness, VO_{2peak} test and steady state exercise

There are minimal risks associated with the fitness test, the VO_{2peak} test and the steady-state exercise. Heart rate will be monitored during all exercise tests using a heart rate monitor, and the tests will be terminated early if your heart rate exceeds 90% of age-predicted maximum heart rate. The risks of being on the treadmill include the possibility of tripping or falling. However, this is unlikely, as you will only be required to walk on the treadmill. There are handles on either side of the treadmill to hold onto, and an emergency stop button in the event that you do trip or fall. All the treadmill testing will be performed under the supervision of a trained professional. You will be given the opportunity to familiarise yourself with walking on a treadmill before the tests so that feel totally comfortable before you start the test.

Fuel utilisation - respiratory exchange measure – during rest and exercise

There are no risks associated with measuring fuel utilisation, however, some people feel anxious with the mask covering their face. Should you experience feelings of anxiousness, the mask will be removed.

Magnetic resonance spectroscopy (MRS) scan

You will not experience any pain or discomfort when having the MRS scan, and there are no known harmful long-term effects of the magnetic fields used in this study. When the scanner takes the pictures, the bed may shake, and you will hear loud banging noises. You will be given earplugs or headphones to protect your ears. Also, some people feel nervous in a small closed space, such as when they are in the scanner. You will be able to see out of the scanner at all times, and we will not start until you tell us that you are comfortable. You will be able to stop at any time by squeezing a ball that you will hold in one hand and can talk to us using an intercom that is built into the scanner. If you have any of the following conditions, you may not have an MRS scan: implanted medical devices such as aneurysm clips in the brain, heart pacemakers, and cochlear (inner ear) implants; lead-based tattoos; or pieces of metal close to

or in an important organ (such as the eye); claustrophobia or fear of being confined in a small space.

Fat and muscle biopsies:

For both the fat and muscle biopsies, you may feel some local stinging for a few seconds after the local anaesthetic is given. You will experience some discomfort during the biopsies, and after the biopsies you may experience some bruising, which will generally feel better within 2-3 days. We have performed many fat and muscle biopsies and have had very few adverse events. These included the temporary loss of feeling in the area around the biopsy site, which resolved on its own after a short while; and local infection, which healed without any problem after treatment. Rarely there may be an allergic reaction to the local anaesthetic or to the preservative in it, methylparaben, which could cause itching and if severe, wheezing or low blood pressure that are symptoms of anaphylactic shock. Severe reactions will be treated with adrenaline, which will be available during the procedure.

Stool sample collection:

There are no risks associated with the collection of stool samples, but you may experience some social discomfort during the collection of the stool specimens. In order to prevent this, you will be given the opportunity to collect a sample at SSISA on three separate days when you feel most comfortable.

12-week exercise/control intervention

The training program is designed for exercise progression to ensure minimal physical discomfort and associated soreness. In the unlikely event that you sustain an injury due to the exercise intervention, you will be referred to the appropriate clinic for treatment at no expense to yourself. However, you might experience some physical discomfort and associated muscle soreness following the first session (and in some cases the first week) of training. All efforts will be made to ensure a suitable training environment, including safe setting up and provision of equipment, sufficient lighting, suitable temperature, suitable ventilation, and convenient access to toilets, etc. The researchers are trained in first aid and basic life support, and a phone will be carried at all times should medical assistance be required.

Are there any benefits to you for being in the study?

You will receive your own results, including body composition (weight, height, waist circumference, muscle and fat mass and bone density), serum lipid profile, blood pressure, risk for diabetes, physical fitness and dietary analysis, with some recommendations made by a dietician on how to adapt your dietary intake to improve your health. If you are in the control group, after the completion of the study, you will have the opportunity to participate in the same exercise training as the exercise group. This is completely voluntary. Following the training (if you were in the exercise or control group), you will receive guidelines and recommendations on how to continue your exercise training. If you have any abnormal results, you will be given a referral letter and directed to the appropriate health practitioner or local clinic.

What will happen when the study is over?

As mentioned above, when the testing of all the women has been completed, you will receive your individual results and the provisional findings of the study will be presented. Detailed analysis of the tissues samples will take more time. However, once these analyses have been completed, the final results of the study will be shared with you. This information will assist in our understanding of the effect of exercising training on the risk for diabetes, and therefore help us to prevent and/or manage the problem of diabetes in South African women.

Will any of your blood, muscle, fat and stool samples be stored and used for research in the future?

The researchers will ask your permission to store your blood, muscle and fat samples for future research. All samples will be kept in a freezer in a secure facility with access limited to research personnel. Future research analyses will be based on new research that we are at present not aware of, but may be important in our understanding of the risk for type 2 diabetes. Any research done on your blood or tissue in the future must be approved by the Faculty of Health Sciences Research Ethics Committee at the University of Cape Town that is set up to determine that the research is done according to accepted standards. You will not be penalized in any way for not allowing the use of your blood or tissue for future research. If you decide not to donate blood or tissue for future research, it will be destroyed on completion of this trial. Strict confidentiality of results will be maintained.

Will you receive reimbursement for transport, time and inconvenience?

All transport required to get to the training and testing facilities will be arranged by the researchers and be at no cost to you. You will receive R30/day to cover their transport costs to the training venue in Khayelitsha (4 x training sessions per week for 12 weeks + 3 monthly monitoring visits). In addition, either transport will be provided or you will receive R50/day for transport to the testing facilities at UCT (R50 x 8 testing sessions). The transport money will be paid to you at the end of each session.

To compensate you for your time and inconvenience, you will be reimbursed R20/hr for the training session (48 hrs), and R50/hr for the testing sessions (17 hrs of testing and monitoring). Payment for time and inconvenience will be paid on a pro-rata basis at the end of the 12-week study period.

Who will see the information that is collected about you during the study?

Strict confidentiality of results will be maintained. Your name will be removed from all data, and you will be assigned a number, which will be used to identify data relating to you. All records will be kept in a locked room and in a secure computer database in the research unit. Your name will not be used in any publication of the results.

What if Something Goes Wrong?

The University of Cape Town (UCT) has insurance cover for the event that research-related injury or harm results from your participation in the trial. The insurer will pay all reasonable medical expenses in accordance with the South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI) in the event of an injury or side effect resulting directly from your participation in the trial. You will not be required to prove fault on the part of the University.

The University **will not be liable** for any loss, injuries and/or harm that you may sustain where the loss is caused by

- The use of unauthorised medicine or substances during the study
- Any injury that results from you not following the protocol requirements or the instructions that the study doctor may give you

- Any injury that arises from inadequate action or lack of action to deal adequately with a side effect or reaction to the intervention
- An injury that results from negligence on your part

By agreeing to participate in this study, you do not give up your right to claim compensation for injury where you can prove negligence, in separate litigation. In particular, your right to pursue such a claim in a South African court in terms of South African law must be ensured. Note, however, that you will usually be requested to accept that payment made by the University under the SA GCP guideline 4.11 is in full settlement of the claim relating to the medical expenses.

An injury is considered trial-related if, and to the extent that, it is caused by study activities. You must notify the study doctor immediately of any side effects and/or injuries during the trial, whether they are research-related or other related complications.

UCT reserves the right not to provide compensation if, and to the extent that, your injury came about because you chose not to follow the instructions that you were given while you were taking part in the study. Your right in law to claim compensation for injury where you prove negligence is not affected. Copies of these guidelines are available on request.

Who do I contact if I have any questions about the study?

If you have any questions or you experience any problems during or after the tests, please contact Professor Julia Goedecke or Dr Amy Mendham:

Associate Professor Julia Goedecke (PhD)

Principal Investigator

Division of Exercise Science and Sports Medicine

Department of Human Biology

3rd Floor, Sports Science Institute of South Africa

Boundary Road, Newlands, 7725

Cape Town

Tel: 021-6504570(w) 0828255616 (cell)

Email : julia.goedecke@uct.ac.za

Dr Amy Mendham (PhD)

Project coordinator

Division of Exercise Science and Sports Medicine

Department of Human Biology
3rd Floor, Sports Science Institute of South Africa
Boundary Road, Newlands, 7725
Cape Town
Tel: 021-6504567 (w) 0729 255 347 (cell)
Email : Amy.Mendham@uct.ac.za

Should you have any concerns about this study, you are also free to contact the head of the University of Cape Town Faculty of Health Sciences Human Research Ethics Committee, Professor Marc Blockman.

Professor Marc Blockman

Head, Human Research Ethics Committee
Faculty of Health Sciences
Room E52-24 Groote Schuur Hospital Old Main Building, Observatory 7925
Telephone [021] 406 6338. Facsimile [021] 406 6411

Subject code:

**MECHANISMS UNDERLYING INSULIN RESISTANCE IN BLACK SA WOMEN:
LESSONS FROM AN EXERCISE INTERVENTION.**

Consent to participate in the study:

“I, _____, hereby give consent to participate in this research trial to be conducted by the Division of Exercise Science and Sports Medicine, within the Department of Human Biology at the University of Cape Town.

I understand that I will need to give two stool (toilet) samples before and after the 12-week study, and that this is a requirement for taking part in the study.

I understand that I will undergo preliminary testing to determine if I am eligible for the study.

I understand that I will be randomly assigned to the exercise or the control group. If I am assigned to the exercise group, I understand that I will be required to complete 12 weeks of exercise training, consisting of 1 hour of aerobic exercise training 4 days/week by a trained facilitator in a central facility in Khayelitsha. If I am assigned to the control group, I understand that I will be required to continue with my normal daily living and not start a new exercise-training programme during the study period, but can be part of the same exercise-training programme once I have completed the study. I understand that irrespective of the group that I am assigned to, I will be required to complete 3 testing sessions before and at the end of the 12-week study. In addition, I understand that I will be required to visit the community centre every 2 weeks to download my pedometer, and have my weight, dietary intake and physical activity measured every month. I understand that the testing sessions will be performed at the Sports Science Institute, CUBIC at Groote Schuur Hospital and the Academy of Plastic Surgery in Claremont, and will include completion of a demographic and lifestyle questionnaire, the measurement of blood pressure, body composition including whole body scans and MRS scans of my calf muscle, liver and pancreas, blood lipid and hormone levels, physical fitness, measures of fuel utilisation at rest and during exercise, stool samples to measure the bacteria in my gut, as well as a test to measure insulin secretion and sensitivity. I also understand that

fat samples (~1.5 cm³) will be taken from the fat stores in my abdominal (belly) and gluteal (bottom) area, and a muscle sample will be taken from my thigh (upper leg) muscle.

I have read and have had explained to me the procedures described. I have had an opportunity to ask questions and my questions have been answered in a satisfactory way. I understand the nature of the trial and the risks and benefits associated with my participation and that I am free to withdraw from this study at any time.

I understand that all the information collected during the study will be treated with the strictest confidentiality and will only be used for scientific research purposes. All samples will be kept in a freezer in a secure facility with access limited to research personnel. All records will be kept in a locked room and in a secure computer database in the research unit. Your name will not be used in any publication of the results. I understand that for data verification and quality control purposes regulatory authorities and/or members of the University of Cape Town Faculty of Health Sciences Human Research Ethics Committee may be allowed access to my personal data under conditions of strict confidentiality.

I have read the information, or it has been read to me. I have had the opportunity to ask questions about it and my questions have been answered to my satisfaction. I consent voluntarily and understand that I have the right to withdraw my consent without this affecting the current research study or my medical care.

Print Name of Participant _____

Signature of Participant _____

Date _____

Subject code:

CONSENT FOR STORAGE AND FUTURE USE OF UNUSED SAMPLES:

Additional consent to: Mechanisms underlying insulin resistance in black SA women: lessons from an exercise intervention.

Information sheet:

We are seeking permission to store your unused blood, muscle, fat and stool samples for possible future in either our own research or collaborators' research studies. Permission to use these samples is in addition to the use of your samples for the current study. This is important as these analyses will be based on new research that we are at present not aware of, but may be important in our understanding of the risk for type 2 diabetes. Before the samples can be used for future research, approval by the University of Cape Town Faculty of Health Sciences Human Research Ethics Committee will be obtained. Please be aware that the samples will not be sold for profit.

When entering into the study, you will receive a unique code that will be used for sample and data analysis, which serves to maintain your confidentiality. When storing samples, you may choose that we keep the unique code on the sample so that we can link any new results to your existing data. If any clinically relevant information relating to this sample is found, we will inform you of the results. Alternatively, you can remove the identifying number, so that your information will not be linked to the sample and you will not be informed of any clinical results relating to the new analyses.

You may also refuse to allow future analyses of samples without being penalised, and your results relating to the current study will not be compromised in any way. If you refuse to allow future analyses of samples, your samples will be destroyed on completion of this trial. Furthermore, you may withdraw permission to use your samples at any time. If you wish to do this, please contact:

Associate Professor Julia Goedecke (PhD)

Principal Investigator
Division of Exercise Science and Sports Medicine
Department of Human Biology
3rd Floor, Sports Science Institute of South Africa
Boundary Road, Newlands, 7725
Cape Town
Tel: 021-6504570 (w) 0828255616 (cell)
Email : julia.goedecke@uct.ac.za

All information collected during the study will be treated with the strictest confidentiality and will only be used for scientific research purposes. All samples will be kept in a freezer in a secure facility with access limited to research personnel; all records will be kept in a locked room and in a secure computer database in the research unit. Your name will not be used in any publication of the results. For data verification and quality control purposes regulatory authorities and/or members of the University of Cape Town Faculty of Health Sciences Human Research Ethics Committee may be allowed access to my personal data under conditions of strict confidentiality.

Certificate of Consent:

1) If any of the **BLOOD** that I have provided for this research project is unused or leftover when the project is completed (Tick **one** choice from each of the following boxes)

- I wish my **blood** sample to be destroyed immediately.
- I want my **blood** sample to be destroyed after ____ years.
- I give permission for my **blood** sample to be stored indefinitely

AND if my **blood** sample is to be stored:

- I give permission for my **blood** sample to be stored and used in future research but only on the same subject as the current research project: “Mechanisms underlying insulin resistance in black SA women: lessons from an exercise intervention”.
- I give my permission for my **blood** sample to be stored and used in future research of any type, which has been properly approved
- I give permission for my **blood** sample to be stored and used in future research except

for research about _____

AND

- I want my identity to be removed from my **blood** sample.
- I want my identity to be kept with my **blood** sample.

2) If any of the **MUSCLE** that I have provided for this research project is unused or leftover when the project is completed (Tick **one** choice from each of the following boxes)

- I wish my **muscle** sample to be destroyed immediately.
- I want my **muscle** sample to be destroyed after ____ years.
- I give permission for my **muscle** sample to be stored indefinitely

AND if my **muscle** sample is to be stored:

- I give permission for my **muscle** sample to be stored and used in future research but only on the same subject as the current research project : “Mechanisms underlying insulin resistance in black SA women: lessons from an exercise intervention”.
- I give my permission for my **muscle** sample to be stored and used in future research of any type, which has been properly approved
- I give permission for my **muscle** sample to be stored and used in future research except for research about _____

AND

- I want my identity to be removed from my **muscle** sample.
- I want my identity to be kept with my **muscle** sample.

3) If any of the **fat** that I have provided for this research project is unused or leftover when the project is completed (Tick **one** choice from each of the following boxes)

- I wish my **fat** sample to be destroyed immediately.
- I want my **fat** sample to be destroyed after ____ years.
- I give permission for my **fat** sample to be stored indefinitely

AND if my **fat** sample is to be stored:

- I give permission for my **fat** sample to be stored and used in future research but only on the same subject as the current research project : “Mechanisms underlying insulin resistance in black SA women: lessons from an exercise intervention”.
- I give my permission for my **fat** sample to be stored and used in future research of any type, which has been properly approved
- I give permission for my **fat** sample to be stored and used in future research except for research about _____

AND

- I want my identity to be removed from my **fat** sample.
- I want my identity to be kept with my **fat** sample.

4) If any of the **STOOL sample** that I have provided for this research project is unused or leftover when the project is completed (Tick **one** choice from each of the following boxes)

- I wish my **stool** sample to be destroyed immediately.
- I want my **stool** sample to be destroyed after ____ years.
- I give permission for my **stool** sample to be stored indefinitely

AND if my **stool** sample is to be stored:

- I give permission for my **stool** sample to be stored and used in future research but only on the same subject as the current research project: “Mechanisms underlying insulin resistance in black SA women: lessons from an exercise intervention”.
- I give my permission for my **stool** sample to be stored and used in future research of any type, which has been properly approved
- I give permission for my **stool** sample to be stored and used in future research except for research about _____

AND

- I want my identity to be removed from my **stool** sample.
- I want my identity to be kept with my **stool** sample.

I have read the information, or it has been read to me. I have had the opportunity to ask

questions about it and my questions have been answered to my satisfaction. I consent voluntarily and understand that I have the right to withdraw my consent without this affecting the current research study or my medical care.

Print Name of Participant _____

Signature of Participant _____

Date _____

Subject code:

CONSENT FOR HIV TESTING:

Additional consent to: Mechanisms underlying insulin resistance in black SA women: lessons from an exercise intervention.

I _____ agree to provide a blood sample for the purposes of confidential HIV testing. I understand that it is necessary for me to have this test to participate in the research study. If I test positive, I cannot participate in the study entitled “Mechanisms underlying insulin resistance in black South African women”, conducted by the Division of Exercise Science and Sports Medicine, within the Department of Human Biology at the University of Cape Town. I am aware that I will receive pre and post-test counselling from a qualified HIV counsellor, and will be referred to an appropriate health care clinic if necessary. I understand the implications of performing the test.

I have read the information, or it has been read to me. I have had the opportunity to ask questions about it and my questions have been answered to my satisfaction. I consent voluntarily and understand that I have the right to withdraw my consent without this affecting the current research study or my medical care.

Print Name of Participant _____

Signature of Participant _____

Date _____

APPENDIX D: FACEBOOK ADVERTISEMENT

BLACK SOUTH AFRICAN WOMEN ARE INVITED TO TAKE PART IN AN EXCITING RESEARCH PROJECT

Mechanisms underlying insulin resistance in black SA women: lessons from an exercise intervention.

Purpose of the project: Within South Africa, there are many people living with diabetes (sugar disease), with black women being the most affected, especially those who are carrying extra body weight (obese). Many studies in other countries have shown that exercise training reduces the risk for diabetes. **Therefore, the aim of the study is to measure changes in the risk for diabetes in response to an exercise training programme in obese black South African women.**

Who can participate?

If you fulfil ALL of the following criteria you will be able to take part in the study:

- XIV. Black South African (both parents Xhosa);
- XV. Aged 20-35 years;
- XVI. Obese: Body mass index (BMI): 30-35 kg/m² weight between 75 – 120 kg
- XVII. No known diseases or not taking medication for any diseases;
- XVIII. HIV negative (compulsory HIV testing);
- XIX. No smoking or recreational drugs;
- XX. Not currently pregnant or breast feeding;
- XXI. Must be using injectable contraception;
- XXII. Weight stable (weight not changed more than 5 kg or no change in your clothes size over the past 6 months);
- XXIII. No muscle or joint pains or medical problems that prevent you from exercising;
- XXIV. Able to attend 4 exercise sessions per week for the 12-week study period in Khayelitsha;
- XXV. Not currently taking part in organized physical activity (exercise training);
- XXVI. No previous adverse reactions to an anaesthetic (e.g. at the dentist).
- XXVII. No surgical procedures in the last 6 months.

Procedures and benefits:

If you fulfil the above criteria, you will be randomly assigned to either an exercise group or a control group.

- The **exercise group**, you will be required to complete 12 weeks of supervised exercise training for 1 hour on 4 days/week by a trained facilitator in Khayelitsha.
- The **control group** will be required to continue with their normal life activities. However, voluntary exercise training will be offered at the end of the study.

Both groups will be required to complete 4 testing sessions before and 4 testing sessions at the end of the 12-week project at the Sports Science Institute of South Africa (SSISA) in Newlands.

These tests include measures of:

- *Body composition (body fat, muscle mass, bone density) using a whole body scanner*
- *Lifestyle factors - dietary analysis and physical activity using questionnaires and activity monitors*
- *Risk for diabetes and heart disease (blood pressure and lipid levels) (blood samples will be taken)*
- *Liver and muscle and fat content (by scans and biopsies)*

You will receive all of your results and compensation for transport and your time (up to R3700 on a pro rata basis).

If you are interested in taking part in the study and would like additional information, please contact:

Nandi Sinyanya: 021-6504575 / 0785145785 / nandipha.sinyanya@uct.ac.za

Khaya Zoneleni: 021-6504575 / 0603381154 / ntomkho@gmail.com

APPENDIX E: RECRUITMENT FLYER

Black South African women are invited to participate in an exciting research study

MECHANISMS UNDERLYING INSULIN RESISTANCE IN BLACK SA WOMEN: LESSONS FROM AN EXERCISE INTERVENTION.

Purpose of the study: Within South Africa, there are many people living with diabetes (sugar disease), with black women being the most affected, especially those who are carrying extra body weight (obese). Many studies in other countries have shown that exercise training reduces the risk for diabetes. **Therefore, the aim of the study is to measure changes in the risk for diabetes in response to a 12-week exercise-training programme in obese black South African women.**

Who can participate?

If you fulfil ALL of the following criteria you will be able to take part in the study:

- XXVIII. Black South African (both parents Xhosa);
- XXIX. Aged 20-35 years;
- XXX. Obese: Body mass index (BMI): 30-35 kg/m² $\text{BMI} = \frac{\text{weight (kg)}}{[\text{height (m)} \times \text{height (m)}]}$
- XXXI. No known diseases or not taking medication for any diseases;
- XXXII. HIV negative (compulsory HIV testing);
- XXXIII. No smoking or recreational drugs;
- XXXIV. Not currently pregnant or breast feeding;
- XXXV. Must be using injectable contraception;
- XXXVI. Weight stable (weight not changed more than 5 kg or no change in your clothes size over the past 6 months);
- XXXVII. No muscle or joint pains or medical problems that prevent you from exercising;
- XXXVIII. Able to attend 4 exercise sessions per week for the 12-week study period in Khayelitsha;
- XXXIX. Not currently taking part in organized physical activity (exercise training);
- XL. No previous adverse reactions to an anaesthetic (e.g. at the dentist).
- XLI. No surgical procedures in the last 6 months.

Procedures and benefits:

If you fulfil the above criteria, you will be randomly assigned to either an exercise group or a control group.

- The **exercise group**, you will be required to complete 12 weeks of supervised exercise training for 1 hour on 4 days/week by a trained facilitator in Khayelitsha.
- The **control group** will be required to continue with their normal life activities. However, voluntary exercise training will be offered at the end of the study.

Both groups will be required to complete 3 testing sessions before and 3 testing sessions at the end of the 12-week study at the Sports Science Institute of South Africa (SSISA) in Newlands. These tests include measures of:

- *Body composition (body fat, muscle mass, bone density) using a whole body scanner*

- *Lifestyle factors - dietary analysis and physical activity using questionnaires and activity monitors*
- *Risk for diabetes and heart disease (blood pressure and lipid levels) (blood samples will be taken)*
- *Liver and muscle fat content (by scans and biopsies)*

You will receive all of your results and compensation for transport and your time (up to R3730 on a pro rata basis).

If you are interested in taking part in the study and would like additional information, please contact:

Nandi Sinyanya: 021-6504575 / 0785145785 / nandipha.sinyanya@uct.ac.za

Khaya Zoneleni: 0603381154 / 0734792665 / ntomkho@gmail.com

Dr Amy Mendham: 021-65045 / 0723879889 / amy.mendham@uct.ac.za

Prof Julia Goedecke: 021-9380267 / 0828255616 / Julia.goedecke@uct.ac.za

APPENDIX F: PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PARQ)

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	7. Do you know of any other reason why you should not do physical activity?

If
you
answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to **all** PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- if you are or may be pregnant — talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME _____

SIGNATURE _____

DATE _____

SIGNATURE OF PARENT
or GUARDIAN (for participants under the age of majority) _____

WITNESS _____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.



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PAR-Q & YOU

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

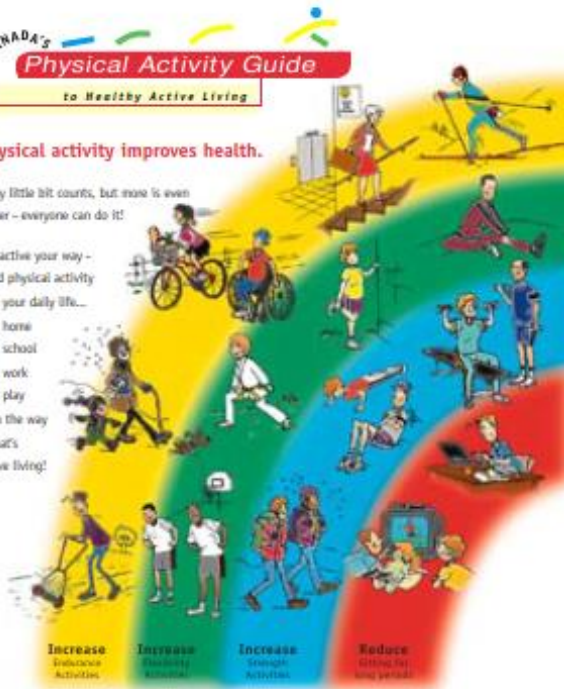


Physical activity improves health.

Every little bit counts, but more is even better - everyone can do it!

Get active your way - build physical activity into your daily life...

- at home
 - at school
 - at work
 - at play
 - on the way
- ...that's active living!



- Increase sedentary activities
- Increase moderate activities
- Increase vigorous activities
- Reduce sitting for long periods

Choose a variety of activities from these three groups:

Endurance
4-7 days a week
Continuous activities for your heart, lungs and circulatory system.

Flexibility
2-7 days a week
Gentle stretching, bending and stretching activities to keep your muscles relaxed and joints mobile.

Strength
2-4 days a week
Activities against resistance to strengthen muscles and bones and improve posture.

Starting slowly is very safe for most people. Not sure? Consult your health professional.

For a copy of the Guide Handbook and more information: 1-888-334-9769, or www.paguide.com

Eating well is also important. Follow Canada's Food Guide to Healthy Eating to make wise food choices.

Get Active Your Way, Every Day - For Life!

Scientists say accumulate 60 minutes of physical activity every day to stay healthy or improve your health. As you progress to moderate activities you can cut down to 30 minutes, 4 days a week. Add-up your activities in periods of at least 10 minutes each. Start slowly... and build up.

Time needed depends on effort				
Very Light Effort	Light Effort	Moderate Effort	Vigorous Effort	Maximum Effort
• Strolling • Bunting	• Light walking • Jogging • Easy gardening • Snowshoeing	• Brisk walking • Skiing • Easy gardening • Swimming • Bunting • Water aerobics	• Aerobics • Jogging • Basketball • Fast swimming • Fast dancing	• Sprinting • Racing
Range needed to stay healthy				

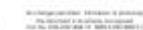
You Can Do It - Getting started is easier than you think.

Physical activity doesn't have to be very hard. Build physical activities into your daily routine.

- Walk whenever you can - get off the bus early, use the stairs instead of the elevator.
- Reduce inactivity for long periods, like watching TV.
- Get up from the couch and stretch and bend for a few minutes every hour.
- Play actively with your kids.
- Choose to walk, wheel or cycle for short trips.
- Start with a 10 minute walk - gradually increase the time.
- Find out about walking and cycling paths nearby and use them.
- Observe a physical activity class to see if you want to try it.
- Try one class to start - you don't have to make a long-term commitment.
- Do the activities you are doing now, more often.

Benefits of regular activity: Health risks of inactivity:

- | | |
|--|--|
| <ul style="list-style-type: none"> • better health • improved fitness • better posture and balance • better self-esteem • weight control • stronger muscles and bones • feeling more energetic • relaxation and reduced stress • continued independent living in later life | <ul style="list-style-type: none"> • premature death • heart disease • obesity • high blood pressure • adult-onset diabetes • osteoporosis • stroke • depression • colon cancer |
|--|--|



Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 <http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf>

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FITNESS AND HEALTH PROFESSIONALS MAY BE INTERESTED IN THE INFORMATION BELOW:

The following companion forms are available for doctors' use by contacting the Canadian Society for Exercise Physiology (address below):

The **Physical Activity Readiness Medical Examination (PARmed-X)** - to be used by doctors with people who answer YES to one or more questions on the PAR-Q.

The **Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy)** - to be used by doctors with pregnant patients who wish to become more active.

References:

- Arraix, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. *J. Clin. Epidemiol.* 45:4 419-428.
- Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy. In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health**. Champaign, IL: Human Kinetics.
- PAR-Q Validation Report, British Columbia Ministry of Health, 1978.
- Thomas, S., Reading, I., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). *Can. J. Sport Sci.* 17:4 338-345.

For more information, please contact the:

Canadian Society for Exercise Physiology
202-185 Somerset Street West
Ottawa, ON K2P 0J2
Tel. 1-877-651-3755 • FAX (613) 234-3565
Online: www.csep.ca

The original PAR-Q was developed by the British Columbia Ministry of Health. It has been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Questionnaire sur l'aptitude à l'activité physique - Q-AAP (révisé 2002)».



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**APPENDIX G: SOCIO-DEMOGRAPHIC AND BASIC HEALTH INFORMATION
QUESTIONNAIRE**

LIFESTYLE QUESTIONNAIRE

DEMOGRAPHIC AND SOCIOECONOMIC DETAILS

1. How many people living in your household, including you? _____
2. How many rooms do you have in your house (including kitchen, lounge, dining room, bedrooms)? _____
3. In your home, how many rooms are there just for sleeping? _____
4. How would you describe your home (tick the one that best describes it)?

House		Flat/Cottage/Townhouse		Residence/hostel	
Shack/Zozo		Government housing (e.g. municipal/RDP housing)		Room in backyard of house (or shared house)	

5. What type of household water do you h access to?

Running water (tap water)		Protected dug out well		Public tap/standpipe	
Piped water into yard/plot		Unprotected dug well		Tanker truck/cart with small tank	
Surface water		Protected spring		Rain water	

6. What type of toilet do you have?

Flush to piped sewer system		Protected dug out well		Bucket system	
Flush to septic tank		Ventilated improved pit (VIP) latrine		Other	
Traditional pit toilet		No facility or bush or field			

7. Which of the following do you have in your household at the present time?

	YE	NO		YES	NO
--	-----------	-----------	--	------------	-----------

	S				
Electricity			Telephone		
Television			Video machine		
Radio			Microwave		
Motor vehicle			Computer		
Fridge			Cellular telephone		
Stove and oven			Mnet		
Washing machine			DSTV		

8. Household food insecurity access scale

1. In the past four weeks, did you worry that your household would not have enough food?			
1. No	2. Rarely	3. Sometimes	4. Often
2. In the past four weeks, were you or any household member not able to eat <u>the kinds of foods you preferred</u> (i.e. VEGETABLES, FRUIT, MEAT/CHICKEN <u>NOT</u> “luxury” food such as pizza, burgers or fried chicken) because of a lack of resources?			
1. No	2. Rarely	3. Sometimes	4. Often
3. In the past four weeks, did you or any household member have to eat a <u>limited variety of foods</u> (e.g. Pap with <u>NO meat</u> OR pap with sweetened water) due to a lack of resources?			
1. No	2. Rarely	3. Sometimes	4. Often
4. In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?			
1. No	2. Rarely	3. Sometimes	4. Often
5. In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?			
1. No	2. Rarely	3. Sometimes	4. Often
6. In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?			
1. No	2. Rarely	3. Sometimes	4. Often
7. In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?			
1. No	2. Rarely	3. Sometimes	4. Often
8. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?			

1. No	2. Rarely	3. Sometimes	4. Often
9. In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?			
1. No	2. Rarely	3. Sometimes	4. Often

9. Marital status:

Single		Divorced/separated	
Married		Widowed	
Living with partner, not married			

10. How many children do you have? _____

11. What are the ages of the children? _____

12. Education (last standard passed):

No formal education		Std 8 (Grade 10)	
Sub A/B (Grade 1-2)		Std 9 (Grade 11)	
Std 1-3 (Grade 3-5)		Matric (Grade 12)	
Std 4-5 (Grade 6-7)		Tertiary education	
Std 6-7 (Grade 8-9)		Other	

Are you:

Employed		A student	
Unemployed		Informal	
Other:			

13. If employed, What work do you do? _____

14. Monthly Household Income:

R0 to 2500		R10 000 to 15000	
R 2500 to 5000		R15000 to 20000	
R5000 to 7500		R20000 to R30000	
R7500 to 10 000		Other range:	

15. How many people do you support with this income? _____ Adults _____ Children:

16. What language do you speak at home?

17. Do you own a car? YES NO

FAMILY MEDICAL HISTORY

Do you have a **close blood relative** (father, mother, brother, sister or child) who has ever had any of the following conditions:

	YES	NO	Don't Know	Comments
High blood pressure				If yes, who?
Heart attack or angina or chest pain when exerting himself/herself				If yes, who?
Was this relative younger or older than 50 years old when they first had a heart attack, angina or chest pain?				At what age?
Stroke				If yes, who?
Diabetes				If yes, who? Adult/child onset?
Obesity (Were they abnormally large? Or have difficulty moving?)				If yes, who?

MEDICATION & SUPPLEMENT USE

Do you use nutritional or other supplements?	YES
	NO
If YES, name the supplement, what is it used for, dosage, frequency and duration of use.	

Do you use any herbal medicine?	YES NO.....
Name of herbal medicine, what you are using for, state the dosage, frequency and duration of use.	
Have you been sick in the past month?	YES NO.....
If YES, what sickness? 8.9.1 Did you take medicine? (yes/no box) What medication(s) did you take? State the dosage, frequency and duration of use.	

BODY IMAGE ASSESSMENT

1. How would you rate your health?

Poor	
Average	
Good	
Excellent	

2. How would you classify your weight?

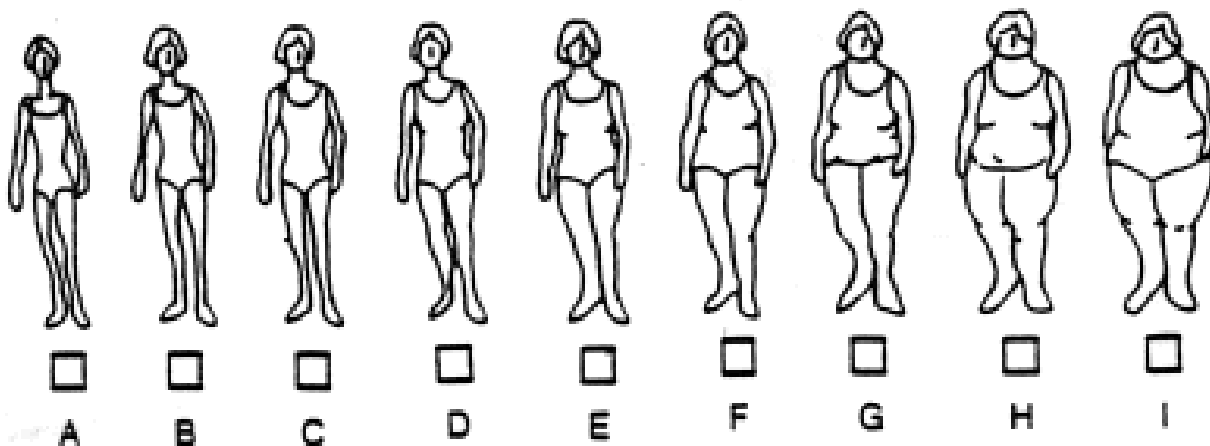
Underweight	
Normal weight	
Overweight	
Obese	

3. Choose the method that you used / are using to lose weight:

Reduced the amount of food I eat		Starve myself	
Exercised more		Use weight-reducing medications	
Skip more meals		Other	
Use a specific diet:		N/A	

4. Choose the method that you think caused you to gain weight

Increase the amount of food I eat		Eat more meals than I usually eat each day	
Exercise more		Take supplements to increase energy intake:	
Use a specific diet:		Other or N/A	



5. Choose the picture of a woman that you think is

Thin		Normal weight		Fat	
------	--	---------------	--	-----	--

6. Which of the pictures do you think you look the most like? _____

7. Which picture would you want to look most like? _____

MENSTRUAL CYCLE

1. What was your age when you had your first period? _____
2. Do you have regular periods? YES NO

If no,

explain _____

If yes, select average time between cycles: 25-30 DAYS 30-35 DAYS >36 DAYS

3. What day of your cycle are you on (Day 1 = first day of bleeding)? _____
4. How many pregnancies have you had? _____
5. When was your last pregnancy? _____

ALCOHOL INTAKE

1 standard drink is equal to 10 g of pure alcohol:

- 200 ml of beer
- 1 glass of wine
- 1 tot (25 ml) spirits

1 small glass (50ml) of sherry/port

1. How often do you have a drink containing alcohol?

Never		2-3 times per week	
Monthly or less		4 or more times per week	
2-4 times per month			

2. On a typical WEEK day, how many drinks containing alcohol do you drink? (how many standard drinks)

1 or 2		7, 8 or 9	
3 or 4		10 or more	

5 or 6		0	
--------	--	---	--

3. On a typical WEEKEND day, how many drinks containing alcohol do you drink? (how many standard drinks)

1 or 2		7, 8 or 9	
3 or 4		10 or more	
5 or 6		0	

GENERAL SELF-EFFICACY QUESTIONNAIRE

Answer the next 10 questions in terms of how much the statement describes you.

	Definitely not	Disagree slightly	Agree slightly	Exactly true
I always manage to solve problems if I try hard enough				
If someone opposes me, I can find the means and ways to get what I want				
It is easy for me to stick to me aims and accomplish my goals				
I am confident that I could deal well with unexpected events				
Thanks to my resourcefulness, I know how to handle unforeseen situations				
I can resolve most problems if I invest the necessary effort				
I can remain calm when facing difficulties because I can rely on my coping abilities				
When I am confronted with a problem, I can find several solutions				

If I am in trouble, I can usually think of a solution				
I can usually handle whatever comes my way				

APPENDIX H: SLEEP LOG DIARY

Code: **Name:** **Issue date:** **Return date: 13 April (Week4)**

DAY	DATE	WAKE UP TIME	SLEEPING TIME
(Example) DAY 0	5/4/2016	8:15	10:30pm
Day 1	6/4/2016		
Day 2	7/4/2016		
Day 3	8/4/2016		
Day 4	9/4/2016		
Day 5	10/4/2016		
Day 6	11/4/2016		
Day 7	12/4/2016		

INSTRUCTIONS:

- ❖ Please wear all the equipment from the date of issue until the last date stated on this form
- ❖ Only remove the red equipment during bathing/shower. Otherwise, the equipment should be worn all day long, including sleeping time.
- ❖ Please only log in the time you wake up in the morning (open your eyes in the morning) and sleep (closing your eyes for sleep at night)

APPENDIX I: FOCUS GROUP DISCUSSION AND IN-DEPTH INTERVIEWS

INFORMED CONSENT FORM

The effect of a 12-week exercise training intervention on cardio-metabolic risk factors, and sedentary behaviour and physical activity patterns in obese black South African women:

Perceptions of a 12-week exercise training intervention amongst overweight and obese black South African women: a qualitative study.

According to the 2013 South African National Health and Nutrition Survey (SANNS) overweight and obesity prevalence in the population 15 years and older was significantly higher in women than men. Overweight and obesity are known risk factors for non-communicable diseases (NCD's), particularly Type 2 diabetes mellitus (T2DM). In South Africa the prevalence of Type 2 diabetes mellitus is higher in women than in men and increases with age. Furthermore, the increased prevalence of Type 2 diabetes mellitus has been shown among black South Africans residing in areas including Khayelitsha, Langa, Gugulethu and Cross roads in Cape Town. South African 2013 statistics ranked diabetes mellitus the fifth leading cause of death for 3 consecutive years. With the Western Cape Province reporting the highest percentage of deaths due to Type 2 diabetes mellitus.

Scientific research shows that moderate and vigorous intensity physical activity (MVPA) contributes to the prevention of Type 2 diabetes mellitus. Also, regular exercise help reduce weight, blood pressure, total lipid profile and blood glucose. There is evidence on the effectiveness of regular exercise on weight loss and reduction in the risk of Type 2 diabetes mellitus. However, to our knowledge there is no research study that has investigated participants' perception from taking part in the exercise intervention. Therefore, the main aim of our study is to conduct focus group discussions and key informant interviews for the purpose of obtaining participants' perception about the exercise intervention.

The focus group discussions will be approximately 60 minutes in duration and will be audio recorded with the consent of the participants. These focus group discussions will take place at the same venue as the exercise sessions. A trained facilitator will conduct all the focus group discussions using guided questions. This will include open-ended questions such as: ‘Did you enjoy the exercises?’; ‘As a control group participant why did you decide not to participate in the exercises even though you were given the option to do so?’ and ‘Would you recommend other women in your area to start exercising?’

Incentive to participate in the focus group discussions

The participants will receive R50 to cover their transport costs to the venue and R20 to compensate them for their time and inconvenience. Refreshments will be offered at all sessions.

Ethical considerations

A trained facilitator who is fluent in English and Xhosa will conduct all the focus group discussions and key informant interviews. Participation is voluntary and participants’ privacy will be protected at all times (No names will be used in the report). Participants will be informed that they have the right to leave the focus group sessions at any time during the discussion. All participants will be required to sign an informed consent form prior to the group discussions.

Perceptions of a 12-week exercise training intervention amongst obese black South African women: a qualitative study.

INFORMED CONSENT

I the undersigned _____ (the participant) hereby agree that I have fully read and understood this form and that I understand the nature, purpose and procedures of this research study entitled:

Perceptions of a 12 week exercise training intervention amongst overweight and obese black South African women: a qualitative study. Conducted by UCT/MRC Research Unit for Exercise Science and Sport Medicine at the University of Cape Town.

I have agreed to participate in the focus group discussions and key informant interviews which will be conducted by a trained facilitator. I am aware that the focus group discussions and the key informant interviews will be audio recorded with an electronic device and that the facilitator might also write down notes of what will be discussed during the group discussions and key informant interviews. I also understand that data gathered through the group discussions and interviews will be analysed anonymously. I also understand that due to the nature of the group discussions, the confidentiality of the discussions that take place cannot be guaranteed to me as a participant.

My agreement to participate in this study is voluntary and I am aware that I can withdraw at any stage that I feel appropriate. On the basis of the above, I hereby agree to participate in this study.

Any questions regarding this project maybe directed to the principle investigators; Dr Lisa Micklesfield Tel: 021 650 4570; e-mail lisa.micklesfield@uct.ac.za, OR Miss Lindokuhle Phiri Tel: 084 278 6310; e-mail greeni_lindokuhle@gmail.com.

If you have any complaints or queries that the investigators have not been able to answer to your satisfaction, you may contact Prof Marc Blockman on 012 406 6338 at the Faculty of Health Sciences Human Research Ethics Committee; University of Cape Town.

Name of participant: _____

Participant Signature: _____ Date: _____

Participant code: _____

Name of Researcher: _____

Researcher Signature: _____ Date: _____



OPEN ACCESS

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Perceptions and experiences of young Black South African women with obesity from a low socioeconomic community after following a 12-week structured exercise intervention

Lindokuhle P. Phiri^{1*}, Lisa K. Micklesfield^{1,2},
Amy E. Mendham^{1,2}, Julia H. Goedecke^{1,3,4} and
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¹Health Through Physical Activity, Lifestyle and Sport Research Centre (HPALS), FIMS International Collaborating Centre of Sports Medicine, Division of Physiological Sciences, Department of Human Biology, Faculty of Health Sciences, University of Cape Town, Cape Town, South Africa, ²SAMRC/WITS Developmental Pathways for Health Research Unit (DPHRU), Department of Paediatrics, School of Clinical Medicine, University of the Witwatersrand, Johannesburg, South Africa, ³Biomedical Research and Innovation Platform, South African Medical Research Council, Tygerberg, South Africa, ⁴Non-communicable Diseases Research Unit, South African Medical Research Council, Tygerberg, South Africa

Background: Previous research has shown that Black South African (SA) women perceive a bigger body size to be acceptable and desirable, but nonetheless have shown interest in participating in community-based exercise programmes. This study aimed to investigate perceptions and experiences of participating in a 12-week exercise intervention designed to study the mechanisms of insulin sensitivity and secretion in young Black SA women with obesity.

Methods: Qualitative data was collected from young (23 ± 2.9 years) Black SA women (n = 17) residing in a low-income setting in Cape Town, who took part in a 12-week structured exercise intervention. Focus group discussions (FGDs) and in-depth interviews (IDIs) were conducted 1–4 months after the completion of the intervention. These were all audio recorded and took between 45 and 60 min. The recordings were transcribed, translated and qualitative content analysis, entailing a systematic process of coding and identification of salient themes, was conducted using the ATLAS.ti software.

Results: Six broad themes were identified from participants' experiences and perceptions: motivational factors, acceptability of the programme, barriers, sustainability and influencing others, benefits of being physically active, definitions and perceptions of exercise. Anticipated weight loss and financial remuneration were identified as motivational factors for enrolment and retention in the exercise programme. Aspects of the training environment and feelings of wellness appeared in the acceptability, sustainability and benefits themes, whereas time scheduling and travel constraints were regarded as barriers. Exercise was perceived as the maintenance of a healthy body, and in some cases, only relevant for specific groups.

Conclusion: Financial considerations played an important role in participants enrolling and staying in the 12-week exercise intervention. Participants liked many aspects of the intervention and identified physical and mental benefits that seemingly outweighed the barriers and disliked aspects of the programme. Optimizing the acceptability of exercise programmes and maximizing the opportunity for participants to experience improved mental well-being may contribute to attracting and retaining young Black SA women in exercise programmes.

KEYWORDS

exercise, training environment, barriers and facilitative factors, self-efficacy, weight loss

Introduction

Participating in regular physical activity has been consistently linked with improved physical and mental well-being (1) and has been shown to play an important role in obesity management (2). Studies have shown black South Africa (SA) women prefer a bigger body size as it is associated with beauty, dignity, confidence (3), respect from others, happiness and wealth (4, 5), with some women commenting that "Our culture says that you are supposed to be fat" (6). African women, therefore have historically not perceived obesity as a threat to their health (7) and on the contrary have been reported to perceive thinness to be associated with diseases such as Human Immunodeficiency Virus (HIV), Acquired Immune Deficiency Syndrome (AIDS) and tuberculosis (TB) (8, 9).

More recently a transition in the perception of obesity toward Western norms of thinness in young SA women have been reported (10, 11). However, the latest South African Demographic and Health Survey showed that ~67% of Black SA women are overweight or obese (12), which has occurred alongside reduced physical activity and an increase in the prevalence of non-communicable diseases (NCDs) (13). Accordingly, exercise interventions designed to alter physical activity patterns and prevent the development of NCDs in young women with obesity are warranted. Findings of previous qualitative work in our study community reported that young Black SA women from a low-income setting were interested in participating in community-based exercise interventions that

incorporate dancing, aerobics and lifting weights as a strategy to lose weight and improve health (6).

However, there are barriers to engaging in physical activity in people living in resource-constrained environments, which include lack of time, cost, accessibility to facilities, other people's perceptions and unsafe residential environments (14). However, little is known about how these barriers conspire to affect the adherence and sustainability to a structured exercise programme. It is anticipated that exploring women's perceptions and experiences of "exercise" after participating in an exercise intervention will assist in identifying barriers, enablers and goals that can be used to design future long-term exercise interventions. Accordingly, this study aimed to investigate the perceptions and experiences of a 12-week structured exercise intervention in a group of young Black SA women with obesity from a low-resource setting.

Materials and methods

Setting and exercise intervention

This qualitative study includes a sub-sample of women who participated in the primary study that examined the mechanisms underlying changes in insulin sensitivity and secretion in response to a 12-week exercise intervention in young Black SA women with obesity (15). The detailed protocol, trial registration (PACTR201711002789113), methods, consort diagram and baseline characteristics of the participants in the primary study have been previously published (15). The study was approved by the Human Research Ethics Committee at the University of Cape Town (HREC REF: 054/2015). This study was performed in accordance with the principles of the Declarations of Helsinki (1964, amended last in the Fortaleza Brazil, 2013) International Conference on Harmonization (ICH) Good Clinical Practice (GCP), and the laws of South Africa. Participants provided written informed consent prior to screening and testing procedures.

Abbreviations: AIDS, Acquired Immune Deficiency Syndrome; ANOVA, Analyses of variance; BMI, Body Mass Index; FGDs, Focus group discussions; GCP, Good Clinical Practice; HR, Heart rate; HIV, Human Immunodeficiency Virus; HREC, Human Research Ethics Committee; IDIs, In-depth interviews; ICH, International Conference on Harmonization; HR_{max}, Maximum heart rate; %HR_{max}, Percentage of maximum heart rate; SD, Standard deviations; SA, South Africa; ZAR, South African Rands; ST, Subthemes; T, Themes.

The first author was a PhD fellow at the time of the study. She has experience in qualitative research and is an exercise specialist with an interest in community-based exercise interventions.

Participants and intervention design

The participants were a convenience sample of Xhosa-speaking women recruited from a low-socioeconomic area in Cape Town, SA. Based on the 2015 City of Cape Town socioeconomic profile, low-income areas are classified using average household income (16). The selected area is classified as a low socioeconomic area, with only 31% of the participants earning more than 5,000 South African Rands (ZAR), equivalent to ~290 United States Dollars (\$) a month (16).

Participant recruitment ensured the following inclusion criteria: (i) South African women self-reported Black (both parents isiXhosa) and between the ages of 20–35 years; (ii) no surgical procedures within the last 6 months; (iii) weight stable (weight not changed more than 5 kg or no change in clothes size over the past 6 months); (iv) physically inactive (self-reported < 60 min a week of regular physical activity and/or planned moderate to vigorous intensity physical activity); (v) on injectable contraceptive (depot medroxyprogesterone acetate, 400 milligram (mg)); (vi) no known metabolic or inflammatory diseases; (vii) no hypertension, diabetes, HIV or anemia; (viii) not taking any medications; (ix) non-smokers; (x) not currently pregnant or lactating; (xi) no orthopedic or medical problems that may prevent exercise participation; (xii) obese (body mass index (BMI) between 30 and 40 kg/m²). At baseline, BMI was measured and socio-demographic questionnaires, including age and measures of education and employment status, were completed by the participants with assistance of an isiXhosa-speaking research assistant.

Forty-five women met the inclusion criteria and were randomized into either an exercise group ($n = 23$) who participated in supervised aerobic and resistance exercise training; 40–60 min, 4 days per week, or a control group ($n = 22$) who were asked to maintain their normal physical activity and dietary behaviors. The project manager conducted block randomization after the participants completed the pre-intervention screening to ensure that researchers performing the testing were blinded to group allocation. A final sample of 35 participants completed the intervention ($n = 20$ in the exercise group; $n = 15$ in the control group).

Both groups were encouraged to maintain their normal dietary patterns. The exercise sessions were prescribed and included both aerobic and resistance training, and were conducted in a group setting and supervised by an exercise specialist registered with the Health Professions Council of South Africa (HPCSA). Participants in the control group were provided the opportunity to participate in the exercise

sessions following the completion of post-intervention testing. Eight control group participants opted to join the exercise sessions. Heart Rate monitors (A300, Vantage NV, Polar, Finland) were used to monitor heart rate (HR) during every exercise session. The aerobic training component included dancing, running, skipping, and stepping at 75–85% of peak HR. The resistance exercises started with participants using their own body weight to perform exercises such as squats, lunges, and push-ups. Participants then progressed to using equipment such as elasticated bands and weights. Both aerobic and resistance exercises were altered to ensure progression and to maintain the required intensity throughout the intervention. Participants received a total of 3,800 ZAR over the course of the study which covered 30 ZAR per day to cover their transport costs to the training venue ($4 \times$ training sessions per week for 12 weeks, plus 3 monthly monitoring visits). Furthermore, to compensate the participants for their time and inconvenience, they were reimbursed 20 ZAR per hour for each training session and 50 ZAR per hour for the testing sessions (total of 17 h of testing and monitoring). The control group were similarly reimbursed for the testing sessions, and if they chose to participate in the exercise sessions post-intervention, they were similarly compensated.

Post-intervention qualitative data collection and analysis

Focus group discussions (FGDs) and in-depth interviews (IDIs) were conducted in 2017, 1–4 months after the completion of the 12-week intervention to ensure that there were enough participants for each group discussion. All recruited participants ($n = 45$) were invited telephonically to participate in the FGDs. Participants who dropped out of the intervention ($n = 10$) and participants in the control group who rejected the opportunity to participate in the intervention at the end of the study ($n = 7$), were also contacted, with the intention to understand potential barriers relating to participating in the intervention. However, we were either unsuccessful in contacting these participants or they were not willing to participate. During the telephone recruitment for the FGDs, participants were informed that they would be remunerated with R50 ZAR to compensate for their transport, time, and inconvenience to participate in the FGD. Two of the eight participants in the control group who completed the post-intervention exercise training participated in the interviews. Participants who seemed to have the strongest opinions during the FGDs were invited to participate in the IDIs, optimizing the opportunity to further explore the themes identified and adding to the richness of the information collected during the FGD (17). The moderator and the scribe selected these participants in a debriefing session after each FGD, using

the notes taken by the scribe to consider the flow of the group discussion and the contribution of the various participants.

The semi-structured focus group questions were formulated by the research group and were based on previous qualitative work done in a similar group of women from the study community (6). Following the question formulation, we sought independent input from external researchers with extensive experience in working with women from similar settings. The focus group questions were aimed at investigating the participants' perceptions about the exercise intervention, and barriers and motivators that might have influenced compliance during the exercise intervention (Table 1). The IDIs contained a single open-ended question. The interviewer allowed the participant to share her experiences of the exercise sessions (Table 1), while prompting her to elaborate on salient points arising from the focus groups. The purpose of the IDIs was to eliminate the influence of others' opinions that could have occurred during the FGDs (18).

A trained facilitator and scribe who were fluent in both English and IsiXhosa, the vernacular of the study population, conducted all the FGDs and IDIs. This ensured that no participant was excluded from the FGD because of language barriers. At the start of each FGD the facilitator and scribe introduced themselves and explained the purpose and reasons for doing the research. The FGDs and interviews were audio recorded and a scribe made notes during the FGDs. The FGDs and IDIs were conducted at a venue at the university and took between 45 and 60 min. No time restriction was set for these discussions and the duration was deemed appropriate for the number of participants in the FGDs and the question schedules. The audio recordings were transcribed from IsiXhosa into English by an independent translator, fluent in both English and IsiXhosa. The accuracy of the transcriptions both in tone and language were checked against the notes taken by the scribe by the first author.

The first author (LP) applied qualitative content analysis to analyse the transcripts (19) using the Atlas.ti Qualitative Data Analysis Software (Scientific Software Development GmbH, Berlin, Germany). This methodological approach allowed description and interpretation of the data using quantification of the data to develop themes. The analysis process started with reading the transcribed data in detail. Thereafter, a consensus process of drafting a coding framework was followed with another researcher (AD) and the codes were then systematically applied to the transcripts. If relevant, applicable codes were applied more than once to the data generated from the same participant. Main themes and sub-themes were then generated by LP and reviewed by both LP and AD after which clear definitions and names for each theme and subtheme were generated. These were checked by the rest of the research group and suggested changes were incorporated in the final document. Data saturation was achieved in the sense that all intervention and control participants, and all dropouts, were invited to participate in

TABLE 1 Focus group discussion and in-depth interview question schedules.

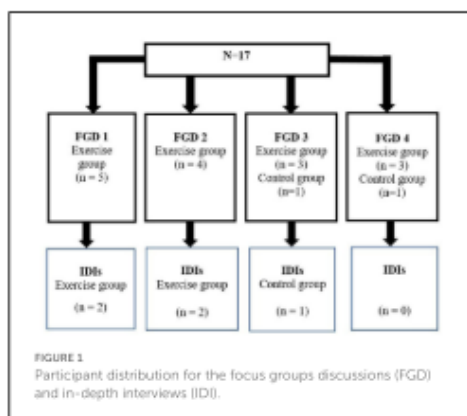
Number	Interview schedules
Focus group discussion questions	
1	Can you please briefly share with us what you have been up to since we last saw you?
2	What is the first thing that comes to mind when you hear the word "exercise"?
3	What are your perceptions about exercise?
4	What are some of the things that influenced you to attend the exercise sessions? This can either be barriers or motivating factors.
5	What did you like the most about the exercise sessions?
6	What did you not like about the exercise sessions?
7	How did the exercise training affect your daily life?
8	What did your friends and family have to say when they found out that you are exercising?
9	Is there anything that could be changed about the exercise training sessions to encourage you to continue exercising and for your friends and family to start exercising?
10	Of all the questions that were discussed today, is there one which you feel was the most important to you?
In-depth interview question	
1	How did you experience the exercise sessions?

the qualitative study and all those who agreed, took part in the FGDs. The voices of most of the participants were therefore heard and additional data was collected through the IDIs to ensure that all issues raised in the FGDs were adequately explored.

Results

Descriptive characteristics of the participants have been described elsewhere (20). The women were all of isiXhosa ancestry and from a low-income community. From all the contacted participants, 17 participants agreed to participate in the FGDs (Exercise, $n = 15$; Control, $n = 2$). There were no differences in age (24 ± 4 vs. 24 ± 4 years), BMI (33.2 ± 2.4 vs. 34.3 ± 3.0 kg/m²) or socio-demographic characteristics, including education (7 vs. 5 participants with tertiary education), household income (75 vs. 72% earned >R5000/month) or housing density (1.3 ± 0.6 vs. 1.4 ± 0.9 people living in the household/room, between the participants who agreed to participate in the FGD and those who did not, respectively).

Five of the FGD participants were selected (Exercise, $n = 4$; Control $n = 1$) to complete IDIs. Two FGDs (FGD 1 and 2) comprised of only exercise participants who completed the intervention, and the other two FGDs (FGD 3 and 4) included a mix of participants from the exercise and control groups. Each FGD consisted of between three to five participants (Figure 1).



Perceptions of the exercise intervention and the perceived barriers and facilitators

Six themes (T) with 2–3 subthemes (ST) each were identified during the analysis process. These themes and subthemes are presented in Table 2. Numbers included in the table reflect the number of fragments of experiences and perceptions brought together to first form the subthemes and later the main themes.

Table 2 shows that experiences relating to motivation and the acceptability of the intervention were the themes with the most quotations attached to them. These were followed by barriers experienced; sustainability and being an influencer; the perceived and experienced benefits of exercise, and lastly how the term “exercise” was perceived and defined.

Figure 2 presents these themes as described in the following presentation of the results and shows some of the possible associations and overlaps between the various themes and subthemes.

Theme 1: Motivational factors

During the analysis process, factors that the participants perceived to play a motivational role during the intervention were grouped together into two sub-themes namely (1) those factors that motivated the participants to enroll in the intervention, and (2) factors that kept the participants in the intervention. These identified factors are to be distinguished from the aspects that participants liked about the intervention which are included in the next theme (acceptability of the programme). Although there are overlaps, the codes informing this theme were drawn specifically from discussion points around what motivated the participants to enroll and then stay in the intervention.

Motivation to enroll

Extrinsic factors played an important role in the decision of participants to enroll in the intervention. Perceived financial advantage was mentioned by participants in all FGDs and some IDIs. This was followed by anticipated weight loss with some participants indicating that both factors played a role in their decisions.

“The money, because I was like, I saw the pamphlet, then I said okay this is so much money, then I was like I need money, and this is going to help me in many things that I need.” (IDI: Participant 36; exercise participant).

“My personal goal was basically to lose weight. I wanted to see how much weight I could lose within those three months.” (IDI: Participant 25; exercise participant).

“This exercise sessions I was going to lose weight. I was going to be on good shape, and I was going to get money” (FGD 4: Participant 45; control participant).

The in-depth interviews revealed additional insight into why financial considerations were so important, with participants reporting that they bought basic food (often refined carbohydrates) with the money.

“The hamper. The rice, the mealie meal, the flour and the sugar, white sugar”. (IDI: Participant 19; exercise participant).

Motivation to continue

Participants reported both extrinsic (financial, weight loss, training environment and support from others) and intrinsic (enjoyment and mental wellness) factors that motivated them to remain in the intervention. Financial considerations remained important even in the face of challenges to continue.

“My time was also affected by the exercise sessions, especially the 4 o’clock one because I would end up getting home at about 7pm. I would arrive home late and that would affect my cooking schedule, and they would shout at me at home for being late, but I didn’t give up because I would be getting money.” (FGD1: Participant 31; exercise participant).

The participants felt toned and fitter as they could now walk long distances faster and climb stairs without becoming breathless.

“But then I didn’t really care about losing weight because I actually felt fitter, I can walk from ... [suburb of Cape Town] to here in 10 minutes. So those were one of the things that I felt the exercise sessions really helped me with” (IDI: Participant 23; exercise participant).

TABLE 2 Experiences and perceptions after a 12-week structured exercise intervention.

Number	Theme	Subthemes	Number of quotations coded
1	Motivational factors	Extrinsic (financial, weight loss, training environment) and intrinsic (enjoyment and mental wellness) motivation to continue with the intervention	44
		Extrinsic motivation to enroll in the intervention (financial and anticipated weight loss)	27
		Total quotations	71
2	Exercise program acceptability	Aspects of wellness and the training environment participants liked	28
		Aspects of the training environment and exercise regime that participants disliked	26
		Total quotations	54
3	Barriers	Travel constraints	11
		Time	10
		Total quotations	21
4	Sustainability and influencing others	Serve as influencer	16
		Keep on exercising	4
		Total quotations	20
5	Benefits of being physically active	Improved self-efficacy	7
		Disease prevention and reduced stress levels	5
		Lifestyle changes	4
		Total quotations	16
6	Definitions and perceptions of "exercise"	Maintaining a healthy body	6
		Change in body composition	3
		Fit and active	1
		Total quotations	10

Influence of family and friends also served as motivators for participants from both the FGDs and IDIs.

"I've got a lot of support from my family. They actually gave me the go ahead, if it is going to work for you, do it. We are behind you all the way. There was also a point where I changed the way I eat, so they were also supporting me in that and my friends also got support from them, there was no negativity". (FGD2: Participant 29; exercise participant).

"My family, they motivated me to go to the exercise because it is important for the health". (IDI: Participant 36; exercise participant).

Other participants however reported remaining motivated despite the negative opinions of friends and family. They persevered with the intervention even though their families expressed that their weight was "normal," receiving remarks that they cannot see that they have lost any weight; or were warned about the negative effects of losing weight.

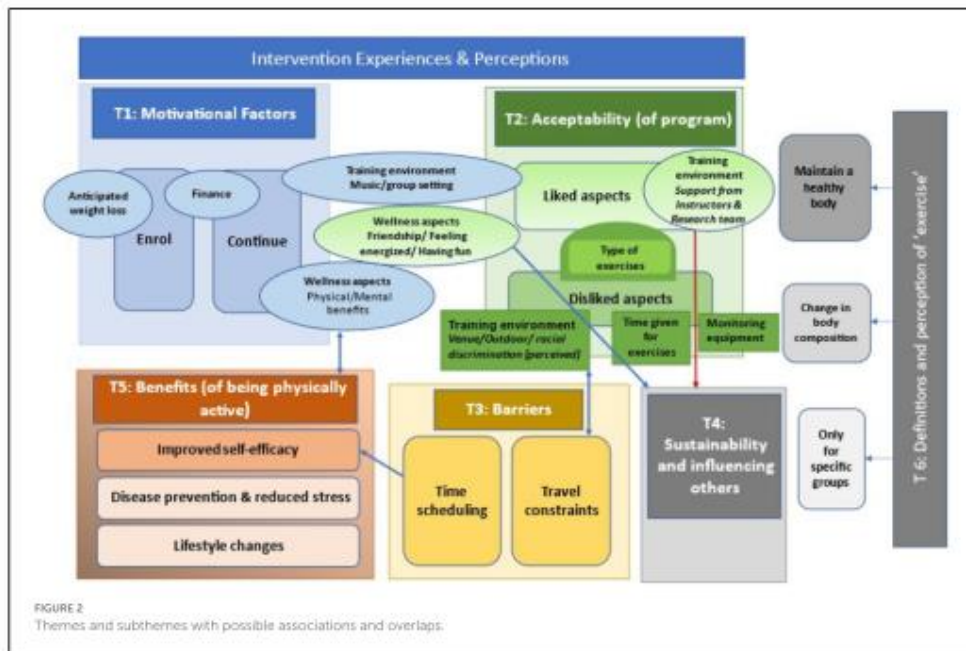
"My friends. My family was like no your body is okay, and we love you as you are. You don't have to lose weight; you know how family is. They were just so supportive of you

that they don't even see that there is a problem. . . . But what about me? What about what I want? So, I told myself that I am going to do it and I did it". (FGD2: Participant 29; exercise group).

No, people were like, are you really exercising we see no difference. They were demotivating me and it was annoying me because they say when you exercise it's like chemotherapy you just go and then come out very thin like thin, extremely thin. It doesn't work like that. With exercise, it takes time to show that you are losing weight.". (FGD4: Participant 25; control group).

Theme 2: Acceptability of the programme

Participants shared their experiences about participating in the intervention and what they liked or disliked about the exercise programme, providing insight into the acceptability of the programme. The disliked aspect can be distinguished from the barrier theme (theme 3) in that the barriers are mostly logistical aspects that made it difficult for the participants to attend the sessions while the disliked aspects were related to various aspects of the exercise programme. Likes and



dislikes were equally distributed with many of the aspects of the programme appearing in both the “like” and “dislike” sub-themes, such as assistance from trainers and the types of exercises.

Aspects that were liked

Four main aspects came to the fore when participants discussed what they liked about the intervention. Three of these relate to the training environment. Participants liked and appreciated the support and assistance from the trainers and research team, this was followed by the type of exercises, music as part of exercise routines and lastly, wellness aspects (including friendship, feeling energized and having fun).

Positive experiences around support from the intervention team included factors such as having patience with and appreciating their challenges such as being late for the exercise classes.

“The things that I loved most about the exercise is the aerobic sessions, the fact that when we are tired, instructors would be patient with us. They would be very supportive. (FGD1: Participant 24; exercise participant).”

As highlighted in the previous quote, aerobics was the type of exercise session that was enjoyed the most. Music was used

with all exercise routines and this component of the exercise programme was enjoyed by many participants. The importance of music was reiterated in the IDIs.

In addition, participants enjoyed training in a group setting and making new friends. This was reaffirmed in the IDIs.

“The one thing that I like the most is that we do it as a group, firstly. It’s not like you’re doing it alone. I can do it with someone else, with people, that is nice and different types of exercises that I enjoyed is that what the question was about” (FGD3: Participant 23; control group).

Aspects that were disliked

Five aspects of the intervention were identified by the participants as contributing to negative experiences. The most discussed were the training environment followed by the types of exercises, time allowed for the exercises, the physical activity monitoring equipment and lastly, the instructors.

The venue, outdoor exercises and perceived racial discrimination were factors in the training environment that contributed to negative experiences. Concerning the racial discrimination some participants indicated that they sometimes felt unwelcome in the

training venue and perceived this to be because they were black.

"I feel like sometimes when we are here, other people down there, were looking at us badly because we are black, they used to say that we are disturbing them, especially when there was another class. They would want us to put our music softer but when we were outside, no one would complain". (FGD1: Participant 19; exercise participant).

Participants identified that the heart rate monitors were uncomfortable to wear. Some of the participants also disliked certain high intensity exercises such as running up and down stairs, sit-ups, jumping jacks and running outside in the sun.

"Having to wear equipment while exercising. Not the watch. Our equipment is very irritating. I get irritated by just looking at it" (FGD 3: Participant 44; exercise participant).

Time available to complete the exercise sessions and negative experiences with the instructors were also raised as factors that negatively affected experiences, the latter were raised by a participant during the IDIs.

"I think it would be a bit more fun if the starter could maybe try to have different trainers with different experience... If there were different trainers maybe that would make things funnier or exciting. There were times when she will seem like she was not in the mood for exercise sessions". (IDI: Participant 23; exercise participant).

Theme 3: Barriers

The most common barriers were travel constraints and lack of time. Some participants felt that the venue was not central, and they had to travel long distances to get to the venue. Three of the five participants mentioned the issue of transport as a barrier during the IDIs.

"It does not accommodate everyone, only accommodate those who are closer to the buildings... So, the traveling is also a barrier" (FGD2: Participant 29; exercise participant).

Most of the participants identifying time as an issue were university students, some of whom worked part time in addition to their studies and had challenges finding time to attend the programme.

"It affected my daily life when I had things to do, and I had to come here to the gym.....So it was very difficult for me to manage time because I had to come here at half past four. I was always late". (FGD1: Participant 27; exercise participant).

Theme 4: Sustainability and influencing others

Participants shared their perceived enthusiasm to continue with the exercise programme after the end of the intervention and influence others to exercise. All FGDs participants indicated that they would encourage family and friends to start exercising. Further, being more physically active as a result of the intervention made them more aware of the benefits and importance of exercise and physical activity.

"I will say yes or motivate someone to go to the gym because black people's mentality is that- one has to have curves. We are the ones, we are Black, you understand because when you're exercising like you are minimizing certain illness so I would say yes" (FGD4: Participant 32; control participant).

Continuing with an exercise programme came up in the FGDs and was explored further in the IDIs. Three of the five participants who participated in the IDIs continued training on their own after the intervention, one with the help of a volunteer instructor in an informal group setting.

"I jog with my friends to the certain place and then when we get there we meet like other people and there's like [Xhosa] we have an instructor, but we don't pay. There is an instructor, but they do it for fun, for the love of it". (FGD1: Participant 19; exercise participant).

One participant however reported difficulty in being consistent with the exercise regime mostly because of a lack of a supportive training environment.

"Because I don't have a personal trainer, so I don't have someone looking after me. I do go sometimes, sometimes I don't go". (IDI: Participant 23; exercise participant).

Theme 5: Benefits of being physically active

Most participants acknowledged that after completing the programme they were more aware of the benefits and importance of being physically active. The perceived benefits could be grouped in three sub-themes. Improved self-efficacy was the strongest sub-theme, followed by disease prevention and reduced stress levels, and lastly, lifestyle changes.

Some participants reported improved self-efficacy in the form of coping and scheduling skills. They expressed that the exercise programme helped improve their ability to cope with busy schedules and assisted with scheduling their busy daily routines.

"Third year students have a lot of work so if I come home late, my body is tired but since I have been exercising, I have been coping. I would leave my room at 4 or 5 and I would

have to come back and cook, eat and do schoolwork but what I realized was that I could cope unlike before when I used to sleep for 30 minutes. Since the gym I feel alright so that was the positive part about the gym. I could cope and be able to climb the stairs". (FGD4: Participant 37; control participant).

"So, like the fact that I had to allocate like some of my time to the gym, like to commit some of my time to this gym thing that's happening, it helps me to plan my daily activities". (FGD1: Participant 24; exercise group).

Participants perceived that exercise increased their energy levels, reduced stress and may reduce risk of diseases such as high blood pressure, diabetes and heart disease.

"like I see exercising as a tool that reduces high blood pressure". (FGD4: Participant 32; control participant).

"Exercise for me personally is a stress reliever". (FGD3: Participant 39; exercise participant).

The participants furthermore perceived exercise to be associated with positive lifestyle changes such as changes in diet and participating in more active leisure time activities (i.e., going to the gym).

Theme 6: Definitions and perceptions of "exercise"

Several sub-themes emerged from the discussion around what the term "exercise" means. Participants defined "exercise" most often in terms of maintaining a healthy body, followed by changes in body composition such as weight loss and increased muscle mass, engaging in any physical activities, and lastly the perception that it is something that a specific group of people do.

"I think the word exercise means getting yourself to be healthy, trying to change your body, get more muscles by doing exercises". (FGD3: Participant 39; exercise participant).

"I feel like exercise has to do more with physical activities than anything else. It is a physical activity. You don't have to do a certain thing and say it's exercising. You can walk, you can [do] anything, moving your body in general". (FGD3: Participant 44; exercise participant).

A few of the participants from the FGD perceived exercise to be associated with ethnicity.

"like I'm going to be very honest, like the word exercise to me, like it has the whiteness on it, like this whiteness, like it's for white people". (FGD1: Participant 24; exercise participant).

Discussion

In this study we aimed to gain an understanding of the experiences and perceptions of young Black SA women living with obesity following their participation in a 12-week structured exercise intervention. Six themes were identified from the focus groups and in-depth interviews and included motivating factors, acceptability of the programme, barriers, sustainability and influencing others, benefits of being physically active, and perceptions of the term "exercise".

Financial advantage in the form of remuneration for costs relating to travel and time were identified as an important extrinsic motivator for enrolling and staying in the programme. This is not a unique finding as financial incentives have, even in high income settings, shown to be effective in behavior change and achieving physical activity goals, as well as to moderate the effects of self-efficacy on weight-loss in adults with obesity participating in interventions (21, 22). Although there is no data on the role of financial gain on physical activity interventions within the South African context, conditional cash transfers have been used in South African high school girls to reduce HIV incidence among young women and address structural factors such as poverty (23). However, the amount of money provided to our participants as reimbursement for their travel and time was small and the perception of financial advantage gained from the project may point to the socio-economic hardships suffered in the communities from which our participants were drawn (24). This opinion is supported by the finding that participants reported using the money to buy high-energy dense staple foods such as maize-meal and sugar. These choices suggest high levels of food insecurity in the households of our participants. The consumption of high energy dense foods in low socio-economic populations and the link with obesity has been consistently reported in the literature (25, 26).

In addition to the financial incentive, participants reported weight loss (anticipated and actual) as a motivator for enrolling and staying in the intervention. Participants were reminded at recruitment that substantial changes in body weight are not commonly shown in response to exercise only interventions (27, 28). Although only a small but significant weight loss was achieved by the intervention group (~1 kg) (20), this was experienced positively by the participants. Physical benefits such as a perceived increase in fitness levels and muscle tone could have contributed to these positive experiences. The multiple socio-cultural, environmental and behavioral factors involved in the risk for Black SA women to become obese (25) provides a further understanding for why even a small weight loss could have been considered an achievement.

Another benefit reported by participants was an improvement in psychological well-being (improved mood

and self-esteem). These findings are supported by quantitative results previously reported from the same intervention, showing reduced symptoms of depression and improved sleep quality in response to the exercise training (29). Our findings are also consistent with previous research findings which suggested that improved psychological and physical well-being are related to increased exercise adherence in women with obesity (30). A study by Cleo et al. (31) reported that participants in a weight loss programme were impressed by the "indirect ripple effect" of health benefits they experienced aside from weight loss, and this seems to be true for our study as well.

Another benefit identified is the perceived increased level of self-efficacy of participants. Some indicated that participation in the programme assisted them with improving their scheduling behavior while feelings of enhanced physical fitness, reduction of stress, and improved mood were all evident and have previously been shown to strengthen self-efficacy (32). An increase in self-efficacy is furthermore associated with persistence in exercise training even in the presence of challenging barriers (30). Barriers to attending the training sessions in our study included lack of time, distance to the training venue, and limited transport to the training venue, all of which have been previously reported in low socioeconomic settings (14). Moreover, participants reported aspects of the programme that they did not like such as the venue, some personal characteristics of the trainers, high intensity exercises and perceived racial discrimination at the venue. The latter is important as racial "everyday discrimination" were found to be positively related to distress (33) and potentially may weaken the positive experiences of participants to similar programmes. When considered together with the perception of exercise as an activity done by "white" people only, careful attention should be given to this aspect in exercise programme development. The dislike of high intensity exercise supports the results of Foster et al. (34) that in a group of relatively untrained young adults the exercise regime with the highest intensity had the lowest enjoyment score.

Intrinsic and extrinsic aspects of the training programme and training environment, such as support by the instructors and group, types of exercises, friendships, fun and music were identified as well-liked aspects of the programme. Participants suggested that these positively experienced factors are important when considering the sustainability of the programme, made them feel motivated to influence others to exercise and motivated them to continue with the intervention. According to Withall et al. (14) once people are active, high levels of social interaction, interest and enjoyment, are associated with improved levels of retention. Our results show that the perceived benefits (motivators) outweighed dislikes and barriers and facilitated the continuation and completion of the intervention. Not only did most participants (87%) complete the programme, but some went on to continue exercising, and all

saw themselves as potentially motivating loved ones to embark on exercise programmes.

A limitation of the study is that no member checking was done to explore the credibility of the findings. Various aspects of the study however contribute to the credibility of the findings. Firstly, the study was preceded by formative work in a similar group of women and the research team had insight into the lived experiences of the study participants. Although the exercise training was prescriptive and not self-selected, the mode of training was based on this formative work (6). Furthermore, extensive notes were taken by a scribe and these notes were considered during the analysis process. The current study only included participants that completed the intervention, as drop out participants were not contactable, but the aim was to describe the perceptions and experiences of those that completed the intervention.

Conclusion

The current study showed that the young Black SA women from a low socioeconomic setting that participated in a 12-week structured exercise intervention identified perceived financial gain and perceived weight loss as motivators for exercise adherence. Furthermore, adherence to an exercise training programme was identified to enhance mood, increase self-esteem, self-efficacy, and the development of skills to cope with perceived barriers. A targeted intervention approach that incorporates elements such as the presence of an exercise instructor, music and dancing in a group setting should be considered when developing public health programmes for sustainability in young women from low-income settings. Lastly, ease and cost of access to training facilities is key to increasing and/or maintaining participation adherence in similar exercise training programmes in this population and should be considered for programme sustainability. Collectively, improved self-efficacy may play an important role in supporting exercise behavior and should be a component that is assessed to ensure sustainability when implementing future exercise programmes. We are of the opinion that financial incentives are not likely to be a sustainable approach for interventions. Further research is required to address other sustainable motivators to exercise adherence such as self-selected exercise training modes and intensities, and combining diet and exercise to maximize weight loss.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study was approved by the Human Research Ethics Committee at the University of Cape Town (HREC REF: 054/2015). The patients/participants provided their written informed consent to participate in this study.

Author contributions

JG, AM, and LM conceived and designed the study and were involved in data analysis. LP analyzed the transcripts, generated codes, and collated codes into potential themes and sub-themes. AV cross-validated the coding. LP prepared figures and drafted the manuscript. AV, JG, AM, and LM read and edited the manuscript and approved the final version. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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