THE EFFECTS OF TWO MODES OF EXERCISE ON OBESITY

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This thesis is presented for the degree of Master of Science (Human Movement) of The University of Western Australia

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2007

Abstract

Purpose: The purpose of this study was to assess the efficacy of two different modes of exercise in an overweight and obese population over a 12-week period. ***Subjects:*** Forty-four overweight or obese individuals were recruited from a weight loss organisation. Participants were randomised into one of two groups which were matched according to age, gender and body mass index (BMI). The interventions consisted of either intermittent interval exercise (INT group), or intermittent steady-state exercise (SS group). Participants in both groups were on an identical strict caloric diet during the intervention period. ***Methods:*** Baseline and post-intervention testing consisted of the assessment of aerobic fitness, blood lipid profile, resting metabolism, body composition, vascular function, quality of life and activity levels. The exercise regime for the INT group consisted of a 1:2 min ratio of moderate intensity (70 – 75% $\dot{V}O_{2peak}$) to low intensity exercise (40 – 45% $\dot{V}O_{2peak}$), while the SS group exercised continuously between 50 – 55% $\dot{V}O_{2peak}$. Total work per session was the same per group. Exercise consisted of walking/jogging twice daily for 15 mins five days per week. Eighteen participants dropped out of the study leaving 12 in the INT group and 14 in the SS group. ***Results:*** Peak oxygen uptake and exercise time to exhaustion increased significantly over time in the interventions ($P < 0.001$). Significant positive changes occurred in several blood tests, including liver function, insulin like growth factor (IGF-1) and lipid levels (cholesterol, triglyceride, low density lipoprotein (LDL) and very low density lipoprotein (VLDL) and coronary risk ratio, all $P < 0.05$ over time). Additionally, uric acid and VLDL levels significantly decreased over time in the SS and INT groups, respectively ($P < 0.05$), whereas IGF-1 levels significantly increased in the SS group over time ($P < 0.05$). Body composition measures, including BMI, body mass, fat mass, percent of body fat, gynoid obesity and hip circumference, as well as waist circumference decreased significantly over time ($P < 0.05$). Several components of the SF-36 quality of life questionnaire (physical function, role physical, bodily pain, general health, vitality, social function and mental health) improved significantly over time ($P < 0.05$), while mental health also significantly improved over time in the SS group ($P < 0.01$). Finally, anxiety and depression levels were significantly reduced over time ($P < 0.05$). However, none of these changes over time significantly differed between the two groups. ***Conclusion:*** Both exercise interventions resulted in

significant improvement over time in numerous health and fitness variables in an overweight and obese population. No significant differences were found, in the interaction term during a 2-way ANOVA, between the two groups at post-intervention. A longer intervention period, or changes to interval duration and intensities may result in more significant differences between the two training methods.

Acknowledgements

Firstly, I would like to acknowledge all the work of my primary supervisor, Dr. Karen Wallman, who was the inspiration behind this thesis and without all of her effort, this would not have been possible. She provided the ideas and support needed to go the journey. I think she talked to every single person she knew, about this study, trying to better it in any way she possibly could. Her energy and passion in this area is phenomenal and I cannot put into words how much I appreciate everything she has done. It has been a pleasure working with her.

Secondly to Dr. Danny Green, his expertise and knowledge strengthened this thesis beyond my expectations. He has passed on valuable skills and knowledge and I also thank him for giving me the opportunity to use first class facilities. I would like to acknowledge the work of Dr. Andrew Maiorana, Cara Weisbrod and Louise Naylor who put in many hours of testing on top of all their other commitments. All of their contributions were greatly appreciated. Thank you to Tim Fairchild, for the ideas and concerns that Karen and I did not raise.

To SureSlim staff and in particular Dr. Robert Vial and Costa Koullapis, who jumped at the opportunity to be involved in this study. I thank them for allowing me to recruit SureSlim clients into this study. Their assistance and funding throughout this thesis has been tremendous. I hope this thesis provides their organisation, as well as numerous other organisations, with some beneficial and interesting findings.

My gratitude goes out to all the staff and students at the University of Western Australia, who had input into this thesis. I must also acknowledge the staff and students at Edith Cowan University, as this is where the journey started.

To my family, the support and advice they have given has been second to none. I appreciate everything they have done for me. They have always pointed me in the right

direction and continue to do so. They have given me every opportunity to succeed. Finally, to my friends, thanks for the good times in between.

To everyone who comes to read the following I hope it provides an interesting read and valuable knowledge in the area of exercise in the obese and overweight. Hope you enjoy…

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Glossary of Terms

Aerobic Exercise	Exercise that improves the efficiency of the aerobic energy-system and involves dynamic muscular contractions of the major muscle groups of the body.
Body Mass Index	The ratio of body weight (kilograms) to height (metres) squared; it is the most commonly adopted criterion for obesity.
Dual Energy X-ray Absorptiometry	Used to estimate body composition by employing low dose radiation X-ray in order to assess fat and lean tissue mass.
Graded Exercise Test	An exercise test in which the rate of work is increased gradually in three minute increments to the point of exhaustion.
Intermittent Exercise	Short bouts of exercise completed several times throughout the day.
Interval Training/Exercise	Refers to the method of physical conditioning in which the body is subjected to short but regular repeated periods of work interspersed with adequate periods of rest during an exercise session.
Maximal Oxygen Consumption	The highest rate of oxygen uptake reached when there is little or no further increase in oxygen uptake despite an increase in exercise intensity during a maximal test.

Obesity	An excessively high amount of body fat or adipose tissue in relation to lean body mass; an excess of body fat characterized by a BMI equal to or greater than 30.0 kg/m^2.
Overweight	Excessive body weight; an excess of body fat characterized by a BMI between 25 kg/m^2 and 29.9 kg/m^2.
Peak Oxygen Consumption	Refers to the highest value of oxygen consumption measured during an exercise period.
Steady-State Aerobic Exercise	Exercise performed continually at a moderate sub-maximal intensity.

List of Abbreviations

ALT	Aspartate Transaminase
AST	Alanine Aminotransferase
ATP-PC	Adenosine Triphosphate - Phosphocreatine
BMI	Body Mass Index
BMR	Basal Metabolic Rate
BP	Blood Pressure
bpm	Beats per minute
BSA	Body Surface Area
CHD	Coronary Heart Disease
CHO	Carbohydrates
DBP	Diastolic Blood Pressure
DEXA	Dual Energy X-ray Absorptiometry
ECG	Electrocardiography
EOC	Exercise Oxygen Consumption
EPOC	Excess Postexercise Oxygen Consumption
ES	Effect Size
ESR	Erythrocyte Sedimentation Rate
FBF	Forearm Blood Flow
FMD	Flow Mediated Dilation
GGT	Gamma Glutamyltransferase
GTN	Glycerol Trinitrate
GXT	Graded Exercise Test
HADS	Hospital Anxiety and Depression Scale
Hb	Haemoglobin
HDL	High Density Lipoprotein Cholesterol
HR	Heart Rate
HR_{max}	Maximum Heart Rate
HRR	Heart Rate Reserve
IGF	Insulin Growth Factor
Kcal	Kilocalorie
LDL	Low Density Lipoprotein Cholesterol
MAP	Mean Arterial Pressure
MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Corpuscular Haemoglobin Concentration
MCV	Mean Corpuscular Volume
MET	Basal Metabolic Unit
NO	Nitric Oxide
NS	Non-significant
ob	Obese Gene
OA-ESI	Older Adult Exercise Status Inventory
PCV	Packed Cell Volume
RCC	Red Cell Count
RCDW	Red Cell Distribution Width
REE	Resting Energy Expenditure
RER	Respiratory Exchange Ratio
RHR	Resting Heart Rate
RPE	Rate of Perceived Exertion
RPH	Royal Perth Hospital

RMR	Resting Metabolic Rate
RQ	Respiratory Quotient
SBP	Systolic Blood Pressure
SEM	Standard Error of Measurement
SD	Standard Deviation
SF-36	Short Form – 36
TEA	Thermic Effects of Activity
TEM	Thermic Effects of Meals
USA	United States of America
UWA	The University of Western Australia
VLDL	Very Low Density Lipoprotein Cholesterol
WCC	Total White Blood Cell Count
$\dot{V}CO_2$	Expired Carbon Dioxide
$\dot{V}_E$	Ventilation
$\dot{V}O_2$	Oxygen Consumption
$\dot{V}O_{2max}$	Maximal Oxygen Uptake
$\dot{V}O_{2peak}$	Peak Oxygen Uptake
$\upsilon\,\dot{V}O_{2max}$	Velocity Associated with $\dot{V}O_{2max}$
$½T_{lim}$	Half Time to Exhaustion
5 FMD	Five Minute Flow Mediated Diameter

CHAPTER 1

Introduction

1.1 Background

Obesity is fast becoming pandemic in the modern world (Chakravarthy & Booth, 2004; Davey, 2004; World Health Organization, 2000), and is the second leading cause of preventable deaths in the United States of America (USA) (McArdle, Katch & Katch, 2001). Figures from the United States National Health and Nutrition Examination Survey show that between 1999-2000, 64.5% of American adults were either overweight or obese (Flegal, Carroll, Ogden & Johnson, 2002), with the direct health care costs of this disorder being placed at a staggering $US61 billion (U.S. Department of Health and Human Services, 2001). Obesity is not just confined to the USA, with many other countries, including Australia, following closely in America's footsteps (Cameron et al., 2003; O' Brien & Webbie, 2004). According to recent figures from the Australian Bureau of Statistics, the prevalence of overweight/obesity has increased in Australian adults, affecting 62% of Australian men and 45% of Australian women. Of these people, 34% were obese (Australian Bureau of Statistics, 2006). A phenomenal increase has been reported for both genders in the 25 to 64 years age-bracket, with the proportion of obese men rising from 9 to 17%, while the number of obese women has more than doubled between 1980-2000, from 8 to 20% (Dixon & Waters, 2003). Further to this, the direct economic cost of obesity to the Australian community was estimated in 2003 to be approximately $AU1.2 billion (Bennett, Magnus & Gibson, 2004).

While a major problem in its own right, obesity is also associated with many other health issues. These include an increased risk of stroke, hypertension, myocardial infarction, type II diabetes mellitus, hyperlipidaemia and other medical co-morbidities (Crespo & Smit, 2003; Pi-Sunyer, 1993), all of which can lead to an increased risk of mortality (Grundy et al., 1999). The National Health and Medical Research Council (1997) has reported that in Australia, approximately 66% of type II diabetes, 22% of

coronary heart disease and 29% of hypertension cases can be attributed to obesity. Additionally, obese people often display vascular disease as demonstrated by endothelium dysfunction. Not only does endothelial dysfunction lead to atherosclerosis but it also results in a number of abnormalities that enhance the atherosclerotic process (Berliner et al., 1995). Consequently, many interventions have been employed in order to counteract the problem of being overweight or obese. Apart from surgery and prescription medicine, three interventions commonly used to facilitate weight loss are: diet (caloric restriction); exercise; and a combination of both diet and exercise.

To date, diet represents the most prevalent weight loss intervention, with the Consumer Advocacy and Financial Counselling Association of Victoria reporting that Australians spend approximately $AU500 million on weight loss programmes each year (World Health Organization, 2000). Yet, diet alone is an ineffective strategy for long-term management of weight loss (Astrup, 1999; McArdle et al., 2001), and weight regain after four to six months is common (Elks, 1999). Reasons for the ineffectiveness of diet, from a physiological perspective, include the loss of lean body tissue that leads to a decline in basal metabolic rate (BMR) (Mahan & Escott-Stump, 2000), as well as the proposed existence of a genetically pre-determined set-point for body mass that the body gravitates back to after periods of weight manipulation (McArdle et al., 2001). Nonetheless, diet interventions are generally successful in the short term (Astrup, 1999; Hansen, Shriver & Schoeller, 2005; Wadden, Stunkard & Brownell, 1983).

Exercise represents an important intervention for weight loss as it is capable of lowering an individual's set-point for body mass (Weigle, 1990), conserving or even increasing lean tissue mass (Wahlqvist, 1990), maintaining or even raising resting metabolic rate (RMR) (Gilliat-Wimberly, Manore, Woolf, Swan & Carroll, 2001; McArdle et al., 2001), as well as inducing metabolic changes that facilitate fat catabolism (Hill, Drougas & Peters, 1993; McArdle et al., 2001). Not only can exercise result in weight loss through increased caloric expenditure (Epstein, Coleman & Myers, 1996; Epstein & Goldfield, 1999; National Health and Medical Research Council, 1997), but exercise can result in numerous health benefits independent of weight loss that can directly reduce the risk of many of the co-morbidities noted earlier (Hansen et al., 2005; McKay, Macdonald, Reed & Khan, 2003; Miller, 2001; NIH Technology

Assessment Conference Panel, 1993; Volek, VanHeest & Forsythe, 2005). Further to this, exercise is associated with long term weight loss (Andersen, 1999; Anderson, Konz, Frederich & Wood, 2001). Of relevance however, is that while exercise interventions have been shown to result in significant weight loss (Andersen, 1999; Heyward, 1998; Ross et al., 2000), numerous researchers have reported that the combination of diet and exercise represents a superior intervention for weight loss than either therapy alone (Blair, 1993; Buemann & Tremblay, 1999; Hill et al., 1993; NIH Technology Assessment Conference Panel, 1993; Pavlou, Krey & Steffee, 1989).

Typically, the most common exercise regime used in an overweight or obese population is steady-state aerobic exercise (Garrow & Summerbell, 1995; Jacobsen, Donnelly, Snyder-Heelan & Livingston, 2003; Keim, Barbieri, Van Loan & Anderson, 1990; Murphy & Hardman, 1998). Aerobic exercise involves exercise that uses the major muscles groups of the body such as walking, jogging, swimming and cycling (American College of Sports Medicine, 1978; American College of Sports Medicine, 1990), while the term steady-state refers to exercise that is performed at a constant low to moderate intensity (McArdle et al., 2001). Of importance, is that an alternative exercise regime, known as interval exercise, may provide more benefits than steady-state aerobic exercise in an overweight or obese population. Interval exercise is a form of training that incorporates short regular periods of high intensity exercise that are interspersed with periods of either rest or lower intensity exercise (Fox, Bowers & Foss, 1993). Studies that have investigated the use of interval exercise in non-obese populations have shown that when compared to steady-state aerobic exercise, interval exercise is associated with greater improvements in cardiorespiratory capacity (King, Panton, Broeder, Browder et al., 2001; Perry, Tapp & Weeks, 1986; Sokmen, Beam, Witchey & Adams, 2002), cardiovascular capacity (Makrides, Heigenhauser & Jones, 1990), blood profiles (Perry et al., 1986), fat oxidation (King, Broeder, Browder & Panton, 2002; Perry et al., 1986), as well as greater energy expenditure (Kaminsky & Whaley, 1993).

To date only two published studies have investigated the effects of interval exercise in an obese population, with both studies focusing on the effects of exercise on excess post exercise oxygen consumption (EPOC) (Kaminsky & Whaley, 1993; King et al., 2002). However, a study by King and colleagues (2001) reported positive changes

in $\dot{V}O_{2max}$, RMR and body composition in an obese population as a result of an interval exercise regime, as compared to no improvement in the same variables after an intervention consisting of continuous aerobic exercise (King, Panton, Broeder, Browder et al., 2001).

Of additional importance is that exercise interventions in an overweight or obese population are often associated with high attrition and poor adherence rates (Hammer, Barrier, Roundy, Bradford & Fisher, 1989). This is supported by Jakicic (1995) who reported a withdrawal rate of approximately 20 to 40% for short-term exercise interventions. Reasons often cited by participants for withdrawing from an exercise intervention include lack of time (Dishman, 1990), physical pain (Sothern, 2001) and/or discomfort associated with increased perspiration (Andersen, 1999). Consequently, an exercise intervention that allows participants to perform exercise intermittently (i.e. a number of short exercise bouts performed over the course of the day) may result in greater adherence and fewer withdrawals (Jacobsen et al., 2003). Intermittent exercise has been shown to have the same overall health benefits, including the same total caloric expenditure (or even more) (Murphy & Hardman, 1998), as continuous bouts of similar intensity exercise of the same total duration (Boreham, Wallace & Nevill, 2000; DeBusk, Stenestrand, Sheehan & Haskell, 1990; Donnelly, Jacobsen, Snyder Heelan, Seip & Smith, 2000; Fulton et al., 2001; Hardman, 2001; Jakicic, Polley & Wing, 1998; Murphy & Hardman, 1998; Pate et al., 1995; Snyder, Donnelly, Jacobsen, Hertner & Jakicic, 1997; Woolf-May et al., 1998). Consequently, an intervention consisting of interval exercise performed intermittently over the course of the day, combined with caloric restriction, may represent a more effective therapy for fat loss in overweight/obese participants, as well as provide greater health benefits than other weight loss modalities commonly used to date.

1.2 Aims of the Study

The aim of this study is to compare two 12-week interventions consisting of:

1) Intermittent steady-state aerobic exercises (SS group) performed at 50-55% of $\dot{V}O_{2peak}$ and

2) Intermittent interval exercise (INT group) performed at 40-45% of $\dot{V}O_{2peak}$ for two minutes followed by 70-75% of $\dot{V}O_{2peak}$ for one minute.

Outcome measures included aerobic fitness, blood profile, resting metabolism, body composition, vascular function, quality of life and activity levels.

1.3 Hypotheses

Hypothesis 1 – Both exercise groups will experience significant improvement over the course of the intervention for the variables listed below:

1.	Aerobic fitness:	Peak oxygen uptake ($\dot{V}O_{2peak}$), time to exhaustion on a graded exercise test (GXT), blood pressure (BP), resting heart rate (RHR)
2.	Blood profile:	Full blood count, renal, liver, thyroid, general biochemistry, lipids, additional tests
3.	Resting metabolism:	Respiratory quotient (RQ), percentage of carbohydrate (CHO) and lipid oxidation, resting oxygen consumption
4.	Body composition:	Body mass index (BMI), body mass, fat mass, lean tissue, percentage of body fat, segmental fat distribution, girth measurements
5.	Vascular function:	Flow mediated dilation (FMD), glycerol trinitrate (GTN) mediated dilation
6.	Quality of life:	Short Form-36 (SF-36), Hospital Anxiety and Depression Scale (HADS)
7.	Activity levels:	Older Adult Exercise Status Inventory (OA-ESI), pedometer, accelerometer

Hypothesis 2 – Post-intervention results will show significantly greater improvement in the INT group compared to the SS group for the variables listed below:

1. Aerobic fitness: $\dot{V}O_{2peak}$, time to exhaustion on a GXT, BP and RHR
2. Blood profile: Full blood count, renal, liver, thyroid, general biochemistry, lipids, additional tests
3. Resting metabolism: RQ, percentage of carbohydrate (CHO) and lipid oxidation, resting oxygen consumption
4. Body composition: BMI, body mass, fat mass, lean tissue, percentage of body fat, segmental fat distribution, girth measurements
5. Vascular function: FMD, GTN mediated dilation
6. Quality of life: SF-36, HADS
7. Activity levels: OA-ESI, pedometer, accelerometer

1.4 Justification of the Study

It is extremely important that a safe, simple and effective weight loss intervention be developed in order to reduce the problem of obesity and its associated co-morbidities. An intervention that effectively produces weight loss will not only produce health benefits but will also reduce the substantial financial costs associated with this disorder. Benefits associated with reduced rates of obesity are noted by the Australian Institute for Health and Welfare who claim that a 20% reduction in the number of individuals classified as being either overweight or obese during 1989 – 2000 would have resulted in a saving of $AU59 million to the health care system and a gain of 2,300 years worth of life (National Health and Medical Research Council, 1997).

While combinations of exercise and caloric restriction have been shown to promote weight loss, there has been little research to date on the effects of intermittent interval exercise on weight loss. Intermittent exercise may encourage greater adherence

to an exercise regime due to its flexible nature, while interval exercise is known to improve physiological function, as well as increase caloric expenditure. Therefore a combination of intermittent interval exercise and diet may play a key role in weight loss in an obese population, as well as improve overall fitness and health.

1.5 Limitations and Delimitations

1.5.1 Limitations

1) All interventions were home based and therefore adherence to exercise depended on each participant's motivation levels.

2) It was assumed that participants were constantly monitoring their food intake according to the guidelines set out for them. The importance of regulating food intake was regularly stressed.

3) The present study was based on participants self-reporting their exercise and it is therefore possible that some over-estimation or under-estimation may have occurred. To try and minimise this limitation, participants were informed of the importance of recording their exercise accurately.

4) Not all participants completed all testing stages and therefore some variables have missing data.

5) Even though pedometers have been reported to be accurate and reliable at reporting steps taken, the pedometer is unable to record non-bipedal activities, and therefore only activities measuring steps are collected. Additionally, the pedometer does not differentiate between the intensity of the steps taken (McCormack, Milligan, Giles-Corti & Clarkson, 2003).

6) The pedometer may also underestimate step counts at very slow walking speeds, however this has not been found to seriously affect its usefulness in assessing steps taken in the majority of adults (Swartz, Bassett, Moore, Thompson & Strath, 2003).

7) Several measurements have a degree of inter-rater variability. In order to avoid differences caused by different testers, efforts were made to keep the same tester measuring the same variables for both the pre-test and the post-test.

8) Changes in estrogen levels can affect RMR and therefore all testing was completed in the luteal phase of menstruation.

1.5.2 Delimitations

1) Participant numbers were restricted to a maximum of 15 participants per group.

2) The age of participants ranged between 18 and 65 years.

3) This study recruited both male and female participants. Both genders were included in this study in order to recruit the required number of participants within the time frame of this Masters research.

4) Participants who began taking any new medications during the course of this study were excluded if these medications affected certain physiological variables.

5) Non-medicated hypertensive patients were excluded from the study.

6) Hypercholesterolaemic participants were included into the study.

7) Female participants who became pregnant during the study were excluded.

8) Post-menopausal females were included into the study.

9) The exercise modality used in this study was walking/jogging only.

10) The intervention duration was 12-weeks.

1.6 Sample Size

A sample size calculation based on the study by King and colleagues (2001) revealed that 34 participants (17 per group) needed to be recruited to this study in order to detect changes that were occurring in the variables at an alpha level of 0.05. However, King and colleagues (2001) used non-dieting, pre-menopausal obese women who only participated in exercise three times per week for eight weeks. Consequently, using the variable of aerobic fitness in order to determine a time effect, as well as factoring in the differences from the King study, the sample size for this present study was revised and it was decided to target the recruitment of 26 participants (13 per group).

CHAPTER 2

Literature Review

2.1 Introduction

This chapter will provide a basic overview of current knowledge pertaining to the assessment of obesity, the aetiology of obesity, as well as the various prevention strategies used in management of this disorder. Additionally, this chapter will review the use of exercise in obesity, with particular emphasis on the efficacy of aerobic exercise and interval training in producing health benefits and weight loss in both normal and overweight populations.

2.2 Background

Obesity is rapidly developing into a worldwide crisis due to its increasing incidence, combined with the fact that it is associated with numerous co-morbidities that result in shortened life expectancy, reduced quality of life and significant health care costs (McKay et al., 2003). Obesity is simply defined as the excessive accumulation of body fat (Heyward, 1998; Proietto & Baur, 2004; U.S. Department of Health and Human Services, 1996) and is a common end-point of a combination of disturbances including genetic, enzymatic, hormonal, neurological and environmental factors, which determine, or may modify, the pattern of body mass regulation (Fox, 1974).

2.3 Measuring Obesity

A commonly used measure of obesity involves the use of a formula known as BMI (Bar-Or, 2003; McArdle et al., 2001; National Health and Medical Research Council, 1997; World Health Organization, 2000), which is determined by dividing an individual's height squared (m^2) into their body weight (kg). A BMI between 25 - 29.9 kg/m^2 defines an individual as being overweight, while a BMI of 30 kg/m^2 or higher defines an individual as obese (World Health Organization, 2000). An individual with a

BMI over 30 kg/m^2 is considered to have exceeded their ideal body weight by at least 20% (Paracchini, Pedotti & Taiolo, 2005). Additionally, Gaesser (2004) reported that men and women with a BMI between 30 - 35 kg/m^2 had a 50% increased chance of early mortality than men and women with a BMI between 23 - 25 kg/m^2. Desirable BMI scores, for European-caucasian descent individuals, range between 21.3 - 22.1 kg/m^2 and 21.9 – 22.4 kg/m^2 for women and men, respectively (McArdle, Katch & Katch, 1996). Although BMI is easy to assess, inexpensive and produces reproducible measures (Owens, 2005), it does not differentiate between fat and muscle mass and may therefore incorrectly categorise an individual who has a large muscle mass as being either obese or overweight (Bar-Or, 2003; McArdle et al., 2001; National Health And Medical Research Council, 2003; World Health Organization, 2000). A preferable approach to use when defining obesity is to assess an individual's body composition. Body composition refers to the relative percentage of fat and lean tissue mass that comprises an individual's body mass (American College of Sports Medicine, 2000). According to Wilmore and Costill (1999), a body fat measurement that is equal to or greater than 25% for males and 32% for females classifies these individuals as being obese, while Heyward (1998) notes that these fat percentages place individuals in a high risk category for certain diseases.

An important consideration relating to body composition is that the severity of health risk in overweight or obese individuals is dependent on where the adipose tissue is distributed in the body (Diskell, 2000; Heyward, 1998; Katzmarzyk, Perusse, Malina & Bouchard, 1999). There are two types of typical fat distributions in the obese, these being android-type obesity, where fat is located in the abdominal region; and gynoid-type obesity, where fat is located in the gluteal and femoral areas (Diskell, 2000; Heyward, 1998; Katzmarzyk et al., 1999). According to He and colleagues (2004), females tend to store fat in the lower body regions (gynoid-type obesity), while males tend to store fat in the upper regions of the body (android-type obesity). This is due to women possessing a greater number of subcutaneous fat cells, whereas males tend to have a greater number of intra-abdominal fat cells (Krotkiewski, Sjostrom, Bjorntorp & Smith, 1975). Android-type obesity has been shown to be a greater health risk than gynoid-type obesity, particularly for heart disease and metabolic abnormalities (Kissebah & Krakower, 1994; Weigle, 1990). A possible reason for this increased health risk is that android obesity has been associated with increased levels of

plasminogen, which can inhibit the conversion of fibrin from fibrinogen, which in turn can cause an antifibrinolytic procoagulant state. Android obesity is also associated with metabolic and circulatory changes, favouring insulin resistance and increased lipoprotein synthesis. This change in lipoproteins increases levels of oxidative stress in the body, which in turn increases cardiovascular risk (Serrano Rios, 1998). While android-type obesity is caused by environmental, genetic and neuroendocrine mechanisms, the anatomical location of this fat, as well as the α/β-adrenoceptor sensitivity, suggest that free fatty acid flux from this tissue may play a major role in suppressing hepatic insulin clearance and creating peripheral insulin resistance (Kissebah & Krakower, 1994), further worsening the individual's health. However, even modest weight loss can reverse these changes (Serrano Rios, 1998).

One quick and non-invasive method for assessing body composition is dual energy X-ray absorptiometry (DEXA). Dual energy X-ray absorptiometry is widely used in clinical and research settings and employs low dose radiation X-ray in order to assess fat and lean tissue mass, leading to greater precision and accuracy in estimating body composition (Mazess, Barden, Bisek & Hanson, 1990; Pollock, Garzarella & Graves, 1995). Dual energy X-ray absorptiometry has been shown to be reliable in numerous studies (Ellis, Shypailo, Pratt & Pond, 1994; Formica et al., 1993; Panotopoulos, Ruiz, Guy-Grand & Basdevant, 2001; Roubenoff, Kehayias, Dawson-Hughes & Heysmsfield, 1993; Van Pelt, Evans, Schechtman, Ehsani & Kohrt, 2002), with its biggest advantage being its ability to accurately assess regional body fat distribution (Lohman & Milliken, 2003). Nevertheless, a limitation associated with employing DEXA in an obese population is that increased tissue thickness may result in the overestimation of body fat (Panotopoulos et al., 2001). Manufactures have therefore made an effort to correct this limitation by using calibration phantoms, with recent reports finding measurements unaffected by anteroposterior body thickness (Heyward & Wagner, 2004). Even when considering this possible limitation, DEXA is still accepted as the gold standard measure for assessing body composition (Bosello & Zamboni, 2000; Field et al., 2003; Lobstein, Baur & Uauy, 2004; Warner, Evans, Webb & Gregory, 2004).

2.4 Aetiology

Causes of obesity are multifactorial (Bar-Or, 1995; Dietz & Gortmaker, 1985; Fontaine & Bartlett, 1999; Goran, Reynolds & Lindquist, 1999; National Health and Medical Research Council, 1997; NIH Technology Assessment Conference Panel, 1993; Saltzman & Roubenoff, 1999; World Health Organization, 2000) and include genetic, social, economic, cultural and environmental factors (Dixon & Waters, 2003; National Health And Medical Research Council, 2003; U.S. Department of Health and Human Services, 2001). Additionally, various medical conditions such as Prader-Willi syndrome and tumours can contribute to obesity, while certain emotional states can also result in overeating (Steinbeck, 1999).

Strong evidence in support of a significant hereditary component to obesity has been demonstrated in twin/adoptee studies that have reported a 30 - 70% genetic contribution (Elks, 1999; Steinbeck, 1999; Stunkard, Harris, Pedersen & McClearn, 1990). This relationship is supported by studies that have reported similar BMI values between adoptees and their biological parents (Price, Cadoret, Stunkard & Troughton, 1987; Sorensen, Holst & Stunkard, 1998; Stunkard et al., 1986), as well as between adoptees and their biological siblings (Sorensen et al., 1998; Sorensen, Price, Stunkard & Schulsinger, 1989).

A particular genetic predisposition may explain individual susceptibility (Mustajoki, 1999; Proietto & Baur, 2004), as well as the concept of a 'set-point'. According to various researchers, individuals have a set-point governed by the hypothalamus that regulates body mass (Elks, 1999; Weigle, 1990). It is proposed that this particular body mass is the one that an individual returns to when dietary modifications are discontinued (McArdle et al., 2001). Additionally, the interaction of several genes play a vital role in obesity as specific genes are proposed to encode for several proteins that are involved in regulating food intake (Clement, Boutin & Froguel, 2002). According to Gutin et al. (1999) a gene called obese (or *ob*) activates a hormone-like protein called leptin. Leptin is transported via the blood-stream to a section of the hypothalamus that controls appetite (McArdle et al., 2001). Leptin is synthesised in quantities proportional to fat stores (Ahima & Flier, 2000), with increased quantities proposed to blunt the urge to eat, resulting in reduced caloric intake

(Kristensen et al., 1998). This particular mechanism lends further support to the theory of a genetic set-point for body mass, with differing quantities of leptin triggering a hypothalamic response that varies between individuals. It has been proposed that a defective *ob* gene may result in inadequate quantities of leptin being produced which, in turn, results in overeating (Strobel, Issad, Camoin, Ozata & Strosberg, 1998). Alternatively, people suffering from obesity may have high levels of leptin in their body, but lack a concomitant central regulatory response (National Health And Medical Research Council, 2003).

A broader conceptual aspect of the role of genes in obesity relates to the belief that, as a result of our evolutionary history as hunter gatherers, the human genome is designed to store fat in order to increase the chances of survival during times of food scarcity. This theory is referred to as the 'thrifty genotype hypothesis' (Neel, 1962) and has plausibility in that it has only been in recent times that an abundance of food has existed in the western world (Ravussin & Kozak, 2004), explaining the contemporary increase in the prevalence of obesity. However, while the thrifty gene hypothesis may play a role in determining individual body mass, the human genome has not changed significantly in recent decades, and this hypothesis cannot entirely explain the rapid increase in the prevalence of obesity during recent times (Kazaks & Stern, 2004).

2.4.1 Role of Inactivity/Sedentary Behaviours

Numerous researchers have proposed that the increasing incidence in obesity is associated with changing lifestyles (Booth, Gordon, Carlson & Hamilton, 2000; Eaton et al., 2002; National Health and Medical Research Council, 1997), that typically involve a caloric intake that exceeds energy expenditure (Diskell, 2000; Elks, 1999; LaMonte, Ainsworth & Tudor-Locke, 2003). Chronic caloric imbalance is most likely a result of virtually unlimited access to palatable, high-fat caloric-dense food (Davey, 2004; Dixon & Waters, 2003; Goran et al., 1999; Hill et al., 1993; Mann, 1974; Mustajoki, 1999), as well as recent advances in technology that have led to more labour-saving devices and consequently a more sedentary lifestyle (Booth et al., 2000; Mann, 1974; Mustajoki, 1999). Increased time spent watching television and playing computer and video games, particularly by children, have also been identified as factors that have contributed to this sedentary lifestyle (Bar-Or, 1995; Cameron et al., 2003; National

Health and Medical Research Council, 1997; Saltzman & Roubenoff, 1999). Sedentary behaviour has also been shown by Steinbeck (1999) to increase snacking behaviour and consequently caloric intake, while research by Dietz and Gortmaker (1985) suggests that a person's risk of becoming obese increases by two percent for every hour spent watching television per week. This research is further supported by Hu, Li, Colditz, Willett and Manson (2003), who reported that a two-hour increase in television viewing per day resulted in a 23 per cent increase in weight gain in 50,277 healthy, non-obese women. This is of concern, as the Australian Bureau of Statistics reported that in 1997, Australians spent approximately 36% of their free time watching television (Australian Bureau of Statistics, 1998). Further to this, the Australian Bureau of Statistics (2002) has reported that in 2001, approximately 31% of Australians aged 15 and over were either not participating in exercise or were only participating at low levels.

Another factor that can play a role in obesity relates to metabolism. Metabolism determines an individual's overall energy expenditure and is comprised of three components, these being: RMR, thermic effect of a meal (TEM) and thermic effect of activity (TEA) (McArdle et al., 2001). A sedentary lifestyle results in a lower TEA and is also proposed to reduce RMR (Gilliat-Wimberly et al., 2001). Additionally, researchers have reported that RMR typically falls when an obese person loses weight through calorie restriction, due to losses in lean tissue mass (Jakicic, 2002; Ravussin et al., 1988). This is important, as RMR is estimated to account for 60 - 75% of an individual's total daily energy expenditure (Danforth, 1981; McArdle et al., 2001). Conversely, researchers have reported that RMR can be increased through medication, diet and/or exercise (Heyward, 1998; Rees & Jacobson, 1994). Consequently, participation by obese subjects in aerobic exercise may counteract any fall in RMR associated with weight/muscle loss.

2.5 Fat Storage in Obesity: the link between obesity, insulin resistance and type II diabetes

The bodies' main sources of energy are CHO and fat (Mann, 1974). Compared to their lean counterparts, obese people typically eat more food than their body oxidises, with excess macronutrients converted to triglycerides and stored in adipose tissue (lipogenesis) (McArdle et al., 2001). It has been reported that insulin sensitivity is

affected differently by different fat depots, with intra-abdominal fat having a greater impact than peripheral fat in normal and overweight individuals (Carey, Jenkins, Campbell, Freund & Chisholm, 1996; Raji, Seely, Arky & Simonson, 2001). Further, there is some controversy as to which compartments of fat are metabolically important and associated with insulin resistance. The reasons for this may be attributed in part to variations in race, gender and degree of obesity or that there is a close correlation amongst all the different adipose tissue compartments (Raji et al., 2001). Insulin resistance often accompanies obesity, however normoglycaemia can be maintained by the pancreatic B-cells hypersecretion of insulin (Zraika, Dulop, Proietto & Andrikopoulos, 2002). This process promotes lipogenesis, inhibits lipolysis and increases lipoprotein lipase activity in adipose tissue (Kahn & Flier, 2000; Semenkovich, Wims, Noes, Etienne & Chan, 1989), which aggravates the obese state. Triglycerides are broken down into fatty acids and glyceride, which worsens insulin resistance (Zraika et al., 2002). Overall this process, combined with excess intake of fats, creates a greater amount of fat storage in the body. Additionally, a high CHO intake results in an increase in the concentration of circulating insulin, which in turn increases the rate at which circulating glucose enters adipose tissue (Zierler, 1969). This process can lead to the "metabolic syndrome", a multifaceted syndrome characterized by excessive body mass, insulin resistance, glucose intolerance, dyslipidemia, and elevated BP (Lakka et al., 2003). A major site of insulin resistance is skeletal muscle, with an increased amount of muscle mass being linked to improved glycaemic control. Consequently, exercise, which can increase muscle mass, has a role to play in increasing insulin sensitivity (Perez-Martin, Raynaud & Marcier, 2001). This is supported by Jurca and colleagues (2005) who reported an inverse relationship between muscular strength and metabolic syndrome in 3,233 men.

The number of adipose cells an individual has located in their body may also influence the chances of developing obesity, as researchers have shown that people who were grossly obese in their childhood possessed a higher number of fat cells than their lean counterparts (Bray, Davidson & Drenick, 1972; Faust, Johnson, Stern & Hirsch, 1978).

2.6 Interventions for Obesity

A number of interventions are available for the treatment of obesity. Surgery, such as gastric banding, banded gastroplasty and modern laparoscopic banding can be used for morbidly obese individuals who are unable to lose weight through traditional means (Bray, 1985; Caterson, 1999; Uusitupa, 1999). However, these methods can have negative consequences. It is estimated that 30% of people who undergo surgery will experience problems including vomiting, stomal narrowing, pulmonary emboli, as well as other major post-operative complications (Caterson, 1999). Apart from these health risks, surgery is an expensive procedure, making this type of intervention a non-feasible option for many obese individuals (Elks, 1999). Consequently, other types of interventions are employed for weight loss, with these predominantly aimed at changing an obese individual's caloric balance from a positive to a negative one (Elks, 1999). This process involves lifestyle changes associated with a reduced caloric intake and/or increased levels of physical activity (Bray, 1985; Elks, 1999).

2.6.1 Diet and Weight Loss

Macronutrient manipulation can significantly influence energy intake and is therefore a potentially important factor in maintaining either a neutral or negative energy balance over a prolonged period of time (Dyck, 2000). According to Riebe and colleagues (2005), 47% of men and 75% of women in the United States have reported a history of dieting in order to lose weight at some point in their life. Of these percentages, 6% of men and 31% of women reported having participated in formal weight loss programmes, while 13% of men and 26% of women reported that they were currently dieting to lose weight (Riebe et al., 2005). According to Gaesser (2004), the prevalence of dieting has increased considerably in the past four decades.

One type of diet used for weight loss is the very low caloric diet, which restricts caloric intake to only 800 kcal per day (NIH Technology Assessment Conference Panel, 1993). One study that assessed the efficacy of this diet in obese subjects, reported an average individual weight loss of between 1.0 - 2.0 kg and 1.5 - 2.5 kg per week for both women and men, respectively (Wadden et al., 1983). A further study by Foster et al. (1992), that involved a liquid formula diet of 800 kcal per day, reported an average individual weight loss of 16.6 ± 0.7 kg in 24 female subjects over a 12-week period. However, while a very low caloric diet is associated with large weight losses, one

problem associated with this form of diet is that it requires constant physician supervision, and therefore should only be administered to the morbidly obese (NIH Technology Assessment Conference Panel, 1993).

Consequently, a more practical diet is the moderate caloric restriction diet, which restricts caloric intake to approximately 1200 kcal per day for women and 1500 kcal per day for men (Wadden, 1993). However, weight loss results for this type of diet have been equivocal. One study by Flechtner-Mors, Ditschuneit, Johnson, Suchard and Adler (2000) required 50 obese subjects to ingest between 1200 – 1500 kcal per day, and reported an average individual weight loss of only 1.5 ± 0.4 kg over a 12-week period. This minimal weight loss was surprising given the low caloric intake, and may reflect non-adherence by subjects to their diet, combined with low levels of involvement in physical activity. In contrast, another study by Dessein, Shipton, Stanwix, Joffe and Ramokgadi (2000) reported an average individual weight loss of 7.7 ± 5.4 kg over a 16-week period in 13 obese males, when caloric intake was restricted to 1600 kcal per day. According to Astrup (1999) low energy diets can produce a five percent weight loss in most, if not all, participants. However, the amount of weight lost will vary depending on physiological differences, such as metabolic rate, hormonal activity, sympathetic activity, age and gender, while behavioural differences, such as ability to adhere to a diet, will also play a role (Astrup, 1999). Of further interest is that moderate caloric restricted diets have been shown to be just as effective as very low caloric diets in producing weight loss after 12-months of dieting (Heber, Ashley, Wang & Elashoff, 1994; Mahan & Escott-Stump, 2000). An overview of the results of various diet interventions used in an obese population can be found in Table 2.1.

Of importance, while dietary modification can have a dramatic impact on weight loss in the short-term (Hansen et al., 2005), dietary interventions have been reported to be ineffective strategies for long-term management of weight loss (Astrup, 1999; McArdle et al., 2001), as weight is often regained once dietary restriction has ceased (Elks, 1999). In fact, 90 – 95% of dieters have been reported to regain weight after ending their diet programme (Rosenbaum, Leibel & Hirsch, 1997; Wadden, 1993), with 62% of dieters reported to regain all of their initial body weight (Schonfield-Warden & Warden, 1997). Reasons for the ineffectiveness of diet are varied and include the loss of lean body tissue, leading to a decline in RMR, as the body becomes more energy

efficient and requires a lower energy intake in order to maintain the lower body weight (Mahan & Escott-Stump, 2000). Low caloric diets have been found to result in an immediate 20 – 30% reduction in RMR as the body attempts to conserve its energy (Byrne & Wilmore, 2001). Additionally, low caloric restriction diets are difficult to sustain over long periods of time (Hill et al., 1993), while as noted earlier, an individual's body mass may return to a genetically determined set-point once caloric restriction ceases (Weigle, 1990). Nonetheless, if a diet is combined with an exercise programme, then this may result in the preservation of lean tissue mass, which may negate a decline in RMR and consequently assist in long-term weight management.

Table 2-1: Results of studies that employed diet only as an intervention in an obese population.
Where only a P value is expressed, no specific data on change was available.

STUDY	SUBJECT DATA	STUDY DESIGN	DIETARY INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Foster et al., 1992)	76 obese women	6-months Diet with addition of some exercise during study	Liquid-formula diets Group 1: 420kcal/d (n = 21) Group 2: 660kcal/d (n = 23) Group 3: 800kcal/d (n = 24)	Weight Body composition Acceptability Symptoms Mood	No significant differences in any variables btwn the three groups
(Flechtner-Mors et al., 2000)	100 overweight/obese men and women	12-weeks Diet	Group 1: 1200-1500kcal/d diet Group 2: isoenergetic diet	Weight BP Blood lipids	↓ Weight Δ -1.3kg ($P < 0.01$) ↓ Systolic BP Δ -9mmHg ($P < 0.01$) ↓ Plasma triglycerides Δ -0.48($P < 0.01$) ↓ Insulin Δ -47.1pM ($P < 0.01$) for Group 2 only
(Dessein et al., 2000)	13 obese males with acute gout	16-weeks Diet	Group 1: 1600kcal/d diet	Weight Gout attacks Blood lipids	↓ Weight Δ -7.7kg ($P = 0.002$) ↓ BMI Δ -2.7kg/m^2 ($P = 0.002$) ↓ Attacks Δ -1.5 per month ($P = 0.002$) ↓ Uric acid Δ -0.10mmol/L ($P = 0.001$) ↓ Total cholesterol Δ-1.3mmol/L ($P = 0.002$) ↓ LDL Δ -0.8mmol/L ($P = 0.004$) ↓ C:HDL ratio Δ -1.5 ($P = 0.002$) ↓ Triglycerides Δ -2.8mmol/L ($P = 0.001$)

2.6.2 Aerobic Exercise and Weight Loss

A strong relationship exists between physical inactivity and increased body weight (Jakicic, 2002). Consequently, physical activity, in particular aerobic exercise, which involves the activation of the body's major muscle groups in activities such as walking, jogging, swimming and cycling (American College of Sports Medicine, 1990), is now considered to be a major cornerstone in the treatment and prevention of obesity (Pate et al., 1995). Aerobic exercise can play a major role in weight loss due to its ability to increase caloric expenditure (Epstein et al., 1996; Epstein & Goldfield, 1999; National Health and Medical Research Council, 1997). Further to this, aerobic exercise can improve the efficiency of the cardio-respiratory system, which can consequently alleviate numerous co-morbidities associated with obesity, such as cardiovascular disease (Wei et al., 1999; Wilmore & Costill, 1999). In particular, aerobic exercise has been reported to reduce the risk of cardiovascular risk, mainly due to its ability to improve vascular function in healthy adults (Green, Cable, Fox, Rankin & Taylor, 1994; Green, Fowler, O'Driscoll, Blanksby & Taylor, 1996; Green, O'Driscoll, Blanksby & Taylor, 1997), as well as in cardiovascular disease patients (Maiorana et al., 2001; Maiorana et al., 2000; Walsh, Swangard, Davis & McPhee, 1999), and in the obese (Watts, Beye, Siafarikas, O'Driscoll et al., 2004).

An early marker of cardiovascular disease is endothelium dysfunction (Celermajer et al., 1992; Mullen, Thorne, Deanfield & Jones, 1997). Endothelium dysfunction may represent the primary vascular wall abnormality that initiates the atherosclerotic process (Mullen et al., 1997; Vita & Keaney, 2002). Atherosclerosis is a chronic inflammatory condition that occurs when LDLs are oxidised and modified, causing a loss of recognition by the LDL receptors with cellular uptake resulting in cholesterol accumulation (Berliner et al., 1995). Brachial artery ultrasound imaging is used to assess endothelium-dependent and -independent conduit vessel function in response to flow mediated dilation (FMD) and glycerol trinitrate (GTN) administration. Explanation of the technique and analysis of brachial artery ultrasound can be found in Woodman et al. (2001).

Other benefits associated with aerobic exercise include management of lean body mass (which was noted earlier to play a role in altering RMR) (Wahlqvist, 1990),

appetite control (Allen & Quigley, 1977; Wahlqvist, 1990), longer life expectancy, enhanced wellbeing, and higher self esteem (Wahlqvist, 1990). Further to this, Buemann and Tremblay (1999) note that aerobic exercise can result in increased insulin sensitivity, reduced low density lipoproteins, as well as improvements in the blood lipid profile, lipoprotein metabolism and glycaemic control. These benefits are demonstrated in a study by Brown (1997), that reported an improvement in insulin sensitivity, as well as in fasting and glucose stimulated plasma insulin levels by 58, 20 and 25% respectively, in obese, hypertensive women after only seven days of aerobic exercise that consisted of walking and cycling for a total of 60 minutes each day. Therefore previous studies have found blood profiles to be a relevant outcome measure, hence this present study will examine the effects of the interventions on numerous blood variables, with further discussion on the variables with greater importance such as lipid levels.

Even if weight loss does not occur, moderate intensity exercise has been shown to cause significant reductions in total fat, visceral fat and skeletal muscle lipid content in middle aged obese men (Lee et al., 2005) and adolescents (Watts, Beye, Siafarikas, Davis et al., 2004; Watts, Jones, Davis & Green, 2005). This finding has important health implications, since significant health risks are associated with abdominal obesity (Van Pelt et al., 2002). Additionally, aerobic exercise has also been shown to maintain BMI, as well as reduce coronary artery disease. This was demonstrated by Niebauer and colleagues (1997), who conducted a six year intervention study on 113 patients suffering from varying levels of coronary heart disease. Participants were randomised into either a control group or an exercise group. The exercise group performed 30 minutes of home-based cycling every day, as well as participated in a 60 minute group exercise session twice a week. Participants in both groups also had their diet monitored. Results for the intervention group showed significant improvement in blood lipids, as well as maintenance of BMI over the six year period. The intervention group also experienced slower progression of coronary artery stenosis and it was concluded that the beneficial angiographic changes were due to the effects of exercise rather than diet (Niebauer et al., 1997).

The optimal volume of exercise, to attain health benefits and reduce the risk of cardiovascular disease in different populations, is unclear (Kraus et al., 2002). In relation to aerobic exercise prescription, the American College of Sports Medicine

(2000) recommend that a non-athletic population participate in low to moderate intensity exercise on at least three to five days per week. A key factor in exercise prescription is duration, which should be between 20 - 60 minutes and performed at an intensity between 55 – 90% of individual HR_{max} (HR_{max} = 220-age) (American College of Sports Medicine, 2000). Other studies have supported this quantity of exercise, stating that the minimal duration of physical activity needed to improve health is 150 minutes per week (Pate et al., 1995; U.S. Department of Health and Human Services, 2001). According to Volek (2005), this amount of exercise will effectively reduce the risks of health-related problems, such as diabetes or cardiovascular disease. However, for those individuals with a low fitness level, an intensity of 40 - 50 percent of individual HR_{max} is considered adequate for a training effect (American College of Sports Medicine, 1990). This intensity may also be appropriate for other populations, with Gaesser and Rich (1984) reporting that seventeen young healthy males improved their aerobic fitness by exercising at only 45 percent of $\dot{V}O_{2\ max}$ for 50 minutes on three days of the week over an 18-week period. Of importance, is that aerobic exercise can be performed by most individuals regardless of their weight or fitness level, with walking being reported to be the recommended mode of exercise for obese participants wishing to lose weight (Gwinup, 1975). An overview of studies that assessed the efficacy of exercise on weight loss can be found in Table 2.2.

Of further importance, is that aerobic exercise can be performed either continuously or intermittently. Continuous exercise involves 'steady-paced, prolonged exercise' (McArdle et al., 2001, p.489) completed in one long bout, whereas intermittent exercise involves short bouts of exercise completed several times throughout the day (Fulton et al., 2001). According to Pate et al. (1995), the majority of the general public believe exercise must be completed in one long single bout of moderate to high intensity exercise and consequently this may be one reason for the lack of participation in physical activity. However, numerous studies have shown that health benefits and caloric burning are cumulative and that the total time spent performing intermittent exercise in one day equates to the same benefits gained from a single continuous exercise bout of the same total time (Boreham et al., 2000; DeBusk et al., 1990; Donnelly et al., 2000; Fulton et al., 2001; Hardman, 2001; Jakicic et al., 1998; Murphy & Hardman, 1998; Pate et al., 1995; Snyder et al., 1997). Some studies have found even greater health benefits associated with intermittent exercise compared to

continuous exercise, as exemplified by higher levels of exercise participation and greater weight loss (Jakicic & Wing, 1997; Jakicic et al., 1995). In response to some of these findings, exercise guidelines proposed by the American College of Sports Medicine (2000) now suggest the use of either intermittent and/or continuous aerobic exercise. Of concern is that only 12% of physicians are reported to be aware of these guidelines (Walsh et al., 1999).

Table 2-2: Results of studies that employed exercise only as an intervention.
Where only a P value is expressed, no specific data on change was available.

STUDY	SUBJECT DATA	STUDY DESIGN	EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Watts, Beye, Siafarikas, Davis et al., 2004)	19 obese adolescents (9 male and 10 female) 20 lean adolescents (9 male and 11 female)	Cross-over design 8-weeks training and non-training	3 x 60 mins circuit training exercise (aerobic 65-85%HR_{max} + resistance 55-70% max strength)	Body composition Vascular function Strength Fitness Lipids BP	↑ Muscular strength ($P < 0.01$) ↓ Body fat in trunk (-0.7kg; $P < 0.05$) ↓ Body fat in abdomen (-0.6kg; $P < 0.05$) ↓ HR response ($P < 0.05$) ↑ Brachial artery FMD after training ($P < 0.05$)
(Paffenbarger et al., 1993)	10,269 men	Questionnaire	Self-assigned	Physical activity Smoking specific Diseases Body size Parental disease Death	↓ risk of death (23%) with moderately vigorous exercise ($P = 0.015$) ↓ risk of death (41%) with ceasing smoking in smokers ($P = 0.001$) ↓ risk of death in recently diagnosed hypertension than those with long-term hypertension ($P = 0.057$) ↓ risk of death in consistently normal BP ($P < 0.001$) ↓ risk of death in lean compared with obese

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STUDY	SUBJECT DATA	STUDY DESIGN	EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Brown et al., 1997)	12 obese hypertensive African American women	7 continuous days of exercise only	Exercise = 10 min warm-up 30 mins treadmill walking 5 min rest 20 mins treadmill walking or cycle ergometry (65%HRR)	Weight Blood lipids Body composition $\dot{V}O_{2max}$	↓ fasting insulin (72±9 to 50±9; P = 0.05) ↓ acute insulin response to glucose (21%; P = 0.05) ↑ 24hr urinary sodium secretion (137±7 to 100±13; P = 0.03) ↓ fasting plasma norepinephrine (26%; P = 0.02)
(Lee et al., 2005)	24 males (8 lean, 8 obese without type II diabetes, 8 obese with type II diabetes)	13-weeks	Exercise = 1x60 mins, 5 d/wk, 60% $\dot{V}O_{2peak}$	Fitness Anthropometric Body composition	↓ waist circumference (P < 0.01) ↑ thigh circumference (P < 0.01) ↑ muscle area (P < 0.01) ↑ mean muscle attenuation (P < 0.01) ↑ total skeletal muscle (P < 0.01) ↓ total fat (P < 0.01) ↓ total abdominal fat (P < 0.01) in all groups
(Watts et al., 2006)	26 obese adolescents (15 male and 11 female)	8-weeks	3 x 60mins circuit training exercise (aerobic 65-85%HR_{max} + resistance 55-70% max strength)	Weight Skinfolds Body composition	↓ abdominal fat by (416.9g; P < 0.05) ↓ waist girth by (2.5cm; P < 0.05)

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STUDY	SUBJECT DATA	STUDY DESIGN	EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Gaesser & Rich, 1984)	16 non-obese young males	18-weeks Randomised	Group A: High intensity (n = 7; 80-85% $\dot{V}O_{2max}$, 25 mins) Group B: Low intensity (n = 9; 45% $\dot{V}O_{2max}$, 50mins) Exercise= cycle ergometer, 3d/wk	Weight Body composition Blood lipids Fitness	↑ $\dot{V}O_{2max}$ in Group A (18.7%) and Group B (15.1%) compared to baseline ($P < 0.05$) ↓ %BF in Group A and Group B (1.3-1.4kg) compared to baseline ($P < 0.05$) Correlation in HDL btwn baseline and post-training (-0.57; $P < 0.05$)
(Manson et al., 2002)	73743 postmenopausal women	5.9 years follow-up Questionnaire	Personal/family questionnaire Physical activity questionnaire	Total exercise Mortality Illness	↓ risk of CVD with ↑ total METS scores ($P < 0.001$) ↓ risk of CVD with ↑ categories of walking ($P = 0.004$) ↓ risk of CVD with ↑ vigorous exercise ($P = 0.008$)
(Yu, Yarnell, Sweetnam & Murray, 2003)	2512 middle aged British men	5 years follow-up questionnaire	Leisure Time Physical Activity Questionnaire	All causes mortality CVD mortality CHD mortality Total exercise	↓ risk of CVD with ↑ total activity tertile ($P = 0.028$) ↓ risk of all causes with ↑ total activity tertile ($P = 0.046$) ↓ risk of CHD with ↑ total activity tertile ($P = 0.025$)
(Wannamethee, Shaper & Walker, 1998)	7735 British men	12-14 years follow-up questionnaire	Questionnaire on disease, mortality and physical activity	Physical activity Pre-existing diseases	↓ risk of CHD and non-CV morality with exercise ↑ risk of CHD and non-CV morality in non-activity/occasionally active ↓ risk of CHD and non-CV morality in previously sedentary

2.6.2.1 Continuous Aerobic Exercise and Weight Loss

Many studies have investigated the effects of continuous aerobic exercise without dietary restriction on weight loss and have reported varying results. A study by Murphy and Hardman (1998) reported that 12 sedentary women lost an average of only 0.9 ± 2.0 kg each after 30 minutes of walking, at 70 – 80% of HR_{max}, performed five days per week over a ten-week period. This modest amount of weight loss was not significant when compared to a control group, suggesting that a ten-week intervention may not have been long enough to produce significant weight loss. However, other variables did improve, such as $\dot{V}O_{2max}$. Another study by Jacobsen, Donnelly, Synder-Heelan and Livingston (2003) used a longer intervention period and also reported minimal weight loss. This study required 26 sedentary, moderately obese females (BMI = 32.36 ± 4.63) to walk for 30 minutes at 60 – 75% of their heart rate reserve (HRR) three times per week. After 16-months the investigators reported a minimal average body weight change of 0.47 kg (80.17 ± 5.75 to 79.70 ± 5.40 kg). An explanation for this poor result may be due to the low weekly exercise frequency, and the fact that diet was not restricted in these individuals. Additionally, this study, like many others, assessed weight loss as opposed to changes in body composition, and was consequently unable to differentiate between possible fat loss and muscle gain (Watts et al., 2005). A study that assessed body composition using DEXA investigated 21 overweight men who undertook aerobic exercise for 30 minutes on at least three days per week over a 12-month period. Self selected exercise was used including walking, jogging, cycling at 65 – 75% of HR_{max}. Results showed that body weight decreased by 3.0 ± 0.8% (87.8 ± 10.1 kg to 85.2 ± 10.4 kg), whereas total fat mass decreased by 11.0 ± 2.6% (18.8 ± 5.0 kg to 17.0 ± 5.6 kg) (Pitchard, Nowson & Wark, 1997).

Finally, Garrow and Summerbell (1995) conducted a meta-analysis on the literature from 1966 to 1993 that investigated the efficacy of exercise interventions versus control interventions on body composition in overweight and obese individuals. By combining studies through statistical methods, 226 participants were studied from 28 publications. The meta-analysis found that without restricting diet, continuous exercise resulted in an average individual weight loss of only 3.0 kg in males after a 30-week intervention period and an average individual weight loss of 1.4 kg in women after a 12-week period, when compared to a sedentary group. The general conclusion made by Garrow and Summerbell (1995) was that aerobic exercise alone did not result

in significant weight loss in an obese population. Table 2.3 gives an overview of studies that have assessed the efficacy of continuous aerobic exercise in an obese or sedentary population.

2.6.2.2 Intermittent Aerobic Exercise and Weight Loss

Interventions employing intermittent aerobic exercise without dietary restriction have also been investigated in an obese population. One study by Murphy and Hardman (1998) compared 30 minutes of continuous exercise with intermittent exercise of the same intensity performed in three, ten minute blocks throughout the day. Exercise was performed five times per week over a ten-week period. Results showed that the overweight women in the intermittent walking group experienced a significantly greater weight loss of 1.7 ± 1.7 kg each, when compared to the continuous walking group. When explaining this outcome, the investigators noted that heart rate rises progressively with exercise in the untrained, and that subjects may have slowed their pace in order to oppose this rise in the 30 minute continuous exercise session, which would result in lower caloric expenditure and hence a lower weight loss (Murphy & Hardman, 1998). In a study by Jacobsen et al. (2003), an intermittent exercise group walked between 50 – 65% of their HRR, twice a day for 15 minutes per session, five times per week. After 16-months, post-intervention body mass was similar to baseline values (85.05 ± 12.90 kg vs 85.85 ± 13.13 kg). An explanation for this marginal weight loss could relate to the lack of diet restriction, as well as the possibility that the 16-month exercise regime may have resulted in increased muscle mass, counteracting the visible benefit of any loss in fat mass (Watts et al., 2005). This possibility highlights the importance of investigating the efficacy of a combination of diet and exercise as a weight loss strategy in an obese population, as well as the need to assess body composition (in particular fat and lean tissue mass), as not all the studies measured the change in amounts of fat and lean tissue mass. Table 2.3 gives an overview of studies that have assessed the efficacy of intermittent aerobic exercise in an obese or sedentary population.

Table 2-3: Results of studies that employed continuous and intermittent aerobic exercise in an obese or sedentary population.

STUDY	SUBJECT DATA	STUDY DESIGN	EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Murphy & Hardman, 1998)	47 sedentary women	Exercise only (n = 47)	10-weeks Group A: Intermittent 3x10mins/d (n = 12) Group B: Continuous 1x30mins/d 5d/wk (n = 12) Group C: Control (n = 10) Exercise= 70-80% HR_{max}	Weight BP Skinfolds Waist circumference Fitness Blood lactate (BL)	↑ $\dot{V}O_{2max}$ in Group A (Δ +2.3%±0.1) and B (Δ +2.4%±0.1) compared to Group C (Δ -0.5%±0.1) ↑ $\dot{V}O_2$ at BL conc. of 2mmol in Group A (Δ +2.6%±2.1) and B (Δ +3.5%±1.7) compared to Group C (Δ -2.1%±6.6) ↓ Skinfolds in Group A (Δ -3.0%±2.4) and B (Δ -2.8%±3.8) compared to Group C (Δ +0.6%±1.0) ↓ Body mass in Group A (Δ -1.7%±1.7) compared to Group C (Δ +0.6%±0.7)
(Jacobsen et al., 2003)	52 overweight, sedentary females	Exercise only (n = 52)	72-weeks Group A: Continuous 1x30mins/d, 3 d/wk (n = 26) Group B: 2x15mins/d, 5d/wk (n = 26) Exercise = 60-75% $\dot{V}O_{2max}$	Attrition Adherence Weight Body composition Fitness	↑ $\dot{V}O_{2peak}$ in Group A (Δ +10.3%) and B (Δ +9.49%)

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STUDY	SUBJECT DATA	STUDY DESIGN	EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Pitchard et al., 1997)	58 overweight men	Diet vs Exercise (n = 58)	12-months Group A: Continuous exercise, 3d/wk, 65-75% HR_{max} Group B: Low Fat Diet (fat=26.4%) Group C: Control	Weight Body composition Energy intake Physical activity indexes	↓ Weight in Groups A (Δ -3.0%±0.8) and B (Δ -7.2%±0.9) compared to Group C ↓ BMI in Group A (Δ -4.4%±0.7) and B (Δ -8.2%±0.9) compared to baseline ↓ Fat mass in Groups A (Δ -11.0%±2.6) and B (Δ -19.4%±2.3) compared to baseline and Group C (Δ -0.4%±1.6) ↑ Lean mass in Groups A (Δ -1.0%±0.5) and B (Δ -3.9%±0.5) compared to baseline and Group C (Δ -0.2%±0.4) ↓ Energy intake in Group B (Δ -30.4%±3.8) compared to Groups A (Δ +3.1%±2.7) and C (Δ +5.5%±4.7) ↑ Physical activity in Group A (Δ 15.6%±2.0) compared to Groups B (Δ 5.9%±1.9) and C (Δ 6.5%±1.5)

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STUDY	SUBJECT DATA	STUDY DESIGN	EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Garrow & Summerbell, 1995)	226 sedentary men in 13 groups, 233 exercising men in 14 groups, 199 sedentary women in 23 groups and 258 exercising women in 28 groups	Meta-analysis; 28 published studies	Aerobic exercise only Resistance exercise only Diet only Diet and exercise	Weight Body composition	Aerobic exercise only = men weight loss 1.4kg in 12-weeks, women weight loss 3kg in 30-weeks Resistance exercise only = men FFM+2kg, women FFM+1kg Diet only = men FFM-2.9kg, women FFM-2.2kg Diet and exercise = men and women FFM -1.7kg
(Snyder et al., 1997)	13 sedentary moderately obese women	32-weeks Intermittent exercise only	Intermittent exercise 3x10 mins, 5d/wk 50-65%HRR	Fitness Body composition Blood lipids Energy intake Circumference Adherence	Correlation btwn adherence and changes in fitness ($r = 0.64$; $P < 0.05$) ↑ treadmill time to exhaustion (2.7 ± 2.4mins; $P < 0.05$) ↓ maximal HR at exhaustion (3.3 ± 5.0bpm; $P < 0.05$) Correlation btwn baseline fitness and changes in insulin ($r = 0.88$; $P < 0.05$)

2.6.3 Diet, Exercise and Weight Loss

Many investigators have suggested that when weight loss is desired, the combination of diet (ie. a restricted caloric intake) and exercise represents a more superior intervention than just diet or aerobic exercise alone (Blair, 1993; Buemann & Tremblay, 1999; Hill et al., 1993; NIH Technology Assessment Conference Panel, 1993; Pavlou et al., 1989). This is supported in a meta-analysis performed by Miller, Koceja and Hamilton (1997) who extracted data from 493 studies that investigated differences in body composition associated with different types of interventions. The studies were only accepted for analysis if they used therapeutic interventions of diet, exercise or diet plus exercise, specifically for weight reduction in obese adults. Results showed that individual weight loss equalled 10.7 ± 0.5, 2.9 ± 0.4 and 11.0 ± 0.6 kg for the diet, exercise, and diet plus exercise intervention, respectively. At the one year follow-up, it was concluded that diet plus exercise was the superior intervention, with subjects maintaining a weight loss of 8.6 ± 0.8 kg compared to 6.6 ± 0.5 kg experienced by participants in the diet intervention group (Miller et al., 1997). Another important point noted in a meta-analysis performed by Garrow and Summerbell (1995), was that a ten kilogram weight loss was associated with greater fat loss after an exercise and diet regime, as compared to a diet only intervention (83% versus 71%, respectively). Similar findings were reported by Kraemer (1999), where the diet only group lost 69% of fat mass, as compared to the diet and exercise group, who lost 78% of fat mass.

Consequently, these studies suggest that the combination of restricted caloric intake and aerobic exercise optimises fat loss (Skender et al., 1996); reduces the loss of lean tissue associated with diet alone approaches (Andersen, 1999); improves metabolic rate (Andersen, 1999); reduces visceral adipose tissue deposits (National Health and Medical Research Council, 1997); and increases high density lipoproteins (National Health and Medical Research Council, 1997). These benefits are advantageous in an overweight and obese population, as they can result in alterations to body composition, as well as improve health (Andersen, 1999) and quality of life (Ortega & Andres, 1999). An overview of studies that used diet and exercise regimens for weight loss is shown in Table 2.4.

Table 2-4: Results of studies that employed a combination of diet and exercise in an overweight/obese or sedentary population. Studies include two meta-analyses and one original investigation.

STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Miller et al., 1997)	Moderately obese middle-aged men and women 493 study groups (average sample size 33±6) from >700 papers	15.6±0.6-weeks Meta-analysis	Diet only Exercise only Diet and exercise	Weight Body composition	Groups initially differed ↓ Weight in diet only (10.7±0.5kg), exercise only (2.9±0.4kg), diet and exercise (11.0±0.6kg) ↓ %BF in diet only (6.0±1.0%), exercise only (3.5±0.5%) and diet and exercise (7.3±0.8%)
(Garrow & Summerbell, 1995)	28 published studies; sedentary men (n = 226), exercising men (n = 233), sedentary women (n = 199) and exercising women (n = 258)	Meta-analysis	Aerobic exercise only Resistance exercise only Diet only Diet and exercise	Weight Body composition	↓ Weight in aerobic exercise only (men -1.4kg in 12-weeks, women -3.0kg in 30-weeks) ↑ FFM in resistance exercise only (men +2kg, women +1kg) ↓ FFM in diet only (men -2.9kg, women -2.2kg) and diet and exercise (men and women -1.7kg)
(Kraemer et al., 1999)	35 overweight men	12-weeks Diet and exercise	Control (n = 6) Diet only (n = 8) Diet + Aerobic exercise (n = 11) Diet + Aerobic/Strength exercise (n = 10) Exercise = 3d/wk	Weight Body composition Strength $\dot{V}O_{2peak}$ RMR Blood lipids	↓ Body weight in diet (9.64kg), diet and aerobic exercise (8.99kg), diet and aerobic/strength exercise groups (9.90kg) ($P < 0.05$) ↓ FFM in diet group ↑ Strength in diet and aerobic/strength group ↑ $\dot{V}O_{2peak}$ in diet + exercise (24.8%) and diet + aerobic/strength (15.4%) groups ↓ Peak and mean power output in diet group ↓ Serum total cholesterol and LDL for diet groups

2.6.3.1 Diet and Continuous Aerobic Exercise

Generally, the combination of diet and continuous aerobic exercise has resulted in significant weight losses. This is demonstrated in a study by Pavlou and co-workers (1989), who compared an intervention consisting of either caloric restriction or caloric restriction combined with continuous aerobic exercise in 80 overweight male police officers over an eight-week period. All subjects had their caloric intake restricted to 1,000 kcal per day, while the exercise regime consisted of 35 – 60 minutes of supervised walking-jogging-running performed at 70 – 85% of individual HR_{max}, which was combined with callisthenics and relaxation therapy. The total duration of the combined therapies equalled 90 minutes, with this routine being performed three times per week. Weight loss in the diet plus exercise group averaged 12.0 ± 1.0 kg each, whereas weight loss in the diet alone group averaged only 7.1 ± 0.5 kg each (Pavlou et al., 1989). The larger weight loss in the diet and exercise group may be partially explained by the large volume of exercise participation combined with the periods of high-intensity exercise (which expends more calories). The investigators also noted that exercise and diet adherence may have had a large role to play, as the subjects were well-disciplined police officers.

Another study by Keim, Barbieri, Van Loan and Anderson (1990) reported similar results, however this study compared continuous aerobic exercise against continuous aerobic exercise plus caloric restriction in ten overweight women over a 14-week period. All subjects lived in a metabolic suite, and their food intake, lifestyle and physical activity levels were constantly supervised. Initially, subjects underwent a two-week stabilisation period, followed by a 12-week intervention period. The aerobic exercise regime consisted of walking for varied durations (based on 15% of individual energy intake) for six days per week, at a pace that equated to 65 – 85% of individual $\dot{V}O_{2max.}$ The diet intervention required subjects to reduce their normal dietary intake by 50% based on stabilisation data, where stabilisation was designed to maintain body weight. Results for the exercise plus caloric restriction group showed an average individual weight loss of 13.1 ± 0.7 kg, whereas subjects performing only exercise lost on average 5.6 ± 0.6 kg each. Investigators suggested that the successful weight loss demonstrated in the diet plus exercise group may have been related to the high prescribed exercise frequency (six days per week), and the placement of all subjects in a controlled environment (Keim et al., 1990).

Results from these studies support the theory that the best way to maximise weight loss in overweight individuals is to use an intervention that combines caloric restriction with aerobic exercise. An overview of studies that examined the effects of diet and continuous exercise can be found in Table 2.5. However, an important question relates to the type of exercise prescription employed. Earlier it was noted that intermittent exercise may provide greater weight loss than continuous exercise (Jakicic & Wing, 1997; Jakicic et al., 1995). Consequently, some recent studies have investigated the combined effects of intermittent exercise and diet restriction on weight loss.

Table 2-5: Results of studies that employed the combination of diet and continuous exercise.
Where only a P value is expressed, no specific data on change was available.

STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Pavlou et al., 1989)	160 male police officers	8-weeks Diet and continuous exercise Diet only	8 Groups= Exercise (70-85% HR_{max}) + Balanced caloric-deficit diet (1000kcal) Protein-sparing modified fast (1000kcal) DPC-70 (420kcal) DPC-800 (800kcal) Non-Exercise + Balanced caloric-deficit diet (1000kcal) Protein-sparing modified fast (1000kcal) DPC-70 (420kcal) DPC-800 (800kcal)	Weight BP Heart rate Fitness	All groups: ↓ Weight ($P < 0.001$) ↓ Resting HR ($P < 0.001$) ↓ BP ($P < 0.001$) Exercise groups: ↑ $\dot{V}O_{2max}$ except DPC-70 ($P < 0.001$) ↑ Quadriceps and hamstring strength ($P < 0.001$) ↑ Endurance ($P < 0.001$) ↑ Treadmill time ($P < 0.001$) ↑ HDL ($P < 0.005$)
(Keim et al., 1990)	10 healthy overweight women	14-weeks Diet and exercise (n = 5) Exercise only (n = 5)	Diet and exercise= 50% reduction in energy intake and moderate intensity aerobic exercise on 6d/wk Exercise only= moderate intensity aerobic exercise on 6 d/wk	RMR TEF TEA $\dot{V}O_{2max}$ RQ Body composition Strength Anaerobic capacity	↓ Weight in diet and exercise (13.08±0.71kg) and exercise (5.61±0.62kg) ↑ $\dot{V}O_{2max}$ in diet and exercise (11%) and exercise (13%) ↓ RMR in diet and exercise group (9%) Training effect on VO_2 Diet had main effect on RQ

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STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Volek et al., 2002)	Overweight men (n = 10) and women (n = 12)	8-weeks	Group A: Diet, exercise, supplement, behavioural modification (n = 22) Group B: Control (n = 8)	Weight Body composition Blood lipids	↓ BMI in women (30.8±7.0 to 29.2±6.4kg/m^2) and men (30.0±0.07 to 0.90±0.06kg/m^2) ↓ %BF in men (-2.7%±1.7) ↓ Cholesterol in men (-18±14mg/dl) ↓ LDL in men (-14±14mg/dl) ↓ Serum leptin in women (-16.2±0.8 µmol/l)

2.6.3.2 Diet and Intermittent Aerobic Exercise

A number of studies have reported greater benefits associated with intermittent aerobic exercise and diet (caloric restriction), when compared to diet alone interventions. This was demonstrated in a 12-week intervention by Schmidt, Biwer and Kalscheuer (2001) who enrolled 26 overweight, female college students into either a diet group or into one of two intermittent exercise and diet groups. All subjects followed a self-monitored calorie restricted diet (total calorie intake equalled 80% of resting energy expenditure (REE)), while subjects in the exercise and diet groups completed between 15 - 30 minutes of exercise performed at 75% of HRR, three to five times a week. Of the two exercise groups, one group completed two exercise sessions per day, while the other group performed three exercise sessions per day. Results found that the dieting group gained 0.06 ± 0.2 kg, whilst the two intermittent groups significantly lost an average of 3.0 ± 1.3 kg (two sessions per day group) and 4.4 ± 2.3 kg (three sessions per day group) of body mass per individual (Schmidt et al., 2001). This weight loss was less than that reported using continuous exercise regimes, however, a possible explanation might be that the subjects in this study underestimated their caloric intake. This conjecture is further supported by the fact that subjects in the diet group gained weight. Additionally, the duration of exercise in this study was only 30 minutes per day, whereas the exercise duration was longer in the studies that assessed the efficacy of continuous exercise. Another limitation of this study was that subjects were not randomised into groups and menstrual cycle status, which can influence RER and therefore affect calorie balance, was not controlled for. Of further interest was that the group who performed three exercise sessions per day lost more weight than the group who performed only two exercise sessions, even though total exercise duration was the same. A possible explanation for this could be that the accumulated recovery time (or EPOC) may have been longer after three sessions of exercise compared to two sessions, resulting in greater caloric expenditure. This concept is further explored in the next section. Table 2.6 highlights studies that have assessed the use of diet and intermittent exercise in an overweight population.

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Table 2-6: Results of studies that employed a combination of diet and intermittent exercise in an overweight population.
Where only a P value is expressed, no specific data on change was available.

STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Schmidt et al., 2001)	Overweight female college students (n = 38)	12-weeks Intermittent exercise vs continuous exercise	Continuous exercise + diet (1x30mins) (n = 12) Intermittent exercise + diet (2x15mins) (n = 10) Intermittent exercise + diet (3x10mins) (n = 8) Diet only (n = 8) Diet=80% REE Exercise=75%HRR, 3-5d/wk	Weight Fitness Body composition REE	↑ $\dot{V}O_{2max}$ ($P < 0.001$) ↓ Weight ($P < 0.0001$) ↓ BMI ($P < 0.0001$) ↓ Skinfolds ($P < 0.01$) ↓ Circumference ($P < 0.01$) from baseline to post-intervention in exercise groups only Diet had main effect of time in all groups ($P < 0.0001$) Attendance had main effect of time for exercise groups ($P < 0.0001$) Difference btwn groups in withdrawals ($P < 0.0001$)

2.6.3.3 Continuous Aerobic Exercise versus Intermittent Aerobic Exercise

Other studies compared the efficacy of diet and intermittent exercise to diet and continuous exercise in an overweight population. One study by Jakicic et al. (1995) required 56 sedentary, overweight females to complete 20 – 40 minutes of either continuous or intermittent aerobic exercise at 70% of individual HRR, three to four times per week, over a 20-week period. Caloric intake was restricted to 1200 – 1500 kcal per day. Results found that the continuous exercise group completed the minimum level of recommended exercise, while the intermittent group performed significantly more exercise. Although similar improvements in cardio-respiratory fitness were seen in both groups, subjects in the intermittent group lost an average of 2.5 kg more weight than subjects in the continuous group, with average individual weight loss equating to 8.9 ± 5.3 kg and 6.4 ± 4.5 kg, respectively. Factors that could have contributed to the greater weight loss in the intermittent group include differences in the amount of exercise completed (35 minutes more per day) and the amount of calories consumed (140 kcal per day) (Jakicic et al., 1995). Compared to the study by Schmidt et al. (2001) (noted in section 2.6.3.2.), the greater weight loss in this study may have occurred as a result of the longer exercise duration, an overall lower caloric intake, as well as the use of behavioural modification sessions.

Another study by Jakicic, Winters, Lang and Wing (1999) assessed weight loss in 73 overweight women who participated in 18-months of diet and regular aerobic exercise, performed for 20 - 40 minutes either continuously or intermittently in ten minute blocks. The investigators reported similar weight losses of 8.2 ± 5.5 kg and 7.5 ± 5.4 kg per individual at six-months and 5.8 ± 7.1 kg and 3.7 ± 6.6 kg per individual at 18-months in the continuous and intermittent groups, respectively. According to the investigators, the reduced weight loss that occurred between 6 and 18-months was most likely due to a decline in exercise participation, as well as an increased caloric intake by many subjects. This outcome suggests that some subjects have difficulty in adhering to a diet and exercise programme over a period of time (Jakicic et al., 1999).

While studies are generally inconclusive on whether intermittent or continuous exercise results in the greatest weight loss, the concept of recovery time or EPOC would suggest that intermittent exercise should result in larger weight losses. Excess post oxygen consumption is defined as the elevation of oxygen consumption above resting

levels after exercise has been completed (Borsheim & Bahr, 2003), and is an exercise-initiated disturbance in homeostasis (Brooks, Fahey, White & Baldwin, 2000). A longer total EPOC period translates to a longer time that metabolism is raised above resting levels, which ultimately results in increased caloric expenditure (Borsheim & Bahr, 2003). A longer overall recovery period after intermittent exercise is supported by Kaminsky, Padjen and LaHam-Saeger (1990) who reported a 117% higher combined EPOC (expressed in kcals) in six women of normal weight after two 25 minute exercise sessions compared to one continuous 50 minute exercise session, where all three trials were performed at 70% of individual $\dot{V}O_{2peak}$. These investigators concluded that intermittent exercise significantly elevated post-exercise energy expenditure and therefore, when exercise was performed on a regular basis, EPOC had an accumulative effect that could alter an individual's body weight (Gore & Withers, 1990). The increase in EPOC reported after intermittent exercise may be due to the accumulative effects of the two separate exercise sessions.

Further to the hypothesis that a longer EPOC results in greater caloric expenditure, intermittent exercise may also be more appropriate in an inactive population as it allows individuals to perform short duration exercise at convenient times during the day. This may improve the likelihood of individuals attaining the recommended level of exercise as prescribed by the American College of Sports Medicine (Blair, Kohl, Gordon & Paffenbarger, 1992; Franckowiak & Andersen, 2003; Jacobsen et al., 2003; Jakicic et al., 1995; Pate et al., 1995; Schmidt et al., 2001; Snyder et al., 1997; Woolf-May et al., 1999). Consequently, this may make it easier for aerobic exercise to be incorporated into an individual's lifestyle (Skinner, 2005). This is particularly pertinent for obese individuals who may experience difficulty in participating in continuous exercise due to reasons such as impaired pulmonary function, friction of body parts, joint pain, and an increased need for muscle fibre recruitment to move the additional body fat (Sothern, 2001). Another consideration is that obese individuals often complain of discomfort associated with sweating that can occur as a result of continuous exercise (Andersen, 1999). Intermittent exercise may reduce the rate of sweating and consequently result in greater adherence by this population to an exercise programme. Finally, as exercise is associated with improved mood and self esteem, Brownell (1998) suggests that intermittent exercise may result in more occasions for feeling positive.

Studies comparing intermittent exercise to continuous exercise have been primarily concerned with associated fitness benefits (DeBusk et al., 1990; Jakicic et al., 1995; Murphy & Hardman, 1998), however, different types of aerobic exercise may also affect blood profiles. Gill, Murphy and Hardman (1998) investigated the effect of intermittent exercise on postprandial lipemia. These researchers recruited 18 participants comprising of normal and borderline hyperlipidaemic healthy males who either performed a 90 minute control trial, a 90 minute continuous treadmill running trial, or three 30 minute sessions of intermittent treadmill running trial, with each running trial being completed at 60% of $\dot{V}O_{2max}$. The results indicated that intermittent exercise, when compared with continuous exercise of the same quantity, performed on the day before a high fat meal, produced a comparable reduction in postprandial lipemia. On completion of the exercise trials, participants involved in the intermittent intervention also experienced lower fasting triacylglyerol concentrations, which may have contributed to the reduced lipemia. The researchers also reported that the benefits associated with exercise on postprandial lipemia was likely to be greater in hyperlipemic individuals (Gill et al., 1998), as greater changes can occur in these individuals. An overview of studies comparing the effects of continuous and intermittent exercises in a variety of populations can be found in Table 2.7.

The above findings strengthen the argument for the use of accumulating short exercise sessions. While these factors suggest that intermittent exercise would be a more effective and appropriate intervention than continuous aerobic exercise in an obese population, another factor that may also play a vital role in optimising the benefits of exercise and in facilitating weight loss is interval exercise.

Table 2-7: Results of studies that compared continuous and intermittent exercise in various populations.
Where only a P value is expressed, no specific data on change was available.

STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Jakicic et al., 1995)	Sedentary, overweight middle aged women	20-weeks (n = 52) Randomised	Intermittent (n = 27) Continuous (n = 25) Exercise = 5d/wk, 20-40mins Diet = 1200-1500kcal, 20% fat	Weight Fitness Adherence BP Heart rate Dietary Intake	Groups differed in exercise prescription ($P < 0.001$) Time effect for mins of exercise per week ($P < 0.001$) ↑ Time to 80%HRR ($P < 0.001$) in continuous (11.2±2.5 to 11.9±2.5mins) and intermittent (11.3±2.9 to 10.0±2.9mins) ↑ $\dot{V}O_{2peak}$ ($P < 0.05$) in continuous (5.6%) and intermittent (5.0%) ↓ Calorie intake ($P < 0.05$) ↓ Weight ($P < 0.001$) in continuous (6.4kg) and intermittent (8.9kg) ↓ BMI ($P < 0.001$) ↓ Diastolic pressure ($P < 0.001$) in continuous (4.1±6.6mmHg) and intermittent (5.3±7.7mmHg)

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STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Schmidt et al., 2001)	Overweight female college students (n = 38)	12-weeks Diet + Intermittent vs continuous exercise	Continuous exercise + diet (1x30 mins) (n = 12) Intermittent exercise + diet (2x15 mins) (n = 10) Intermittent exercise + diet (3x10 mins) (n = 8) Diet only (n = 8) Diet = 80% REE Exercise = 75%HRR, 3-5d/wk	Weight Fitness Body composition REE	↑ $\dot{V}O_{2max}$ ($P < 0.001$) ↓ Weight ($P < 0.0001$) ↓ BMI ($P < 0.0001$) ↓ Skinfolds ($P < 0.01$) ↓ Circumference ($P < 0.01$) from baseline to post-intervention in exercise groups only Diet had main effect of time in all groups ($P < 0.0001$) Attendance had main effect of time for exercise groups ($P < 0.0001$) Difference btwn groups in withdrawals ($P < 0.0001$)
(Kaminsky et al., 1990)	6 healthy women	Cross-over Design Continuous vs intermittent exercise	Continuous (1x50 min run) vs Intermittent (2x25 min run) Exercise= 75% $\dot{V}O_{2peak}$	EPOC Fitness	↑ EPOC after intermittent compared to continuous (13.8 vs 6.39kcal) ↑ VE ↑ HR above baseline 30mins after exercise in second 25min run ↓ RER below baseline 30mins after exercise in 1x50min and first 25min run

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STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Murphy & Hardman, 1998)	47 sedentary women	Randomised, controlled Exercise only (n = 47)	10-weeks Intermittent: 3x10 mins/d (n = 12) Continuous: 1x30 mins/d 5d/wk (n = 12) Control (n = 10) Exercise= 70-80% HR_{max}	Weight BP Skinfolds Waist Circumference Fitness Blood lactate	↑ $\dot{V}O_{2max}$ in intermittent (Δ +2.3%±0.1) and continuous (Δ +2.4%±0.1) compared to control (Δ -0.5%±0.1) ↑ $\dot{V}O_2$ at BL conc. of 2mmol in intermittent (Δ +2.6%±2.1) and continuous (Δ +3.5%±1.7) compared to control (Δ -2.1%±6.6) ↓ Skinfolds in intermittent (Δ -3.0%±2.4) and continuous (Δ -2.8%±3.8) compared to control (Δ +0.6%±1.0) ↓ Body mass in intermittent (Δ -1.7%±1.7) compared to control (Δ +0.6%±0.7)
(DeBusk et al., 1985)	36 sedentary healthy men	Intermittent vs continuous exercise	8-weeks Continuous (1x30 mins/d) Intermittent (3x10 mins/d) Exercise= 65-75% HR_{peak}	Adherence Heart rate RPE $\dot{V}O_{2max}$ BP	↑ $\dot{V}O_{2max}$ in continuous (13.9%; $P < 0.0001$) and intermittent (7.6%; $P = 0.0064$) ↑ Exercise duration in both groups (12%; $P < 0.01$)

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STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Gill et al., 1998)	15 normolipidaemic and 3 hyperlipidaemic healthy males (n = 18)	Intermittent vs continuous exercise	2 days 3 trials Control trial (rest) Continuous trial (1x90 mins) Intermittent trial (3x30 mins) Exercise = 60% $\dot{V}O_{2max}$	$\dot{V}O_2$ RER Fat/CHO oxidation EE Heart rate Blood lipids	↑ mean HR after continuous exercise ($P < 0.05$) ↓ total lipemic response in intermittent (7.22mmol/l/6h) and continuous (7.18mmol/l/6h) compared to control (8.77mmol/l/6h) ($P < 0.05$)
(DeBusk et al., 1990)	36 healthy males Randomised	8-weeks Continuous vs intermittent exercise	Continuous (1x30 mins/d) Intermittent (3x10 mins/d) Exercise= 65-75% HR_{peak}	Fitness Heart rate Adherence Sweat RPE	↑ $\dot{V}O_{2max}$ in continuous (13.9%; $P < 0.0001$) and intermittent (7.6%; $P = 0.064$) from baseline to post-test ↑ $\dot{V}O_{2max}$ in continuous compared to intermittent ($P = 0.03$) ↑ exercise test duration in continuous and intermittent (12%; $P < 0.01$) ↓ submaximal HR in continuous and intermittent (6%; $P < 0.001$)

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STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Fulton et al., 2001)	32 women	Repeated measures (3 conditions)	Continuous (1x30 mins) Intermittent (3x10 mins) Control	EE Accelerometer	↑ total daily EE for continuous and intermittent compared to control ($P < 0.001$) ↑ trunk movement for continuous and intermittent compared to control ($P < 0.001$) ↑ total daily EE for continuous compared to intermittent ($P < 0.02$) ↑ trunk movement for continuous compared to intermittent ($P < 0.02$)
(Woolf-May et al., 1998)	49 sedentary individuals (n = 28 men; n = 21 women)	18-weeks Controlled	Continuous (20-40 mins, 3d/wk; n = 17) Intermittent (3x10-15 mins, 3d/wk; n = 16) Control (n = 16)	Blood lipids Fitness Heart rate	↓ maximal HR in continuous (4.3%) and intermittent (4.9%) groups ($P < 0.05$) ↑ conc. of HDL in females compared to males ($P < 0.001$) ↑ conc. of apo AI in females compared to males ($P < 0.001$)
(Woolf-May et al., 1999)	56 subject (n = 19 males; n = 37 women)	18-weeks Randomised, controlled	Continuous (20-40 mins; n = 19) Intermittent (3x10-15 mins; n = 10) Short (4x5-10 mins; n = 14) Control Exercise = 70-75% $\dot{V}O_{2max}$	Fitness Blood lipids	Differences in amount of exercise ($P < 0.0001$) ↓ BL in exercise groups ($P < 0.005$) ↓ LDL and apo AII in continuous and intermittent compared to control

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STUDY	SUBJECT DATA	STUDY DESIGN	DIET AND EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Jakicic & Wing, 1997)	48 obese females	7-weeks Randomised	Continuous (1x30 mins; n = 23) Intermittent (3x10 mins; n = 25)	Amount of exercise Weight Adherence	↑ exercise on more days per week in intermittent (4.9±1.5d/wk) compared to continuous (3.8±1.4d/wk) ($P <$ 0.02) ↓ weight for intermittent (11.5±4.2lbs) and continuous (8.9±4.9lbs, $P < 0.04$) Correlation btwn weight loss and exercise time (r=0.51, $P < 0.001$) Correlation btwn weight loss and exercise days (r=0.58, $P < 0.001$)
(Donnelly et al., 2000)	22 sedentary, moderately obese women	18-months Continuous vs Intermittent exercise	Continuous (1x30 mins, 3d/wk) Intermittent (2x15 mins, 5d/wk) Exercise= 60-75% $\dot{V}O_{2max}$	Fitness Weight Body composition Blood lipids BP Circumference	↓ %BF for continuous group (41.76±3.37 to 40.01±2.86%) ↓ weight for continuous group (81.40±5.71 to 79.70±5.40kg) ↑ $\dot{V}O_{2max}$ in continuous (8%) and intermittent (6%) groups ↓ resting HR (7bpm, $P < 0.05$) ↓ systolic BP (14mmHg, $P < 0.05$) ↑ HDL in continuous (18%) and intermittent (9%) groups

2.7 Interval Exercise

The majority of studies referred to earlier in this review employed aerobic exercise that was performed at a constant pace throughout the exercise bout(s) (i.e. steady-state exercise). However, exercise can also be performed at varying intensities throughout a bout. Interval exercise (or interval training) is defined by Fox, Bowers and Foss (1993) as a form of physical conditioning that employs short but regular periods of work stress that are interspersed with relief periods during one exercise session. In this study, the term 'interval' exercise is used differently to 'intermittent' exercise, which refers to when more than one exercise session is completed throughout the day. Consequently, interval exercise can be used to improve any one of the three energy systems. To date, interval exercise has typically been employed by athletes in order to improve their cardiovascular fitness.

2.7.1 Effects of Interval Training on Aerobic Capacity

Studies have shown interval exercise to be an effective way for athletes of all levels to improve their aerobic capacity (Billat, 2001; Billat et al., 2000). Billat et al. (2000) conducted a study on eight endurance trained male athletes comparing steady-state exercise to interval training. Participants completed a continuous steady-state training session at approximately 90% of the velocity associated with $\dot{V}O_{2max}$ ($\upsilon\,\dot{V}O_{2max}$; the speed an individual is travelling at when $\dot{V}O_{2max}$ is achieved) and an interval exercise session at 100% of $\upsilon\,\dot{V}O_{2max}$ for 30 seconds, followed by 30 seconds at 50% of $\upsilon\,\dot{V}O_{2max}$. The results showed that interval exercise allowed the subjects to maintain their $\dot{V}O_{2max}$ for a longer period of time and that this resulted in a lower accumulation of blood lactate (Billat et al., 2000). This was proposed to be due to the buffering of blood lactate during the rest periods, which consequently allowed the athlete to exercise for longer.

Non-athletes have also used interval exercise as a means of improving fitness (Sokmen et al., 2002). A study by Makrides (1990) investigated the efficacy of a 12-week interval training programme in 12 young and 12 elderly, healthy sedentary males. The protocol used in this study consisted of 60 minute sessions performed three days a week at intervals consisting of 65% and 45% of $\dot{V}O_{2peak}$, at a ratio of one minute each, with a gradual increase in intensity as the weeks progressed. On completion of the

intervention, the elderly males demonstrated a 38% increase in $\dot{V}O_{2peak}$ (1.60 ± 0.073 to 2.21 ± 0.073 L.min^{-1}), whereas the young males experienced a 29% improvement in $\dot{V}O_{2peak}$ (2.54 ± 0.141 to 3.26 ± 0.181 L.min^{-1}). This improvement was also associated with improved vascular conductance, maximal cardiac output and aerobic muscle power (Makrides et al., 1990). Another study conducted by Sokmen, Beam, Witchey and Adams (2002) compared the effects of a typical steady-state programme with a high intensity interval programme in young adults. Forty-two participants were randomly assigned to one of the two groups and exercised three times per week over a ten-week period, with the intensity of exercise increasing as the intervention progressed. The steady-state group exercised at a constant intensity throughout the exercise session, whereas the interval group performed exercise at 120 – 150% of $\dot{V}O_{2max}$ during the work intervals and 30 – 40% of $\dot{V}O_{2max}$ during the relief intervals within each session. Both groups experienced significant increases in $\dot{V}O_{2max}$ and sprint times, however improvements were greater in the interval exercise group (Sokmen et al., 2002). Fitness improvements were proposed to be due to the greater strain placed on the cardiovascular system by the high intensity exercise component employed during interval exercise. Of further importance, the interval training group also significantly improved in the 300°·s^{-1} leg extension and leg flexion tests, whereas the steady-state group did not improve in any isokinetic tests. It was postulated that this improvement in the interval exercise group was a result of increased muscle mass.

Another study by Adeniran and Toriola (1988) investigated the use of interval exercise in 76 healthy, secondary school aged girls who exercised outdoors, three times per week for eight-weeks. Exercise consisted of either steady-state jogging at 80 – 85% HR_{max} or interval exercise performed at 90% of HR_{max} for four minutes interspersed with four minutes of relief walking repeated four times throughout the bout. Results showed that both training groups increased their $\dot{V}O_{2max}$; however the interval exercise group displayed a slightly larger increase in aerobic (11.5%) and anaerobic power (14.6%) compared with the steady-state group (10.2% and 13.2%, respectively) (Adeniran & Toriola, 1988). Again, this increase was most likely due to the greater load the high intensity components of the interval training regime placed on the cardiovascular system.

Further research by Perry, Tapp and Weeks (1986) investigated a ten week programme consisting of interval exercise performed at 85% of HR_{max} followed by rest (3min to 3 min ratio over a 36 min period). Participants included six sedentary males and six post-menopausal sedentary women. Results showed a significant decrease in systolic (SBP; 127 ± 4.92 to 117 ± 2.49mmHg) and diastolic BP (DBP; 82.1 ± 2.66 to 75.16 ± 2.08mmHg), and percentage of body fat (27.55 ± 1.57 to 25.75 ± 1.75%), as well as improved $\dot{V}O_{2max}$ (32.85 ± 3.00 to 38.05 ± 3.23 $ml/kg^{-1}/min^{-1}$). Conversely, a control group showed no improvement in any of these measures. The exercise group also demonstrated a 6% (NS) decrease in total cholesterol, an 11% (NS) decrease in low density lipoproteins (LDL), a 33% (NS) decrease in very low density lipoproteins (VLDL), a 28% (NS) decrease in triglyceride levels, as well as a 3% (NS) increase in high density lipoproteins (HDL). Of further importance was that the interval exercise significantly lowered the lipoprotein risk ratio (LDL/HDL). The investigators concluded that the individuals, who possessed the least favourable lipid profiles initially, experienced the most beneficial changes (Perry et al., 1986).

Ahmaidi et al. (1998) also studied the clinical and cardiorespiratory responses to interval exercise in 22 elderly, sedentary individuals. Individuals were randomly assigned into either a training group or control group. The training group participated in interval walking/jogging, twice a week, for 12-weeks at the individual's ventilatory thresholds. Different ratios of high and low intensity exercise were used throughout the bouts, as well as different durations of intervals per session, with the duration increasing from 30 - 60 minutes by week 12. Results demonstrated a significant increase in $\dot{V}O_{2max}$ (1.77 ± 0.2 to 2.11 ± 0.3 L/min), ventilatory threshold and exercise tolerance in the training group. Of importance, the interval exercise programme was clinically well tolerated by this population, while exercise adherence was excellent (73%) (Ahmaidi et al., 1998).

Other physiological benefits have been associated with the use of just high intensity exercise. Hardman (2001) conducted a meta-analysis review on a number of studies that investigated the effects of high intensity exercise compared to low intensity exercise on aerobic fitness in sedentary individuals, where energy expenditure was equivalent. While these studies did not involve interval exercise, the effects of high intensity exercise are pertinent as they may be applicable to the high intensity

components of interval training. These studies showed that 45 - 50 minutes of exercise, performed on three to five days per week, increased $\dot{V}O_{2max}$ to a greater extent when exercise was performed at a high intensity. One randomly controlled study reported a 16% improvement in $\dot{V}O_{2max}$ with high intensity exercise compared to only a 4% increase when lower intensities were used (Duncan, Gordon & Scott, 1991). Further to this, O'Donovan et al. (2005) conducted a 24-week intervention involving sedentary males, aged between 30 and 45 years. Participants were randomly assigned into one of three groups: a control group; a moderate intensity exercise group which exercised at 60% of $\dot{V}O_{2max}$; and a high intensity exercise group that exercised at 80% of $\dot{V}O_{2max}$; where neither group altered dietary intake or lifestyle. By week eight, both exercise groups participated in three exercise sessions per week and caloric expenditure was the same for each exercise group, equating to 400 kcals per sessions. On completion of the intervention, the high intensity exercise group demonstrated a significant increase in $\dot{V}O_{2max,}$ compared to the moderate intensity group (0.55 ± 0.27 versus 0.38 ± 0.14 $L.min^{-1}$ increase). Finally, the assessment of blood lipids demonstrated that the coronary risk factor decreased in the high intensity exercise group only. This study concluded that high intensity exercise in sedentary men was the most effective intervention for improving cardiorespiratory fitness compared to moderate intensity exercise, when the energy cost of exercise was equal (O'Donovan et al., 2005).

2.7.2 Interval Exercise Training and Body Composition

Interval exercise has also been shown to have a role in positively influencing body composition. This is demonstrated in a study by Tremblay (1994), in which 27 inactive, normal weight subjects were required to either cycle for 20-weeks at 60 – 85% of HRR, or to participate in interval training for 15-weeks with exercise being performed at different intensities and for different durations throughout the intervention period. Results showed higher energy expenditure in the endurance group (120.4 ± 31.0 MJ) compared to the interval training group (57.9 ± 14.4 MJ). However, of interest, the interval training group had a greater change in skinfold measurements (94.2 ± 37.7 to 80.3 ± 36.0mm) compared to the endurance group (79.2 ± 35.1 to 74.7 ± 34.2mm). When the sum of skinfolds was divided by energy expenditure in the interval group, the amount of subcutaneous fat loss was ninefold greater than the endurance group. This suggested that high intensity exercise played a large role in fat loss. The investigators concluded that the high intensity components of interval exercise enhanced post-

exercise lipid utilization and therefore favoured a greater body lipid deficit following exercise (Tremblay et al., 1994). Another study by Treuth (1996) compared the difference between 60 minutes of low intensity training performed at 50% of $\dot{V}O_{2max}$ to interval exercise that consisted of 15 bouts of exercise performed at 100% of $\dot{V}O_{2max}$ with a work to rest ratio of 2:2 mins. The interval exercise group demonstrated higher energy expenditure during the 24-hour period following the exercise, with this resulting in a greater amount of fat mass loss (Treuth et al., 1996).

The study referred to in the previous section by O'Donovan and colleagues (2005) also analysed body composition. Percent of body fat significantly decreased in both exercise groups (22.6 ± 4.2% to 22.3 ± 4.5% and 23.4 ± 3.9% to 21.9 ± 3.9% in the moderate and high intensity groups, respectively), while, the control group actually put on body fat during the intervention period.

2.7.2.1 Interval Exercise in an Obese Population

Interval exercise is not only a beneficial training regime for trained athletes, it can also be used for those individuals who are unable to sustain a moderate exercise intensity across a continuous bout of exercise, such as the very unfit or the chronically ill (Foss & Strehle, 1984; Fox et al., 1993; Hunter, Weinsier, Bamman & Larson, 1998; Kaminsky & Whaley, 1993). Of relevance, interval exercise can be adapted for use in an obese population, yet to date there has been little research performed in order to determine the efficacy of interval exercise in this type of population.

A study by Kaminsky and Whaley (1993) assessed the effect of interval exercise on EPOC in five obese women and five women of normal weigh after two exercise trials on a treadmill. The first trial consisted of steady-state walking at 60% of individual $\dot{V}O_{2max}$, while the second trial involved interval exercise performed at speeds that equated to 30 and 90% of individual $\dot{V}O_{2max}$. Results showed EPOC to be 127% longer and 93% greater in magnitude after the interval trial compared to EPOC values after steady-state walking (Kaminsky & Whaley, 1993). As noted earlier, a longer EPOC results in greater caloric expenditure and should promote greater weight loss if caloric intake is reduced or kept constant.

Further to this, a study by King, Broeder and Panton (2002) investigated changes in substrate utilization when comparing eight-weeks of interval exercise to steady-state exercise in 15 non-dieting, pre-menopausal obese women. Subjects participated in three exercise sessions per week, with each exercise bout equating to an energy expenditure of 300 kcals per session. The interval exercise programme consisted of two minutes of exercise performed at 95% of $\dot{V}O_{2max}$, followed by three minutes at 25% of $\dot{V}O_{2max}$, whereas the steady-state programme used a constant intensity of 50% of $\dot{V}O_{2max}$. Both programmes were equivalent in terms of mean intensity, duration and caloric expenditure. The outcome of this study demonstrated that interval exercise resulted in a significant increase in caloric expenditure at a given RER value, which consequently increased absolute fat utilization, resulting in fat loss (shown below). Additionally, $\dot{V}O_2$ significantly increased after the interval exercise programme from 13.59 ± 3.85 to 16.53 ± 2.70 $ml/kg^{-1}/min^{-1}$ (King et al., 2002). Further, another study by King and colleagues (2001) assessed additional variables. Results for the interval group showed a 13.1% improvement in $\dot{V}O_{2max}$ (25.2 ± 4.2 $ml/kg^{-1}/min^{-1}$ to 28.5 ± 5.1 $ml/kg^{-1}/min^{-1}$, $P < 0.03$), a 5.4% increase in RMR assessed 24 hours after exercise (1671 ± 406 kcal/day to 1761 ± 412 kcal/day, $P < 0.04$), and a 4.8% decrease in body fat percent (45 ± 8.4% to 42.8 ± 7.2%, $P = 0.08$). The steady-state exercise group showed no improvement in these variables after the intervention period (King, Panton, Broeder, Browder et al., 2001).

The studies noted above and in Table 2.8 would suggest that interval exercise may be a more effective intervention to use in overweight populations than steady-state aerobic exercise. The constantly changing pace of interval exercise may also make this form of exercise more interesting to participate in, as compared to a long bout of steady-state aerobic exercise, which may consequently contribute to greater exercise adherence (King, Panton, Broeder & Browder, 2001). Further to this, interval exercise may result in higher energy expenditure as a result of a greater and longer EPOC. According to Hunter et al. (1998), the development of time-efficient programmes that increase metabolic rates are vital in stemming the increased prevalence of obesity, and consequently further studies are needed in order to investigate the impact of interval exercise on weight loss and fitness in an obese population.

Table 2-8: Results of studies that have investigated the effects of interval training in an obese population.

STUDY	SUBJECT DATA	STUDY DESIGN	EXERCISE INTERVENTION	VARIABLES MEASURED	SIGNIFICANT FINDINGS
(Kaminsky & Whaley, 1993)	5 normal weight women and 5 obese women (n = 10)	Cross-over Design	Steady-state exercise (60% $\dot{V}O_{2max}$) Interval exercise (3 mins 30% $\dot{V}O_{2max}$ / 3 mins 90% $\dot{V}O_{2max}$)	EPOC EE	↑ Postexercise $\dot{V}O_{2max}$ above baseline following interval (37.5±6.8mins) compared to steady-state (+16.5±1.5min) ($P < 0.01$) ↑ magnitude of EPOC following interval (+17.4±2.0kcal) compared to steady-state (+9.0±0.6kcal) ($P < 0.01$) ↑ EPOC/EOC ratio following interval (+7.4±0.7%) compared to steady-state (+3.9±0.3%) ($P < 0.01$)
(King et al., 2002)	15 obese women	8-weeks Randomised	High intensity interval group (2 mins 95% $\dot{V}O_{2max}$ / 3 mins 25% $\dot{V}O_{2max}$; n = 7) Lower intensity steady state group (50% $\dot{V}O_{2max}$; n = 8)	EPOC	Interval group showed at 0.85 RER: ↑ $\dot{V}O_2$ (13.59±3.85 to 16.53±2.70ml/kg^{-1}/min^{-1}; $P < 0.05$) ↑ Kcal/min/kgBW (0.066±0.18 to 0.081±0.013; $P < 0.05$) ↑ Kcal.min/kg/FFW (0.113±0.026 to 0.143±0.018; $P = 0.01$) ↑ Absolute $\dot{V}O_2$ (1.21±0.26 to 1.49±0.28L/min; $P = 0.08$) ↑ kcal/min (5.88±1.27 to 7.26±1.35; $P = 0.08$)

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(King, Panton, Broeder, Browder et al., 2001)	15 obese women	8-weeks Randomised	High intensity interval group (2 mins 95% $\dot{V}O_{2max}$ / 3 mins 25% $\dot{V}O_{2max}$; n = 7) Lower intensity steady state group (50% $\dot{V}O_{2max}$; n = 8)	Fitness Body composition	Interval group showed: 13.1% improvement in $\dot{V}O_{2max}$ (25.2 ± 4.2 ml/kg^{-1}/min^{-1} to 28.5 ± 5.1 ml/kg^{-1}/min^{-1}, $P < 0.03$) 5.4% increase in RMR assessed 24 hours after exercise (1671 ± 406 kcal/day to 1761 ± 412 kcal/day, $P < 0.04$) 4.8% decrease in body fat percent (45 ± 8.4% to 42.8 ± 7.2%, $P = 0.08$).

2.7.3 Determining the Work to Relief Ratio of an Interval Exercise Programme

Prior to commencing an interval training programme, it is important to determine the optimal work/relief duration in order to elicit the most effective results (Billat et al., 2001). Franch, Madsen, Djurhuus and Pedersen (1998) studied moderately trained recreational runners over a six-week period. The three exercise interventions used in this study consisted of continuous steady-state running performed at 90% of $\dot{V}O_{2max}$, long interval exercise (4:2 mins work/relief ratio) and short interval exercise (15 - 15 seconds work/relief ratio) performed at supra-$\dot{V}O_{2max}$ levels. The researchers found that the greatest improvements in aerobic fitness were associated with the long interval exercise which showed a 6.0% improvement in $\dot{V}O_{2max}$ (4.22 to 4.47 $L.min^{-1}$), compared to 5.9% (3.89 to 4.12 $L.min^{-1}$) and 3.6% (4.10 to 4.24 $L.min^{-1}$) for the steady-state and short interval exercise group, respectively (Franch et al., 1998). Millet, Candau, Fattori, Bignet and Varray (2003) studied eight well trained triathletes who exercised at 100% and 50% of $\upsilon\dot{V}O_{2max}$. Three different interventions were compared comprising of work/relief intervals performed at 30 – 30 seconds, 60 - 30 seconds or half exercise time to exhaustion - half exercise time to exhaustion ($½T_{lim}$). Results demonstrated that intermittent running sessions of the same overall running time, but with different work interval durations, led to different individual responses in $\dot{V}O_2$ and heart rate in athletes. Peak oxygen uptake values were significantly lower in the 30 - 30 seconds group (65.4 ± 4.9 $ml/kg^{-1}/min^{-1}$) compared to the other two groups (60 - 30 seconds group: 71.7 ± 4.8 $ml/kg^{-1}/min^{-1}$ and $½T_{lim}$: 72.2 ± 6.1 $ml/kg^{-1}/min^{-1}$). This trend also occurred in peak heart rate values with the 30 - 30 seconds group also displaying significantly lower values (183.1 ± 8.5bpm) compared to the other two groups (60 - 30 seconds group: 188.8 ± 10.4bpm and $½T_{lim}$: 187.0 ± 11.4bpm) (Millet et al., 2003). This study further supports the use of long interval intermittent runs. Additionally, after reviewing several articles, Billet (2001) concluded active recovery (interval exercise) had several benefits over passive recovery as it not only elicits and maintains $\dot{V}O_{2max}$ but also stimulates lactate removal. As there has been minimal investigation of interval exercise in an obese population the ideal work to relief ratio of interval exercise is still unknown. Further studies are needed to explore this concept, especially in relation to body composition.

2.7.4 Summary of Interval Training

An individually-tailored interval exercise regime that incorporates low intensity exercise periods that can be performed at a comfortable walking pace, combined with high intensity exercise represented by a walking or jogging pace not normally undertaken yet achievable, should be suitable for use in an obese population. This regime may result in the following changes that affect aerobic capacity and energy expenditure:

(1) The high intensity periods of exercise should overload the anaerobic energy system encouraging adaptation as characterised by improved aerobic and anaerobic fitness (Hunter et al., 1998; McArdle et al., 2001). Consequently, interval exercise should increase maximal oxygen uptake (Brooks et al., 2000);

(2) The low intensity exercise periods allow for partial recovery from the higher intensity exercise in that heart rate (bpm) falls, oxygen and adenosine triphosphate and phosphocreatine (ATP-PC) stores are partially replenished, and greater removal of lactic acid can occur (Fox et al., 1993). This process is likely to increase the total duration of exercise undertaken by an individual compared to what may have been achieved if only high intensity exercise was undertaken (Brooks et al., 2000). This will result in higher overall calorie burning (Quinn, Vroman & Kertzer, 1994);

(3) Compared to lower intensity exercise performed at a constant pace, the higher intensity exercise component of interval exercise should result in a higher body temperature, higher levels of hormone activation, increased lactic acid production and a greater depletion of oxygen stores, which ultimately results in an increased recovery time or EPOC (Sharkey, 1990). A longer EPOC after higher intensity exercise has been reported by a number of researchers (Bahr, Opstad, Medbo & Sejersted, 1991; Gore & Withers, 1990; McArdle et al., 1996; Quinn et al., 1994; Sedlock, Fissinger & Melby, 1989; Treuth et al., 1996). More specifically, Kaminsky and Whaley (1993) reported a higher EPOC after interval exercise compared to steady-state exercise. As EPOC is associated with an elevated metabolic rate (Borsheim & Bahr, 2003; Sedlock et al., 1989), a longer EPOC period will result in increased energy expenditure (Quinn et al., 1994), which should promote weight loss;

(4) High intensity exercise performed over a period of time has been shown to increase RMR (Borsheim & Bahr, 2003; Treuth et al., 1996), which may be a result of an increase in muscle mass that is associated with this form of exercise (King, Panton, Broeder & Browder, 2001). Consequently, interval exercise (which incorporates a high intensity exercise component) may also result in a higher RMR, if performed regularly over a period of time, with a concomitant increase in energy expenditure and weight loss (King, Panton, Broeder & Browder, 2001). According to Quinn et al. (1994), elevated metabolism is vital for successful weight loss, as it facilitates weight loss even if the individual is not exercising (King, Panton, Broeder & Browder, 2001);

(5) It has often been thought by the general public that when weight loss is desired, exercise should be completed at a low intensity as a greater percentage of fat is oxidised. Even though high intensity exercise uses a lower percentage of fat and a higher percentage of carbohydrate oxidation for energy compared to low intensity exercise, the absolute rates of fat oxidation are similar (Hansen et al., 2005; King, Panton, Broeder & Browder, 2001). The substrate utilisation is not only limited to the exercise bout, as exercise can alter nutrient oxidation and metabolism after the bout has been completed. Even if the effects of exercise are small to modest, the post-exercise phase constitutes a longer time period and can result in a major cumulative effect (Hansen et al., 2005). According to King et al. (2001) the total number of fat calories used during and after exercise for a given duration is actually greater during high intensity exercise compared to low intensity exercise (King, Panton, Broeder & Browder, 2001). Additionally, after high intensity exercise fat metabolism may be further increased if it is used to replenish the depleted glycogen stores (King, Panton, Broeder & Browder, 2001).

2.8 Conclusion

The health burden of obesity, particularly in Western society, is of grave concern, as this disorder is associated with an increased risk of morbidity and mortality, as well as large financial costs, both to the individual and to society (Grundy et al., 1999). Obesity can also reduce quality of life and result in psychological and psychosocial problems in some individuals (Hamilton & Greenway, 2004; Stewart & Brook, 1983). Reductions in the prevalence of obesity can increase life expectancy,

reduce pressure on the health care system, as well as result in large financial savings (National Health and Medical Research Council, 1997).

From the preceding review of the literature, it can be concluded that 30 minutes of aerobic exercise combined with a moderate caloric restricted diet represents a successful weight loss intervention in an obese population. It has also been noted that intermittent aerobic exercise (several exercise bouts completed throughout the day) allows greater flexibility in completing a daily exercise regime, yet still produces similar if not greater benefits than continuous aerobic exercise (one long constant exercise bout) of the same total duration. Further to this, interval exercise (exercise interspersed with high and low intensity exercise) has been shown to improve fitness and increase metabolism both during and after an exercise session. A higher metabolic rate results in greater caloric expenditure, which should promote weight loss, if total daily energy expenditure is greater than total daily caloric intake. Additionally, levels of exercise intensity used during interval exercise can be manipulated to suit each individual's fitness level. Consequently, it is proposed that an intervention that consists of diet and interval training that is performed intermittently over the course of a day may produce greater health benefits and weight loss than an intervention consisting of both diet and intermittent training with steady-state exercise. Therefore this study will assess the efficacy of diet and intermittent, interval exercise in an overweight and obese population.

CHAPTER 3

Methods

3.1 Recruitment of Participants

In order to recruit participants, the primary researcher conducted presentations, which outlined the research study, to groups of individuals attending a weight loss organisation. Interested individuals were issued with a flyer about the study (see Appendix A) and were asked to complete a questionnaire (see Appendix B), which was used to assess the individual's eligibility for the study. Exclusion criteria were also noted on this questionnaire, which included, if individuals were aged younger than 18 or older than 65 years of age, their BMI was less than 27 kg/m^2, they participated in more than 20 minutes of exercise on three or more times per week, they were pregnant, they were taking certain medication (i.e. beta blockers, BP medication, thyroid medication) they were diabetic, they had a BP greater than 160/90, they had lost more than five kilograms in the last three months or they had musculoskeletal problems that prevented walking. All interested individuals were contacted via phone and informed whether or not they were eligible to participate in the study.

The original aim of the study was to recruit 30 participants (15 per group). A total of 125 individuals responded to the questionnaire. Of this number, 65 people were excluded because they did not meet the study's criteria (based on responses to the questionnaire). Of the remaining 60 people, a further 14 individuals withdrew after reading the information letter, while 2 individuals were rejected as a result of their blood lipid profile. Of the 44 participants who commenced the study, 2 withdrew during the pre-testing stage due to work commitments and sickness, while another participant was excluded due to the results of a GXT. The remaining 41 participants were matched and randomised into either the INT ($\underline{n}$ = 21) or the SS ($\underline{n}$ = 20) group. Participants were randomised by time of entry into the study (once the first individual was accepted to participate in the study they were placed in Group A with the second participant being placed into Group B and so on). During the course of the intervention,

9 participants from the group and 6 participants from the SS group withdrew from the study. Reasons given for withdrawals from steady-state exercise were time constraints (n = 4) and work commitments (n = 2). Participants withdrew from interval exercise because of time constraints (n = 4), work commitments (n = 1), sickness (n = 1), holidays (n = 1), could not be contacted (n = 1) and pregnancy (n = 1). Therefore the total number of individuals, who participated in the present study, by completing the majority of testing requirements, pre and post-intervention, was 26 (SS group, n = 14 and INT group, n = 12).

Prior to testing, all procedures were explained and participants were required to read an information sheet (see Appendix C) and sign an informed consent form (see Appendix D). This research study was approved by the University of Western Australia Human Ethics Committee.

3.2 Baseline Measurements

Prior to the start of the interventions, baseline measurements were performed for a number of variables. The first assessment required participants to attend a pathology clinic in order to have a blood profile analysis performed. Subsequent to this assessment, participants were then required to attend Royal Perth Hospital (RPH) in order to have their BMI, BP and $\dot{V}O_{2max}$ assessed. Randomly selected participants also had their vascular function assessed. Finally, participants were required to attend the Human Performance laboratory at the University of Western Australia (UWA) in order to have their resting metabolism, body composition and segmental girths measured. Also, during this visit, participants were required to complete two questionnaires related to well being, depression and anxiety.

3.2.1 Aerobic Fitness

3.2.1.1 Protocol

The protocol chosen for the GXT was the modified Balke protocol (see Figure 3.1) (Balke & Ware, 1959). This test was chosen as a constant treadmill speed

throughout the test was desirable as it requires only initial adaptation in stride and produces less electrocardiogram (ECG) and BP artefacts than protocols that involve increasing speeds (Callaham et al., 1989). The protocol required participants to perform a walking test where the speed was set at five kilometres per hour, while the grade increased incrementally every three minutes until the participant could no longer continue (see Figure 3.1). The test was terminated if the researchers noted any physiological abnormalities. During the exercise test, ratings of perceived exertion (RPE; Borg, 1982) and BP were recorded at the end of every stage, while a 12-lead ECG (Cardiofax V Ecaps 12, 8370K, Nihon Kohden Corporation, Tokyo, Japan; see Figure 3.2) assessment was performed by an experienced clinical exercise physiologist. Heart rate was recorded every minute during the exercise test and for ten minutes following the completion of the exercise test using the ECG printout. Oxygen uptake was also assessed during the exercise test. Details regarding this measurement are noted below in section 3.2.1.3. Throughout the exercise test the researchers regularly communicated with the participant in order to ensure that they were not experiencing any problems, as well as to encourage a maximal effort.

STAGE	TIME (mins)	SPEED (km)	GRADE (%)
1	0 - 3	5	0
2	3 - 6		2.5
3	6 - 9		5
4	9 - 12		7.5
5	12 - 15		10
6	15 - 18		12.5
7	18 - 21		15
8	21 - 24		17.5
9	24 -27		20

Figure 3-1: Modified Balke protocol.

Figure 3-2: 12-lead electrocardiogram machine.

3.2.1.2 Measurement of Oxygen Consumption during the Graded Exercise Test

Prior to each participant's arrival, the flow sensor (Vmax Mass Flow Sensor) of the metabolic cart was calibrated and then secured to the mixing chamber (Vmax, SensorMedics, Yorba Linda, CA). On arrival, the participant's demographics were entered into the computer programme (Vmax Vision Software for Windows, Version 05-2A, SensorMedics), and also into the ECG monitor. Gas analysers were then calibrated using reference gases of known concentration to ensure that the correct percentages of oxygen and carbon dioxide levels would be recorded throughout the test. Headgear was placed on the participant's head and the mouthpiece was secured in a comfortable position. A nose clip was also attached so that no air could pass through the nose. The participant was then instructed to stand on the electronically controlled treadmill (Series 2000 Treadmill, SensorMedics, WI, USA**;** see Figure 3.3) and to breathe as normally as possible whilst three minutes of baseline measurements were recorded. The volume of inspired and expired air was sampled every 20 seconds. Ventilation ($\dot{V}_E$), and respiratory exchange ratio (RER) were also recorded at 20 second intervals (see Figure 3.4). Oxygen uptake was calculated from minute ventilation, which was measured using mass flow ventilometry and mixing chamber analysis of expired gas fractions. For an example of a typical printout of the GXT data and an example of the calculations, see Appendix E. This appendix also includes an example graph of how the equivalent heart rate to oxygen consumption ($\dot{V}O_2$) was determined, as well as an example ECG trace print out.

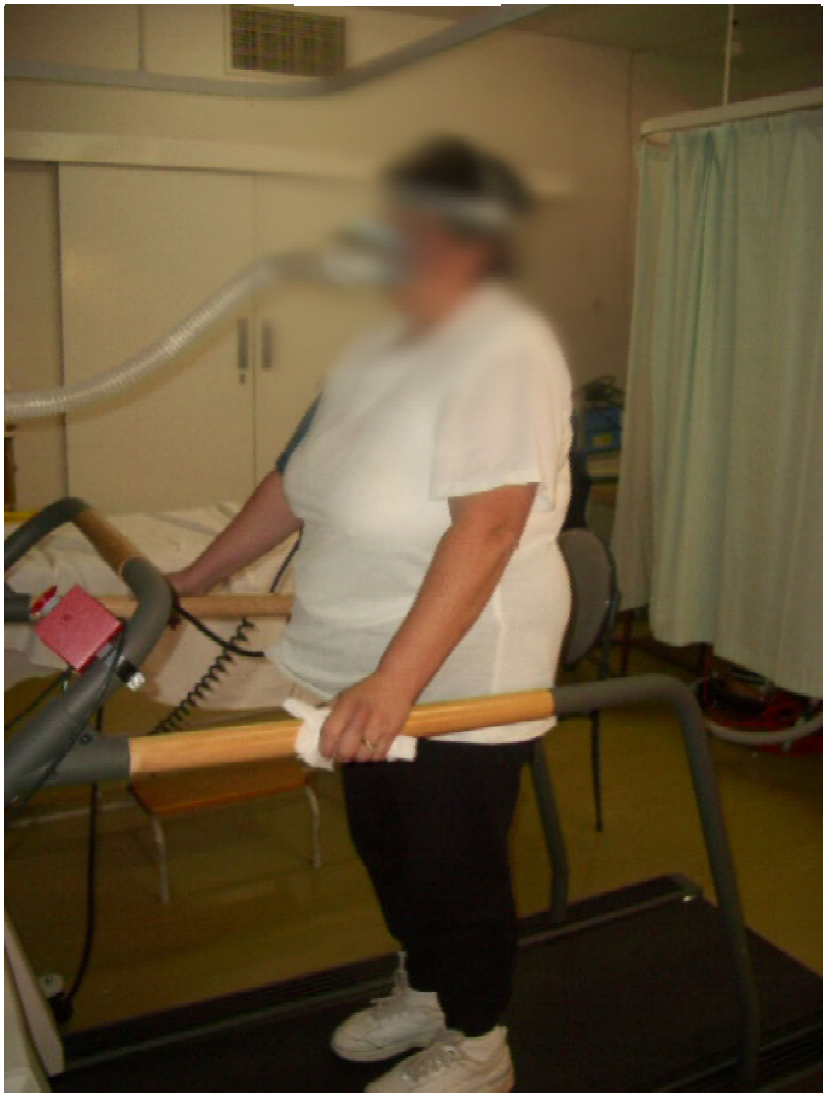

Figure 3-3: Participant with the headgear and nose clip on the treadmill.

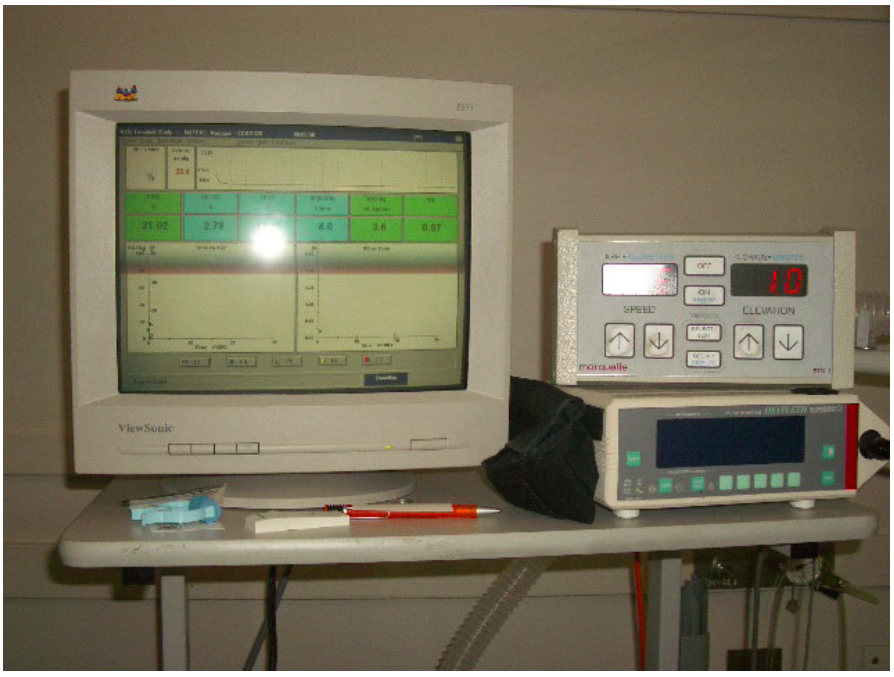

Figure 3-4: Computer used to collect data.

3.2.1.3 Measurement of Blood Pressure

Blood pressure was measured manually using a sphygmomanometer and a stethoscope. Blood pressure was assessed in a quiet room prior to the exercise test and then again during the last minute of each stage of the graded exercise test. Blood pressure was further assessed three and seven minutes post exercise.

3.2.1.4 Measurement of Rate of Perceived Exertion

Rate of perceived exertion was measured using a Borg Scale, which uses a numbering system of 6-20 to indicate how hard the participant perceives the exercise to be, with a higher number indicating harder exercise.

3.2.2 Blood Profile

Participants were required to undergo a fasted blood test at a pathology clinic that assessed general haematology, including a full blood count, as well as liver function (aspartate transaminase, gamma glutamyltransferase, alanine aminotransferase), renal function (urea, creatinine, sodium, potassium), thyroid function (thyroid stimulating hormone), general biochemistry (glucose, uric acid) and lipid profile (cholesterol, triglycerides, HDL, LDL, VLDL and coronary risk ratio). Testing was also performed to determine participant's c-peptide, haemoglobin A1c, insulin-like growth factor, c-reactive protein and fasting insulin levels. On the basis of abnormal liver function tests, a number of subjects were excluded from participation. If the participant's blood profile was unacceptable for this study, the weight loss organisation where participants were recruited, informed the participant and the participant's general practitioner via written communication.

3.2.3 Resting Metabolism

3.2.3.1 Resting Metabolic Rate

As RMR is affected by the menstrual cycle (Donahoo, Levine & Melanson, 2004) all pre-menopausal females participants were required to make their appointment when they were in the luteal phase of their menstrual cycle (within 14-days of their next

menstruation) (Kaminsky et al., 1990). Each individual fasted for a 12-hour period prior to testing. On arrival, the participant was asked to lie quietly on a bed in a supine position and to rest as best as they could. The lights in the room were turned off and peaceful music played in the background. A rug and pillow were supplied in order to make the participant as comfortable as possible during the testing session. The participant rested for 20 minutes before a mouthpiece was inserted and a nose clip was attached (see Figure 3.5). The subject was instructed to inspire and expire normally into the mouthpiece. Prior to testing, the subject breathed into a 120 litre chain compensated Tissot gasometer tank (Collins Inc, Braintree, Massachusetts; see Figure 3.6) over an eight-minute period. The tank was subsequently flushed, with the participant's expired air, on two occasions. The flushing process is designed to remove any previously measured residual gases that may have been in the tank so to avoid sample contamination. After the flushing procedure had been performed, the initial volume of the tank was recorded and once the participant had rested for 29 minutes, a further one-minute of respiratory gases was collected into the tissot tank. The final gas volume, gas temperature and barometric pressure of the room were then recorded. A rubber two litre sample bag, which had been vacuumed prior to collection, was used to collect a gas sample from the tank. A standard gas analysis system comprising of an oxygen gas analyser (Servomex Basic O_2 Anlyser, 500A, Crowborough, Sussex, England) and a carbon dioxide gas analyser (Datex Normocap CO_2 monitor, CD102, Helsinki, Finland) were used for measurement of the fractional concentration of carbon dioxide and oxygen in the expired air, respectively. Expired gases were assessed by analysing one minute of the sample gas and averaging the last 15-seconds of the minute. The gas analysis system was calibrated prior to testing using three certified gravimetric beta-grade gas mixtures (BOC Gases, Chatswood, Australia) of known concentrations. The barometric temperature was converted to mmHg by multiplying by 0.75. The participant's data, the barometric pressure and the corrected water vapour temperature were then entered into an Excel spreadsheet programme that was designed to compute the individual's RMR, energy expenditure (kilocalorie; kcal), RQ and percentage of CHO and fats oxidised during rest.

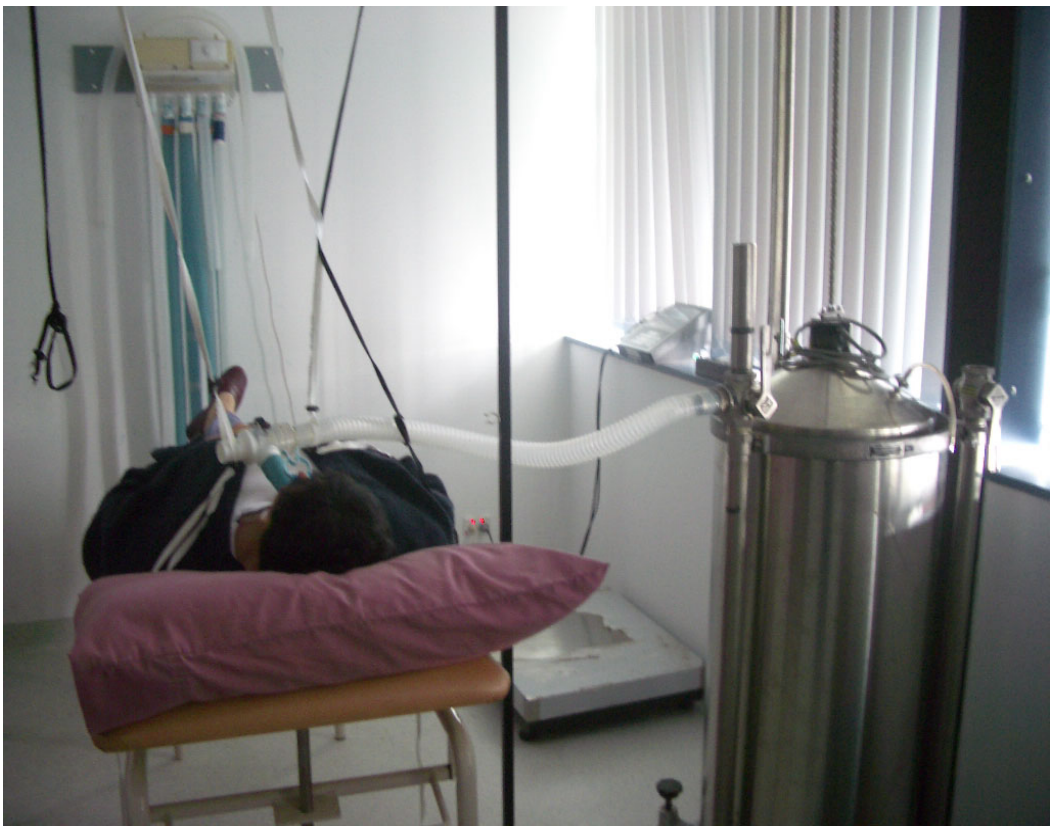

Figure 3-5: RMR testing.

Figure 3-6: Tissot tank used to collect expired air.

3.2.4 Body Composition

3.2.4.1 Body Mass Index

On arrival, the participant removed their footwear and any heavy items that they were wearing eg. jumpers. Height was recorded to the nearest 0.01 cm while the participant stood as straight as possible in the anatomical position, with their back against a standard stadiometer. Weight was measured to the nearest 0.01 grams using a calibrated scale (HW-200KGL, A&D Weighing Ltd, CA, USA; see Figure 3.7). Each individual's BMI was then determined by the following formula: body mass (kg) / height (m^2). This assessment ensured that all the participants had a BMI either equal to or greater than 27 kg/m^2.

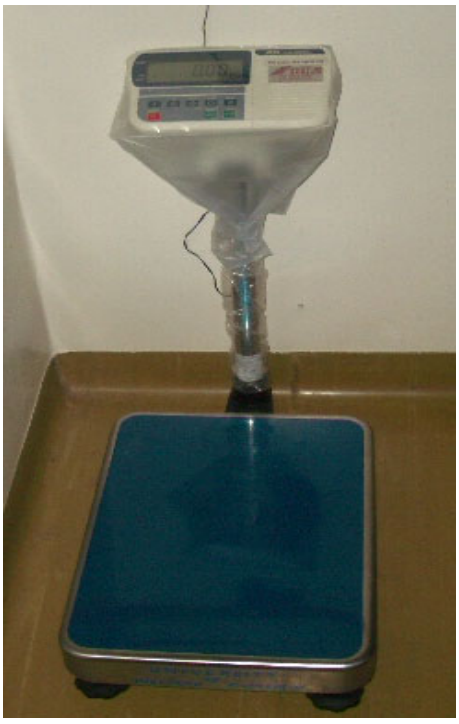

Figure 3-7: Calibrated scale.

3.2.4.2 Dual Energy X-ray Absorptiometry

Body composition was assessed using a DEXA scanner (GE Lunar Prodigy Vision DEXA machine, GE Medical Systems, Madison, WI; see Figure 3.8). Prior to participant arrival, the scanner was calibrated via a two-part process. First, system diagnostics were tested using a calibration standard known as a daily quality assurance scan. This was then followed by a quality control spine phantom scan that assessed the precision and accuracy of the scan. This resulted in precise measurements of whole body fat, regional fat and lean tissue mass.

As DEXA uses radiation (approximate dosage from a total-body scan being 0.4 – 2.0 μSv), all female participants of childbearing age were required to check for pregnancy prior to their scan. On arrival, all participants signed a form that provided detail regarding radiation exposure, while relevant individuals were required to confirm that they were not pregnant. Participants were asked to remove their footwear and any metal objects that they were wearing (i.e. jewellery) and to lie on the scanning bed in a supine position. The researcher explained that participants were required to lie as still as possible for approximately seven to ten minutes. The scanning process resulted in the quantification of each individual's bone mineral content, total fat mass and lean tissue mass (McArdle et al., 2001). The scans were validated by ensuring the bone mineral content was the same for each body segment for both pre-testing and post-testing (Watts et al., 2005). Approval was gained from the Radiation Protections Office to use DEXA in the present study. For an example of a typical printout of the DEXA data, see Appendix F.

Figure 3-8: Dual Energy X-ray Absorptiometry.

3.2.4.3 Girth Measurements

Girth measurements were taken at the waist and the hip using a girth tape (Lufkin, Executive Thinline Steel Tape). The participant assumed a standing position and the tape measure was placed around the participant's body. The waist girth was

defined as the level of the narrowest point between the tenth rib and the iliac crest. The measurement was taken at the end of the participant's expiration. The hip girth was measured with the participant's feet together and taken at the level of greatest posterior protuberance of the buttocks. The participant relaxed their arms by their sides during both measurements and the researcher used the cross hand technique to position the tape ensuring that it did not excessively indent the skin (ISAK, 2001). Segmental girth measurements have been shown to provide more accurate assessment of the regional distribution of body fat than gross body weight (Watts et al., 2005).

3.2.5 Vascular Function

In the present study, conduit vessel function was assessed using high-resolution brachial artery ultrasound images in order to determine the brachial artery diameter response to a brief period of forearm ischemia and, subsequently, sublingual GTN administration. Flow mediated and GTN mediated vasodilation were expressed as a percentage of the resting vessel diameter.

Participants fasted for a minimum of four hours prior to testing. Testing was conducted in a quiet, temperature controlled laboratory, and upon arrival participants were required to rest in a supine position on a bed while an automated sphygmomanometer cuff (Dinamap, Critikon, Paris) was placed on their right arm. The researcher exposed the individual's left arm, aligned the supinated distal forearm perpendicular to their body, and secured the arm in a foam capsule (see Figure 3.9). A rapid inflatable pneumatic cuff, which provided the stimulus for FMD, was attached to the forearm, distal to the humeral epicondyles, of the participant's left arm. The three-lead ECG allowed continuous monitoring of heart rate. Mean arterial pressure (MAP) was determined via measuring SBP and diastolic blood pressure DBP using the automated sphygmomanometer (MAP = DBP + [0.333 (SBP-DBP)]). A 10 MHz multi-frequency linear array probe, which was attached to a high-resolution ultrasound machine (Aspen, Acuson/Seimens, Malvern, PA), was used to image the brachial artery and was repositioned until a clear image of the lumen and arterial wall interface was visible on the computer (see Figure 3.10 and 3.11). Once a suitable image was attained

the probe was held in a stable position, via a stereotactic clamp and optimal ultrasound parameters were set for the remainder of the study.

3.2.5.1 Measurement of Diameter

To assess endothelium-dependent dilation and blood flow, three minutes of baseline measurements were recorded, allowing assessment of the internal diameter of the brachial artery at rest. After baseline measurement, the pneumatic cuff was inflated to 200 mmHg for five minutes in order to induce ischemia. After this ischaemic period, the cuff was rapidly deflated, causing reactive hyperaemia, augmented shear stress and FMD in the brachial artery of the arm. Images were recorded for 30 seconds before cuff deflation and for another five minutes after cuff deflation**.**

Participants rested for a further ten minutes to allow arterial diameter to return to normal. Glyceryl trinitrate (GTN; Nitroglyceride, 400µg, "Nitrolingual pumpspray" Aventis Pharma, Lane Cove, NSW) was then administered in spray form, which induced an endothelium-independent dilation response in the brachial artery, meaning that GTN effects the smooth muscle causing the vessel to dilate independently of the endothelium (Celermajer et al., 1992). Participants were asked to abstain from swallowing the drug for a 30 second period in order to allow the drug to be absorbed instead of digested. Images were then recorded for a ten minute period. This procedure was performed to measure the response of artery diameter and blood flow to GTN.

3.2.5.2 Reproducibility

This non-invasive technique is a well established method of assessing endothelial dysfunction (Doshi et al., 2001; Joannides et al., 1995) and had been reported to be both reproducible and reliable (Sorensen et al., 1995). Data was analysed using custom-designed edge-detection and wall-tracking software. This procedure has been proven to be a valid and reproducible analysis method and is described in detail in Woodman et al. (2001). Comparison between the FMD response during rest and the response after GTN administration were conducted. Mean diameter, velocity and blood flow measurements were determined.

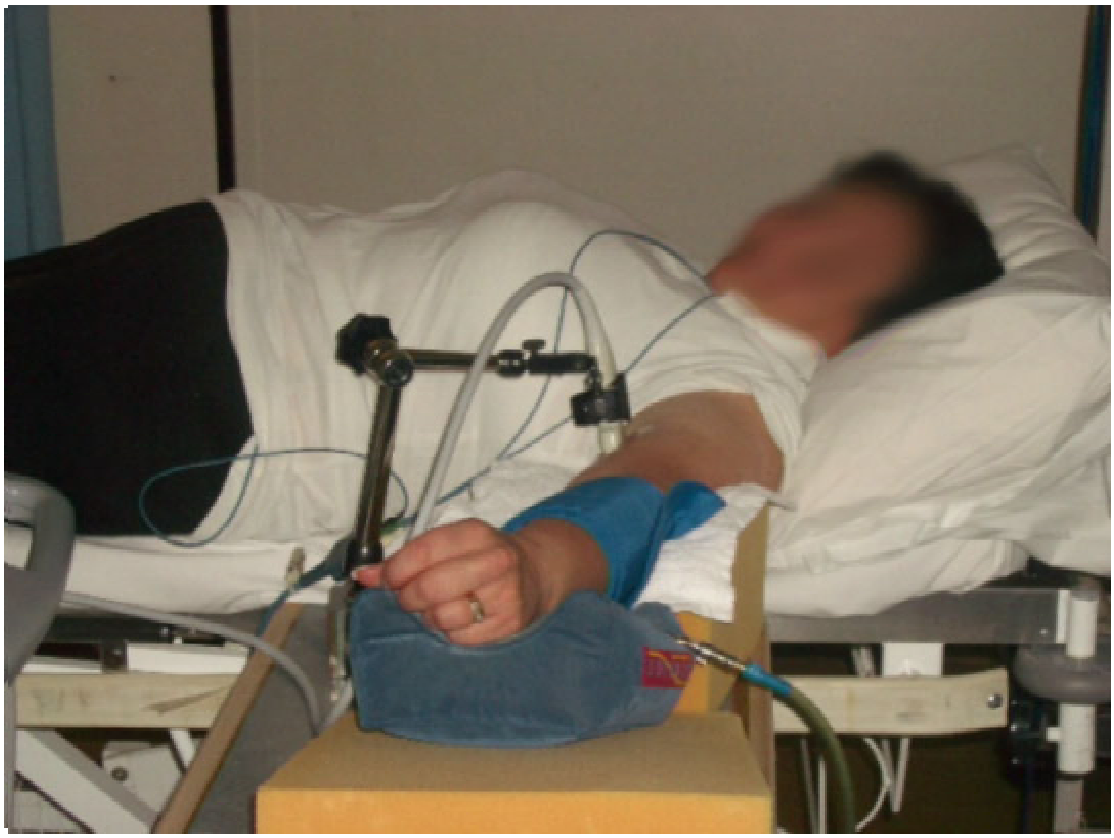

Figure 3-9: Participants arm in a supine position on the foam capsule with the probe attached.

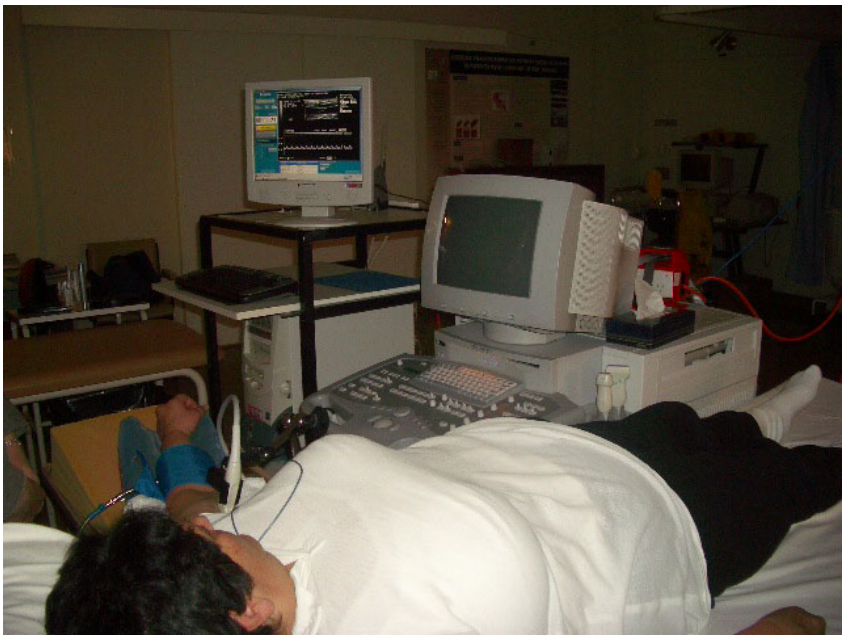

Figure 3-10: The set-up for vascular function testing.

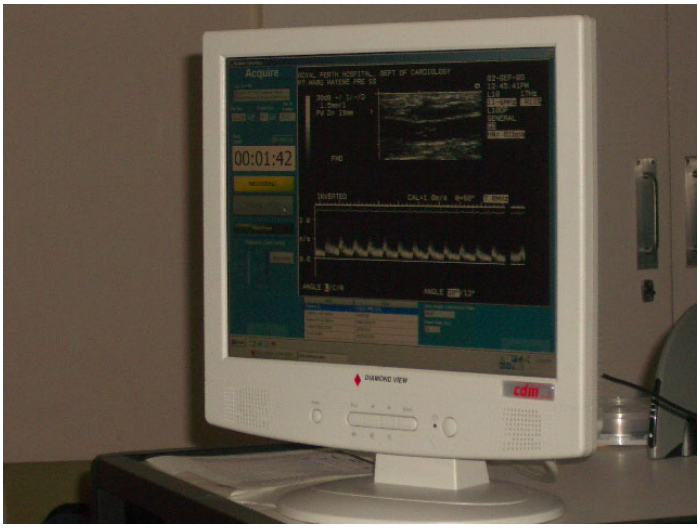

Figure 3-11: The computer used to image the blood vessel diameter and blood flow.

3.2.6 Quality of Life Questionnaires

On completion of the RMR test, participants were required to fill in the SF-36 (wellbeing levels) questionnaire and the HADS (anxiety and depression levels) (see Appendix G).

3.2.6.1 Short Form -36 (SF-36)

The SF-36 is a multipurpose, short form health survey. It consists of 36 questions designed to assess general health and wellbeing. It measures eight domains of health including physical functioning, role limitations due to physical health, bodily pain, general health perceptions, vitality, social functioning, role limitations due to emotional problems and mental health. The physical functioning dimension indicates to what extent a person is limited by their health in performing different physical activities. Role limitations due to physical health are the effects of physical health on the performance of work and daily activities, whilst the bodily pain sub-section of the questionnaire looks at the severity of bodily pain and whether it interferes with daily activities. General health is a measure of the individual's current expectation and perception of their health compared to the health of others, while vitality is an indicator of an individual's energy and fatigue levels. Social function is determined by the impact of health and emotional problems on the quality and quantity of social interaction with others, while role limitations due to emotional problems indicate the effects of emotional problems on work performance or daily activities. Finally, mental

health signifies the amount of time an individual feels nervous, anxious, depressed or happy. This questionnaire is used extensively and has been reported to be a reliable and valid measure in clinical and population settings (Australian Bureau of Statistics, 1997).

3.2.6.2 Hospital Anxiety and Depression Scale (HADS)

The most commonly encountered emotional disorders are anxiety and depression (Moorey et al., 1991). The HADS is a valid measure for assessing the severity of anxiety and depression and functions as two scales to measure the two distinct mood states. Psychometric properties have been established for HADS (Moorey et al., 1991), while reliability and validity have also been confirmed (Clark & Fallowfield, 1986; Moorey et al., 1991; Zigmond & Snaith, 1983). The HADS was scored according to the standard protocol outlined in the HADS manual (Snaith & Zigmond, 1994), with both scales marked out of a possible total score of 21.

3.3 Interventions

Having completed baseline measurements, participants were then matched in groups of two according to gender, age and BMI. Participants were then block randomised to one of two intervention groups that consisted of (1) steady-state aerobic exercise and diet (SS) and (2) interval exercise and diet (INT) (see Figure 3.12). All exercise sessions were home based and monitored via phone communication.

SS Group	**INT Group**
Diet + Steady-State Aerobic Exercise (performed 2 x 15 mins on 5 days per week)	Diet + Interval Training (performed 2 x 15 mins on 5 days per week)

Figure 3-12: Schematic drawing of the **t**wo intervention groups.

3.3.1 Dietary Control

Independent of what group participants were assigned too, all participants participated in a strict diet developed and implemented by a weight loss organisation. This diet consisted of a low carbohydrate (low glycemic), moderate fat diet. The macronutrient breakdown was approximately 50 percent carbohydrate, 30 percent fat (mostly monosaturated fat) and 20 percent protein. Caloric intake was individually restricted for all participants based on their height and weight, with restrictions generally equalling approximately 1200 kcals for women and 1400 kcals for men. Participants attended weekly weigh-ins with the weight loss organisation. Participants were asked to contact the investigator if they did not follow their recommended diet regime.

3.3.2 Exercise Interventions

3.3.2.1 Groups

3.3.2.1.1 Steady-State Aerobic Exercise and Diet Group

Individuals in the SS group participated in continuous walking, performed twice a day in 15 minute bouts. These sessions were completed throughout the day with at least three hours separating each exercise bout in order to eliminate any residual physiological effects of previous bouts. Exercise was performed on five days of the week. The SS group only participated in walking that was performed at a constant intensity for the entire 15 minutes (see Figure 3.13), which was set at approximately 50 percent of individual symptom limited $\dot{V}O_{2peak}$ (based on the GXT). Heart rate values (bpm) recorded during the GXT that equated to these individual percentages of $\dot{V}O_{2peak}$ were determined, in order to provide a guide (with the assistance of a heart rate monitor; Polar F3 Electro Oy, Kempele, Finland), to the intensity that participants needed to walk at during their exercise sessions.

0 – 15 mins
Moderate Intensity (HR equivalent of 50% $\dot{V}O_{2peak}$)

Figure 3-13: Diagrammatic presentation of the 15 minutes of intermittent aerobic exercise completed by the SS group.

At the beginning of the seventh-week of the exercise intervention, exercise intensity was increased from 50 to 55 percent of individual $\dot{V}O_{2peak}$ in order to account for any improvements in aerobic capacity that may have resulted from the previous six-weeks of exercise. The individual heart rate values that occurred at these higher intensities were calculated for each participant and participants were then instructed to exercise at these higher levels using their heart rate monitor for guidance.

3.3.2.1.2 Interval Exercise and Diet Group

Individuals in the INT group participated in a walking/jogging regime (depending on what level of activity the desired individualised heart rate correlated to) that was performed twice a day in 15 minute bouts. The sessions were completed throughout the day with at least three hours separating each exercise bout in order to eliminate any residual physiological effects of previous bouts. Exercise was performed on five days of the week. Each 15 minute bout of exercise commenced with two minutes of low intensity exercise, followed by one minute of high intensity exercise, repeated five times throughout the bout. Normally, a ratio of 1:1 is suggested when training the aerobic system using interval training (McArdle et al., 2001), however the researchers considered a ratio of 2:1 (low to high intensity) to be more appropriate in an obese population. The low and high intensity levels were set at approximately 40 percent and 70 percent of individual symptom limited $\dot{V}O_{2peak}$ (based on the GXT), respectively. Heart rate values (bpm) recorded during the GXT that equated to these individual percentages of $\dot{V}O_{2peak}$ were determined, in order to provide a guide (with the assistance of a heart rate monitor; Polar F3 Electro Oy, Kempele, Finland), to the intensity that participants needed to walk/jog at during their exercise sessions. Every effort was made to equate the average total intensity of each exercise bout between the two exercise groups. An example of the interval exercise protocol is shown below in Figure 3.14.

0 - 2 mins	2 - 3 mins	3 - 5 mins	5 – 6 mins	6 – 8 mins
Low Intensity (HR equivalent of 40% $\dot{V}O_{2peak}$)	High Intensity (HR equivalent of 70% $\dot{V}O_{2peak}$)	Low Intensity (HR equivalent of 40% $\dot{V}O_{2peak}$)	High Intensity (HR equivalent of 70% $\dot{V}O_{2peak}$)	Low Intensity (HR equivalent of 40% $\dot{V}O_{2peak}$)

8 – 9 mins	9 – 11 mins	11 – 12 mins	12 – 14 mins	14 – 15 mins
Low Intensity (HR equivalent of 40% $\dot{V}O_{2peak}$)	Low Intensity (HR equivalent of 40% $\dot{V}O_{2peak}$)	High Intensity (HR equivalent of 70% $\dot{V}O_{2peak}$)	Low Intensity (HR equivalent of 40% $\dot{V}O_{2peak}$)	High Intensity (HR equivalent of 70% $\dot{V}O_{2peak}$)

Figure 3-14: Diagrammatic presentation of the 15 minute block of interval training completed by the INT group.

At the beginning of the seventh-week of the exercise intervention, exercise intensity was increased by five percent of each individual's $\dot{V}O_{2peak}$ in order to cater for any improvements in aerobic capacity that was expected to have resulted from the previous six-weeks of exercise. Low intensity activity was increased from 40 to 45 percent of $\dot{V}O_{2peak}$, while high intensity exercise was increased from 70 to 75 percent of individual $\dot{V}O_{2peak}$. This intensity was converted to the equivalent heart rate value in order to allow participants to monitor their exercise intensities.

3.3.3 Diary

All participants were issued with a diary containing instructions and recording sheets dependent on their allocated group (see Appendix H). All participants were required to record information relating to their daily activity, and dietary intake (see Appendix J) and exercise sessions (see Appendix I) in their diary throughout the 12-week programme. Exercise adherence was calculated as the actual number of exercise sessions that the participant completed divided by the number of exercise sessions prescribed.

3.3.3.1 Daily Activity Information

Daily activity data for a week was recorded during weeks 1 and 12 of the intervention using the Older Adult Exercise Status Inventory (OA-ESI) questionnaire

(see Appendix G). The OA-ESI questionnaire is a seven day self-report inventory that assesses the duration, frequency and level of intensity of a broad range of work and leisure activities apart from those involving sitting and lying down (O'Brien-Cousins, 1996). This scale involves activities that both young and old people can participate in and also includes a section for the inclusion of activities not already listed. The two page inventory prompts subjects with categories and includes an open category in order to include activities not listed. Total activity for the week is determined by first summing the minutes assigned to each activity, then multiplying this value by the appropriate MET (basal metabolic unit) value. Total values for each activity were then summed to attain the total gross kilocalorie expenditure. Reliability and validity have been established for this questionnaire (O'Brien-Cousins, 1996).

3.3.3.3 Pedometer

All participants wore a pedometer (Yamax, Digi-walker, SW-700, Tokyo, Japan) during weeks 1 and 12 of their programme in order to collect step data. The Yamax Digi-walker pedometer has been reported to accurately and reliably measure steps during walking and running in normal weight, overweight and obese individuals (Bassett et al., 1996; Swartz, Bassett et al., 2003; Tudor-Locke & Myers, 2001). This accuracy is supported by reports showing a correlation of 0.977 between a Yamax pedometer (Yamax DW-500) and a measuring wheel (Bassett, Cureton & Ainsworth, 2000). Additionally, the accuracy of the pedometer is not affected by different walking surfaces (Bassett et al., 1996).

The participant's body weight and stride length were recorded and entered into the pedometer, with any changes in weight being re-entered during week 12. Stride length was determined by measuring the total distance of ten normal steps, and then dividing this number by ten, to work out one step. The participant was instructed to wear the pedometer for the entire day (i.e. from when they got out of bed in the morning until they went to bed at night, only removing it when in contact with water). The pedometer was worn on the waistband at the mid-line of the thigh, oriented vertically (Swartz, Bassett et al., 2003). At the end of each day, participants recorded the total number of steps they had taken, the total distance they had travelled and the amount of

calories they had expended for the day. Additionally, participants also recorded step counts before and after their walking sessions on their five exercise days. Participants recorded this information for each of the seven days during the designated weeks, with the monitor being reset each morning.

Pedometers possess a certain degree of measurement error, due to external factors, eg. vibrations being recorded as steps. Even though, pedometers have been reported to be accurate and reliable at reporting steps, the pedometer is unable to record non-bipedal activities. Additionally, the pedometer does not differentiate between the intensity of the steps taken (McCormack et al., 2003). To try and overcome, or at least minimise this limitation, participants who were involved in the exercise programme were required to fill in an activity questionnaire detailing the minutes they spent doing certain physical activities each day whilst wearing the pedometer. However, the pedometer was considered to be an acceptable means of measuring physical activity for this study.

3.3.3.4 Accelerometer

Selected exercising individuals (n = 6) wore an accelerometer during weeks 1 and 12 of the exercise programme. Participants were instructed to wear the accelerometer, which was attached to a strap around their waist, as soon as they got up in the morning and until they went to bed at night, only removing it when in contact with water. The accelerometer was used to record the duration of movement (minutes), as well as the intensity levels (i.e. light, moderate, hard, very hard) of daily activities. The number of daily steps and kilocalorie expended was also determined for the selected weeks. Accelerometers have been proven to provide reasonable estimates of energy expenditure (Jakicic & Gallagher, 2003). Even though the pedometer and accelerometer both measure the amount of daily steps, the accelerometer is considered to be a more accurate device.

3.3.3.5 Dietary Food Intake Information

Participants were required to record daily information about their food intake in their diaries at weeks 1, 6 and 12 of their programme (see Appendix J). A sample food diary based on a commercial weight loss clinic's programme was also included in the diary so that the participant could determine the type of information they needed to record. The food diary included type and quantities of food ingested. The diaries were analysed using the computer programme, FoodWorks Professional Edition 2005, which calculated total weekly kilocalorie intake for each participant.

3.3.4 General Information

The researcher phoned participants weekly throughout their programme. During this conversation the researcher asked the participant a series of standardised questions that included information about the participant's diet, exercise sessions, health and their motivation levels (see Appendix K). The researcher also determined whether the participant had missed any exercise sessions for the week. If the participant missed a full complete week of exercise due to such factors as being sick or injury the participant was required to make up these sessions at the end of the original 12-week programme, this does not include if a participant missed exercise sessions equivalent to a week (eg. one session a week for five weeks).

3.4 Post-Intervention

Once the participant had completed the 12-week intervention, they were invited back for reassessment of all the measurements taken during baseline testing.

3.5 Statistical Analysis

The present study used a pre-test, post-test randomised group design. Statistical analysis was performed using the computer programme Statistical Packages for Social Science (SPSS) version 14.0 (Chicago, IL) for Windows, and alpha was set at $P < 0.05$. The results for baseline and post-intervention testing are reported as means and standard deviations (SD; see Appendix L). In order to determine whether the two groups were

different at baseline independent t-tests were performed (see Appendix M). All data was assessed using the Levene's test for equality of variance and is only noted if equal variance was not assumed. Baseline and post-intervention scores for all variables measured were analysed using a 2 (group) x 2 (time) mixed design ANOVA with repeated measures on the second factor to test for main effects for time, group and interaction. *Post hoc* t-tests, which included paired and independent t-tests, were then performed if there was an interaction effect that approached significance ($P \leq 0.1$), to determine where the significant differences existed. Pearson's product-moment correlation analyses were also performed on the relationship between fat mass and hip, as well as waist girth. Effect sizes (ES) were calculated for those variables that either approached significance or significantly altered during some aspect of the study. Cohen's conventions for effect size were used for interpretation, where effect sizes equal to 0.2, 0.5, and 0.8 were considered as small, medium or large, respectively (Cohen, 1988).

CHAPTER 4

Results

The results presented below represent baseline and post-intervention data for the INT (n = 12) and the SS (n = 14) groups over the 12-week intervention. Not all participants completed the full set of testing for all variables and therefore participants who had incomplete data for a specific variable were excluded from statistical analysis. Results are presented for the following: demographic details; adherence to an exercise intervention; aerobic fitness; blood lipids; resting metabolism; body composition; vascular function; responses to quality of life questionnaires; and caloric intake. All results described in the text and tables are presented as means ± standard deviations (SD), while results shown in graphs are presented as means ± standard error of the mean (SEM). All statistical procedures used are described in Chapter 3. Raw data and statistical analysis for the measured variables can be found in Appendices L and M, respectively.

4.1 Participant Demographics

Demographic details for age, body mass, height and BMI of participants recorded at baseline are shown in Table 4.1. Statistical analysis revealed no significant difference between the groups at baseline for each demographic variable analysed; age (t = -0.149, P = 0.883), body weight (t = -0.945, P = 0.354), height (t = -0.276, P = 0.785) and BMI (t = -0.824, P = 0.418).

Table 4-1: Participant Characteristics. Baseline physical characteristics for SS (n = 14) and INT (n = 12).

	SS Group (n = 14)	**INT Group (n = 12)**
Age (yr)	44.4 ± 10.4	43.8 ± 10.4
Body mass (kg)	93.1 ± 17.7	87.6 ± 10.7
Height (cm)	165.4 ± 9.1	164.5 ± 7.8
BMI (kg/m^2)	33.9 ± 5.0	32.5 ± 3.8

4.2 Adherence

An independent t-test revealed that there was no significant difference between the two groups for adherence of exercise over the 12-week intervention period (t = -1.029, P = 0.314). The INT and SS group reported an adherence of 87.67% and 92.90%, respectively.

4.3 Aerobic Fitness

During the GXT, several variables were measured and these results are displayed below. These measurements included; $\dot{V}O_{2peak}$, exercise time to exhaustion, RHR, HR_{max}, BP and final RPE.

4.3.1 Peak Oxygen Consumption

Prior to the interventions, there was no significant difference between the two groups for $\dot{V}O_{2peak}$ values (t = 0.930, $P = 0.363$). Upon completion of the intervention, statistical analyses showed a significant main effect for time (F = 44.330, $P < 0.001$; ES = 0.77 and 0.98 in the INT and SS groups, respectively), but not for group (F = 1.051, $P = 0.316$), or for the interaction of time by group (F = 0.190, $P = 0.667$). Post-intervention results revealed that peak $\dot{V}O_2$ increased in both the INT and SS groups, as represented by increases of 4.62ml/kg^{-1}/min^{-1} and 3.85ml/kg^{-1}/min^{-1}, respectively. This change equated to a 15.36% (27.29ml/kg^{-1}/min^{-1} to 31.49ml/kg^{-1}/min^{-1}, $P = 0.004$) increase in the INT group and a 14.40% (25.54ml/kg^{-1}/min^{-1} to 29.22ml/kg^{-1}/min^{-1}, $P < 0.001$) increase in the SS group. Results are shown in Figure 4.1.

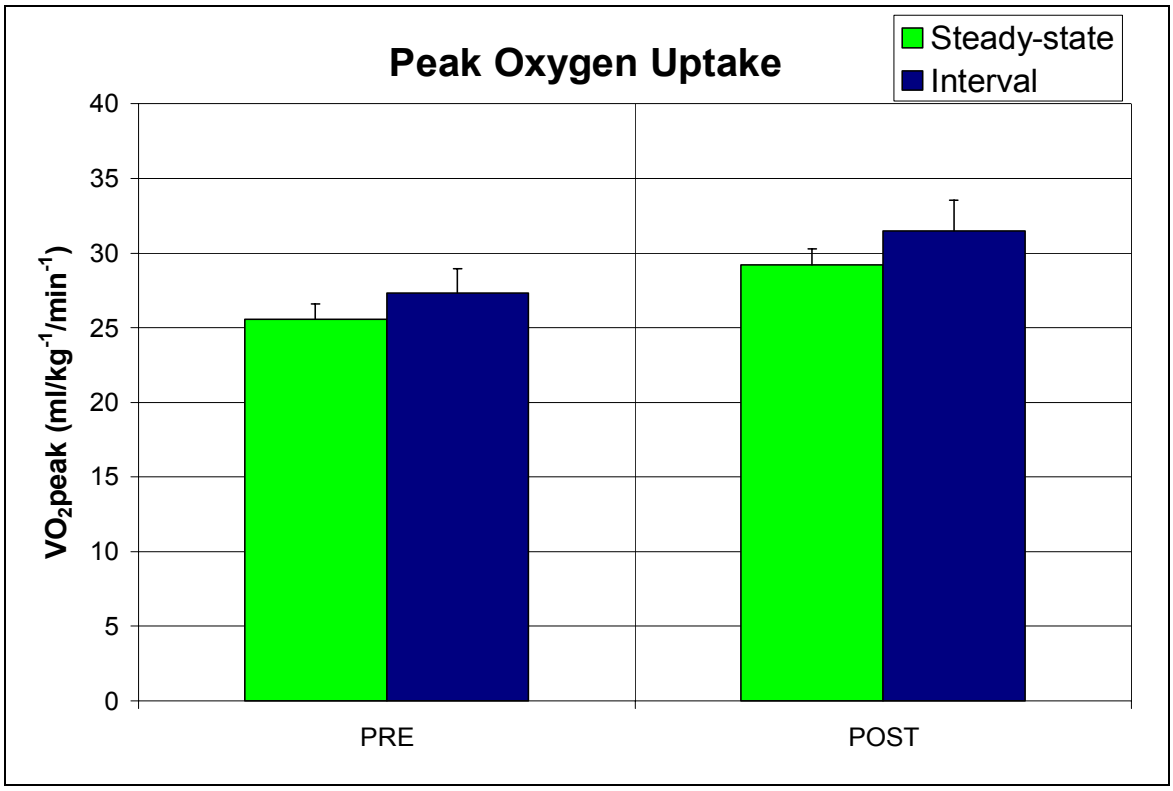

Figure 4-1: $\dot{V}O_{2peak}$ values during the GXT at baseline and post-training for the SS group (n = 13) and the INT group (n = 11).

4.3.2 Exercise Time to Exhaustion

Exercise time to exhaustion was not significantly different between the INT and SS groups at baseline (t = -0.0.27, P = 0.979). On completion of the intervention, time to fatigue on the GXT increased in both the INT group and the SS group (5min 08sec increase; 31.33% and 4min 59sec increase; 30.59%, respectively). Statistical analyses showed a significant main effect for time (F = 112.429, P < 0.001; ES = 1.10 and 1.30 in the INT and SS groups, respectively), but not for group (F = 0.000, P = 0.997). Additionally, there was no significant interaction main effect (F = 0.013, P = 0.912). Results are shown in Figure 4.2.

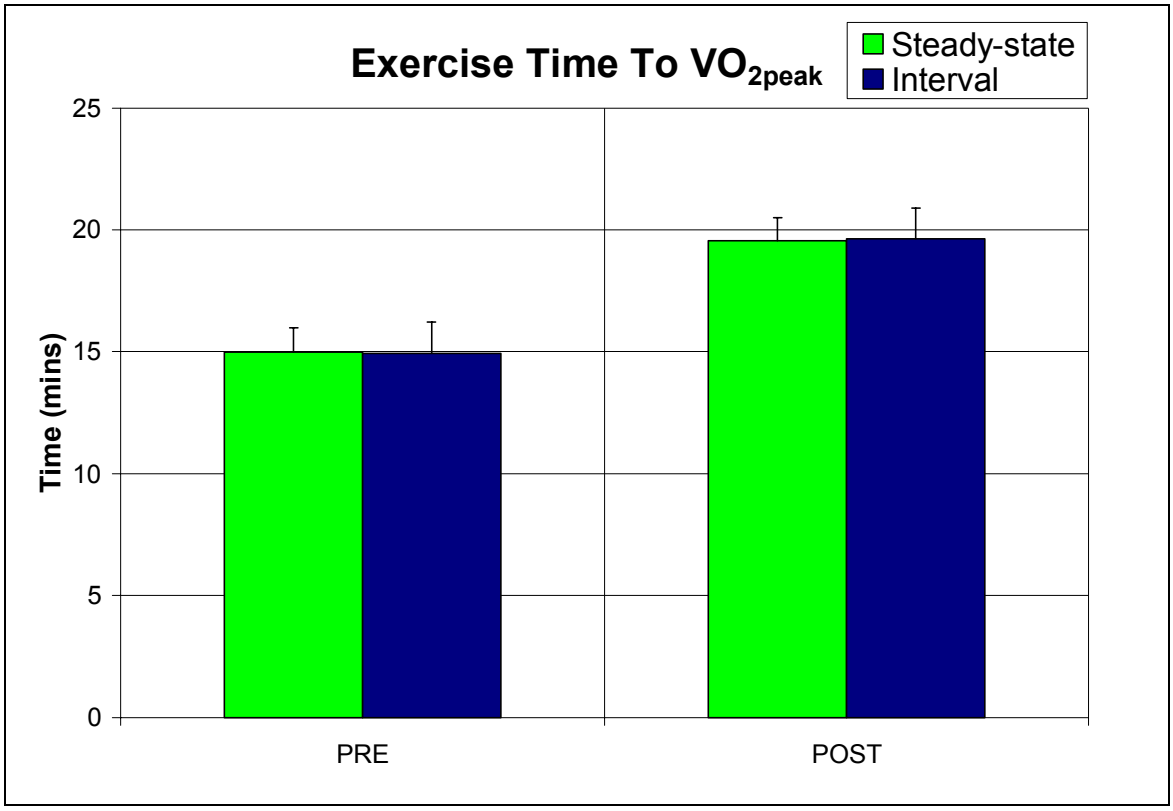

Figure 4-2: Exercise time to $\dot{V}O_{2peak}$ during the GXT at baseline and post-training for the SS (n = 13) and INT group (n = 11).

4.3.3 Additional Measures

Details for RHR (bpm), percent of calculated age matched HR_{max}, SBP (mmHg), DBP (mmHg) and final RPE are shown in Table 4.2. Statistical analyses revealed no significant difference between the two groups for any of these variables at baseline. Post-intervention analyses revealed no significant main effects for time, group, or the interaction of group and time for any of these variables except for DBP, which demonstrated a significant interaction effect ($F = 5.165$, $P = 0.033$). *Post-hoc* analysis revealed that the INT group approached a significant decrease in DBP values over time ($t = 2.111$, $P = 0.061$, ES = 0.442), whereas DBP values for the SS group did not change significantly over time ($t = -0.977$, $P = 0.348$, ES = 0.273). Additionally, there was no significant difference between the INT and the SS group post-intervention ($t = -0.946$, $P = 0.354$).

Table 4-2: Additional Measures for Aerobic Fitness. Baseline and post-intervention results for the SS (n = 13) and the INT group (n = 11).

	SS Group (n = 13)		**INT Group (n = 11)**	
	BASELINE	**POST INTERVENTION**	**BASELINE**	**POST INTERVENTION**
RHR	74.0 ± 13.5	76.6 ± 11.5	76.7 ± 11.1	76.5 ± 9.0
% HR_{max}	97.8 ± 8.9	97.0 ± 9.1	99.7 ± 5.8	98.8 ± 5.6
SBP	112.8 ± 13.3	114.8 ± 15.6	123.6 ± 18.8	118.4 ± 14.6
DBP	77.2 ± 7.6	79.2 ± 6.4	81.7 ± 12.6	76.3 ± 8.9 *
Final RPE	17.5 ± 1.9	17.9 ± 1.7	17.9 ± 2.3	17.8 ± 1.9

* $P < 0.1$ significantly different over time compared to baseline in the INT group.

4.4 Blood Profile

Several tests were performed on the participant's blood. These tests included a full blood count, as well as assessment of liver function, renal function, thyroid function, general biochemistry, lipid levels and several additional tests.

4.4.1 Full Blood Count

Specific results for various blood measures are presented in Table 4.2. These results include baseline and post-intervention data for the following: haemoglobin (Hb); packed cell volume (PCV); mean corpuscular volume (MCV); red cell count (RCC); red cell distribution width (RCDW); mean corpuscular haemoglobin (MCH); mean corpuscular haemoglobin concentration (MCHC); total white blood cell count (WCC); neutrophils; lymphocytes; monocytes; eosinophils; basophils; platelets and erythrocyte sedimentation rate (ESR).

Mean data for all blood profile variables assessed at baseline were within an acceptable range. Statistical analyses performed during baseline measurements revealed no significant differences between the two exercise groups for any of the variables listed in Table 4.3. Further to this, analyses of post-intervention results also demonstrated no significant differences between the two groups for any of these variables, except for a significant main effect for time, which was demonstrated for PCV ($F = 5.266$, $P = 0.032$; ES = 0.54 and 0.14 for the INT and SS groups, respectively), RCDW ($F = 18.066$, $P < 0.001$; ES = 0.54 and 0.94 for the INT and SS groups, respectively), MCH ($F = 6.286$, $P = 0.020$; ES = 0.22 and 0.34 for the INT and SS groups, respectively), WCC ($F = 4.705$, $P = 0.041$; ES = 0.18 and 0.71 for the INT and SS groups, respectively) and ESR ($F = 11.468$, $P = 0.003$; ES = 0.57 and 0.21 for the INT and SS groups, respectively).

Table 4-3: General Blood Test. Baseline and post-intervention results for the SS (n = 12) and the INT group (n = 12).

	SS Group (n = 12)		INT Group (n = 12)	
	BASELINE	**POST INTERVENTION**	**BASELINE**	**POST INTERVENTION**
Hb (g/L)	141.3 ± 12.6	139.9 ± 13.5	137.8 ± 14.4	134.0 ± 11.6
PCV	0.4 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	0.4 ± 0.0
MCV (fl)	88.2 ± 2.6	88.8 ± 2.9	89.0 ± 3.6	88.7 ± 4.1
RCC (pl)	5.0 ± 0.5	4.9 ± 0.5	4.8 ± 0.4	4.7 ± 0.4
RCDW	13.2 ± 0.5	13.7 ± 0.6	13.3 ± 0.6	13.7 ± 0.5
MCH (pg)	28.4 ± 1.0	28.8 ± 0.8	28.6 ± 1.5	28.9 ± 1.7
MCHC (%)	32.3 ± 0.9	32.4 ± 0.6	32.2 ± 1.2	32.4 ± 1.1
WCC (nl)	6.1 ± 1.2	5.3 ± 1.1	6.0 ± 1.5	5.7 ± 1.3
Neutrophils (nl)	3.4 ± 1.0	2.8 ± 0.8	3.4 ± 1.1	3.4 ± 0.9
Lymphocytes (nl)	2.1 ± 0.4	1.9 ± 0.6	1.8 ± 0.8	1.7 ± 0.7
Monocytes (nl)	0.5 ± 0.3	0.4 ± 0.1	0.4 ± 0.2	0.4 ± 0.1
Eosinophils (nl)	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.2	0.1 ± 0.1
Basophils (nl)	0.1 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.1 ± 0.0
Platelets (nl)	280.1 ± 41.3	269.6 ± 37.3	250.4 ± 52.2	249.7 ±55.5
ESR (mm/hr)	9.2 ± 10.5	7.0 ± 7.0	9.7 ± 7.4	5.4 ± 4.6

4.4.1 Liver, Renal and Thyroid Function

Analysis of liver function involved the assessment of aspartate transaminase (AST), gamma glutamyltransferase (GGT) and alanine aminotransferase (ALT), while renal function assessment involved the analyses of urea, creatinine, sodium and potassium. Further to this, thyroid function was also assessed. Statistical analyses performed during baseline measurements revealed no significant differences between the two exercise groups for any of the liver, renal or thyroid variables assessed (Table 4.4). Additionally, analyses of post-intervention results demonstrated no significant differences between the two groups for any of these variables, except for a significant main effect for time, which was demonstrated for GGT ($F = 10.788$, $P = 0.003$; ES = 0.61 and 0.53 in the INT and SS groups, respectively), ALT ($F = 6.713$, $P = 0.017$; ES = 0.49 and 0.54 in the INT and SS groups, respectively) and sodium levels ($F = 4.851$, $P = 0.038$; ES = 0.51 and 0.79 for the INT and SS groups, respectively). Furthermore, creatinine approached a significant change over time ($F = 3.287$, $P = 0.083$; ES = 1.38 and 0.04 in the INT and SS groups, respectively), as did potassium levels ($F = 3.417$, $P = 0.078$; ES = 0.73 and 0.25 in the INT and SS groups, respectively).

Table 4-4: Liver, Renal and Thyroid Function. Baseline and post-intervention results for the SS (n = 12) and the INT group (n = 12).

	SS Group (n = 12)		INT Group (n = 12)	
	BASELINE	**POST INTERVENTION**	**BASELINE**	**POST INTERVENTION**
LIVER FUNCTION				
AST	21.3 ± 4.6	18.3 ± 3.5	23.3 ± 8.3	25.8 ± 19.5
GGT	26.7 ± 16.8	17.8 ± 9.8	32.8 ± 17.7	22.0 ± 15.3
ALT	26.5 ± 15.1	18.4 ± 9.5	28.6 ± 13.4	22.0 ± 13.0
RENAL FUNCTION				
Urea	4.8 ± 0.9	5.0 ± 1.3	5.1 ± 1.1	5.2 ± 1.3
Creatinine	65.8 ± 11.6	66.3 ± 12.3	62.0 ± 8.0	67.6 ± 11.1
Sodium	138.9 ± 2.1	140.6 ± 2.2	139.8 ± 1.5	140.6 ± 1.4
Potassium	4.0 ± 0.4	4.1 ± 0.3	4.0 ± 0.3	4.2 ± 0.4
THYROID FUNCTION				
TSH	1.7 ± 0.7	1.7 ± 1.0	1.7 ± 0.7	1.5 ± 0.6

4.4.2 General Biochemistry

4.4.2.1 Glucose

Glucose values for both groups were within normal range. Further to this, statistical analyses revealed that glucose values for both groups were similar at baseline (t = -0.874, *P* = 0.392). Statistical analysis also showed a significant main effect for time (F = 6.878, *P* = 0.016; ES = 0.33 and 0.40 in the INT and SS groups, respectively), but not for group (F = 1.042, *P* = 0.319) or for interaction (F = 0.002, *P* = 0.966). Post-intervention assessment showed a 5.28% decline in glucose values in the INT group (*P* = 0.126) and a 4.86% decline in the SS group (*P* = 0.053). Results are shown in Figure 4.3.

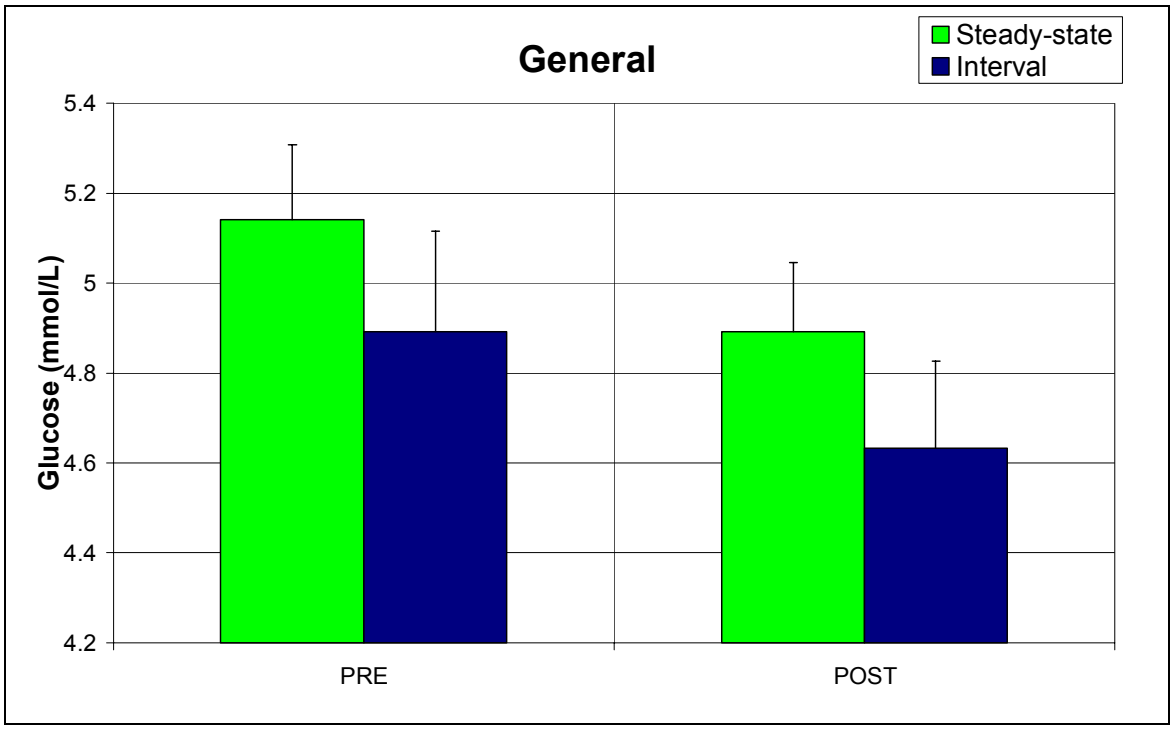

Figure 4-3: Glucose values at baseline and post-intervention for the SS group (n = 12) and the INT group (n = 12).

4.4.2.2 Uric Acid

Baseline values for uric acid were within normal range and were similar between the two groups at baseline (t = -0.252, *P* = 0.804). There was no significant main effect for time (F = 2.448, *P* = 0.132) or for group (F = 0.322, *P* = 0.576), however the main interaction effect of time by group was significant (F = 5.040, *P* = 0.035). Post-intervention results showed that uric acid levels increased by 2.46% in the INT group, yet conversely declined by 12.86% in the SS group**.** *Post-hoc* analysis revealed that the SS group (t = 3.334, *P* = 0.007, ES = 0.113) significantly reduced uric acid levels over time, whereas change in the INT group was not significant (t = -0.414, *P* = 0.687, ES = 0.645). Furthermore there was no significant difference between the two groups at post-testing (t = 1.091, *P* = 0.287). Results are shown in Figure 4.4.

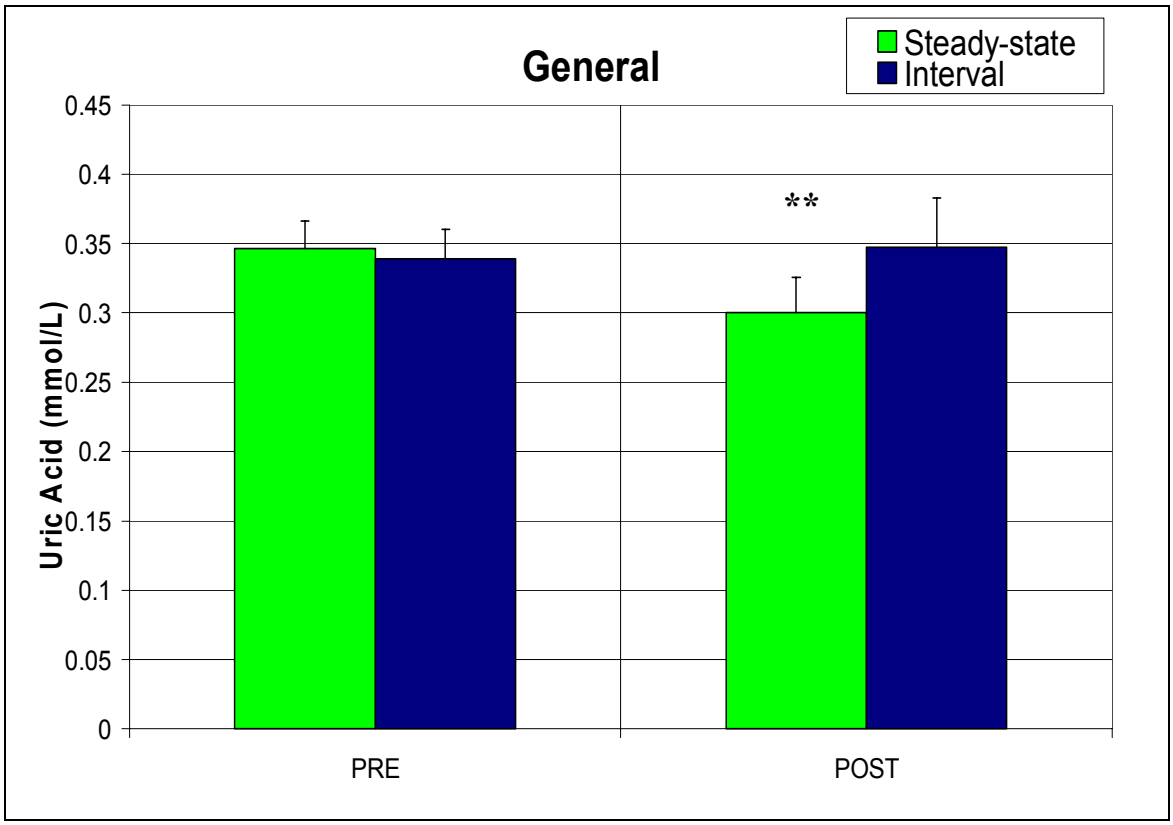

Figure 4-4: Uric acid values at baseline and post-intervention for the SS group (n = 12) and the INT group (n = 12).
** *P* < 0.05 significantly different over time compared to baseline in the SS group.

4.4.3 Lipids

4.4.3.1 Total Cholesterol

While total cholesterol was not significantly different between the two groups at baseline (t = 1.943, $P = 0.066$), mean cholesterol values were not within the acceptable range for the INT group. There was a significant main effect for time (F = 17.765, $P < 0.001$; ES = 0.36 and 0.41 for the INT and SS groups, respectively), while the group effect approached significance (F = 3.448, $P = 0.077$). The interaction of time and group (F = 1.106, $P = 0.305$) was not significant. Post-intervention cholesterol values showed a decrease of 12.24% in the INT group ($P = 0.012$) and 9.37% in the SS group ($P = 0.014$), resulting in normal cholesterol values for both groups. Results are shown in Figure 4.5.

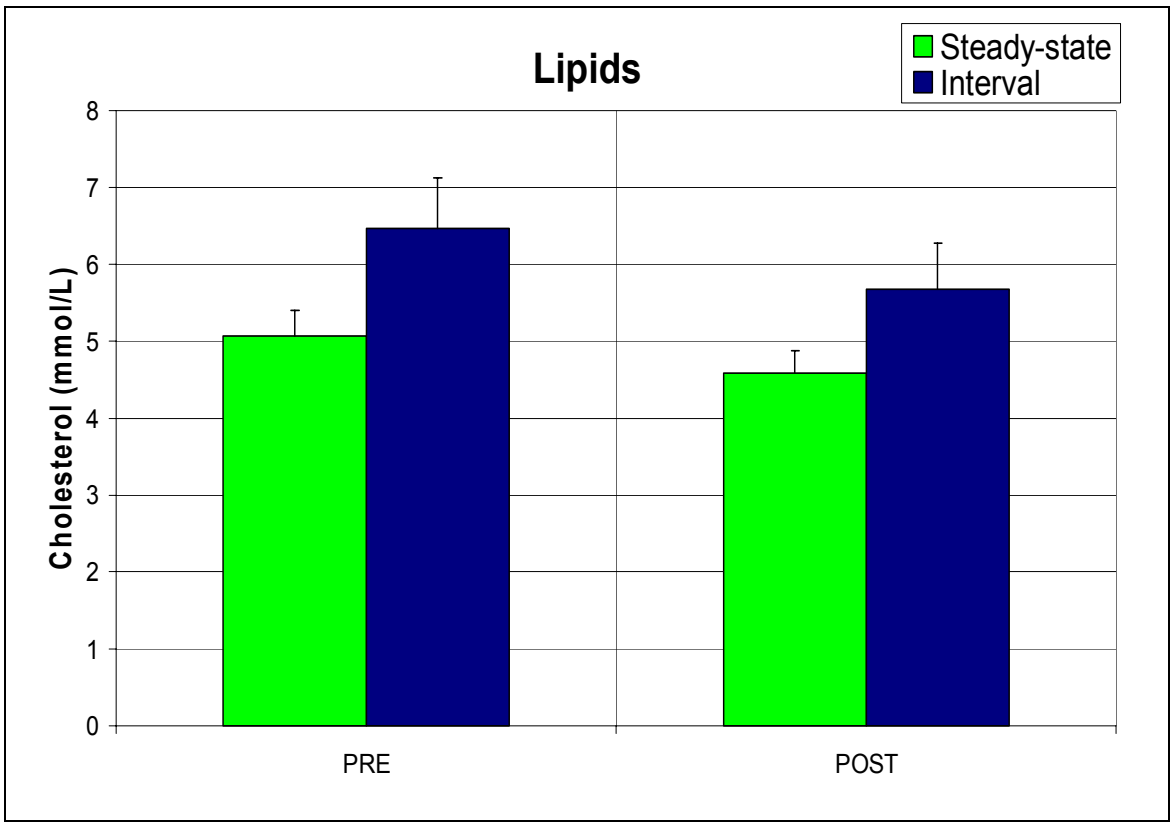

Figure 4-5: Cholesterol values at baseline and post-intervention for the SS group (n = 12) and the INT group (n =11) group.

4.4.3.2 Triglycerides

At baseline, triglycerides levels were within an acceptable range and were similar between the two groups (t = 1.113, *P* = 0.278). After the intervention, a reduction in triglyceride levels was seen in both intervention groups (INT group = 33.78% decrease and SS group = 11.46% decrease). A significant main effect occurred for time (F = 5.581, *P* = 0.028; ES = 0.64 and 0.23 for the INT and SS groups, respectively), however both the main effect for group (F = 0.260, *P* = 0.615) and the interaction of time and group (F = 1.943, *P* = 0.178) were not significant. Results are shown in Figure 4.6.

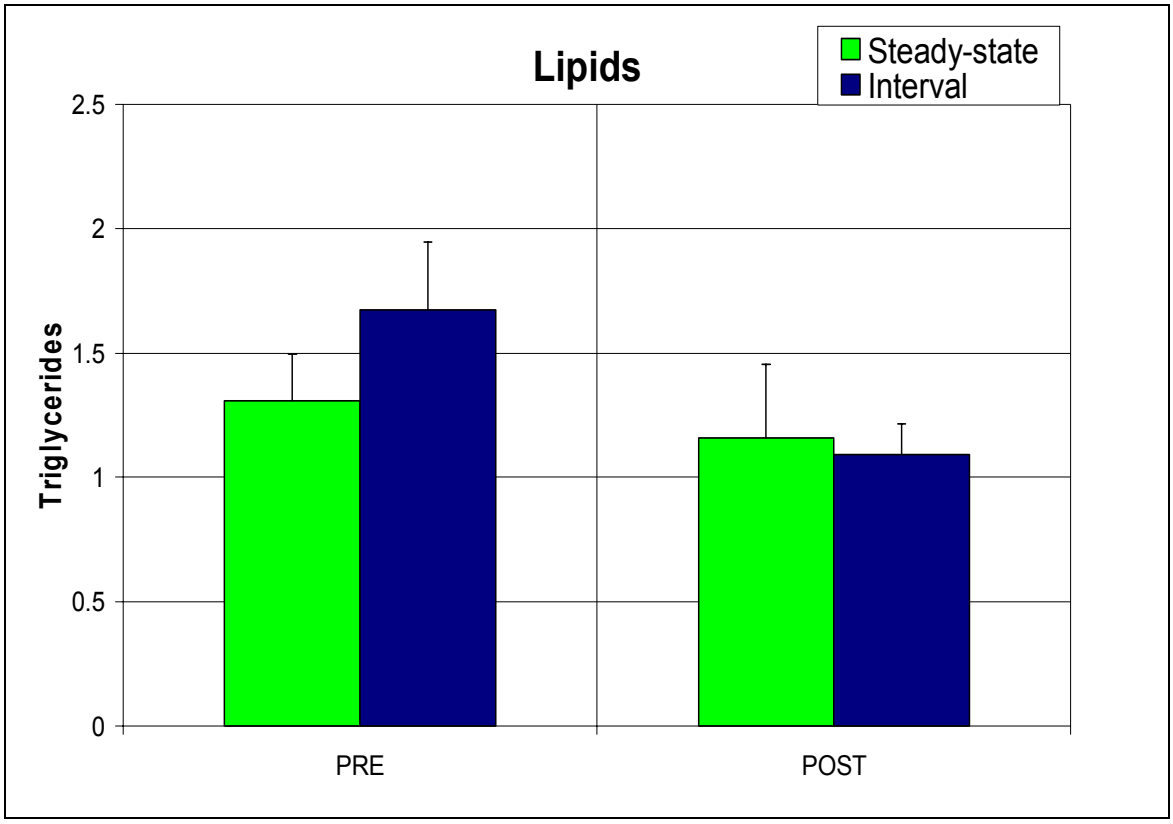

Figure 4-6: Triglycerides levels at baseline and post-intervention for the SS group (n = 12) and the INT group (n = 11).

4.4.3.3 High Density Lipoprotein

Levels of HDL were normal prior to the intervention for both groups. Baseline values of HDL were also similar between the two groups (t = 0.475, *P* = 0.640). High density lipoprotein levels increased minimally post-intervention resulting in a 1.02% and 1.15% increase in the INT and SS groups, respectively. The main effect of time (F = 0.054, *P* = 0.819), group (F = 0.171, *P* = 0.684) and interaction (F = 0.000, *P* = 0.993) were all not significant. Results are shown in Figure 4.7.

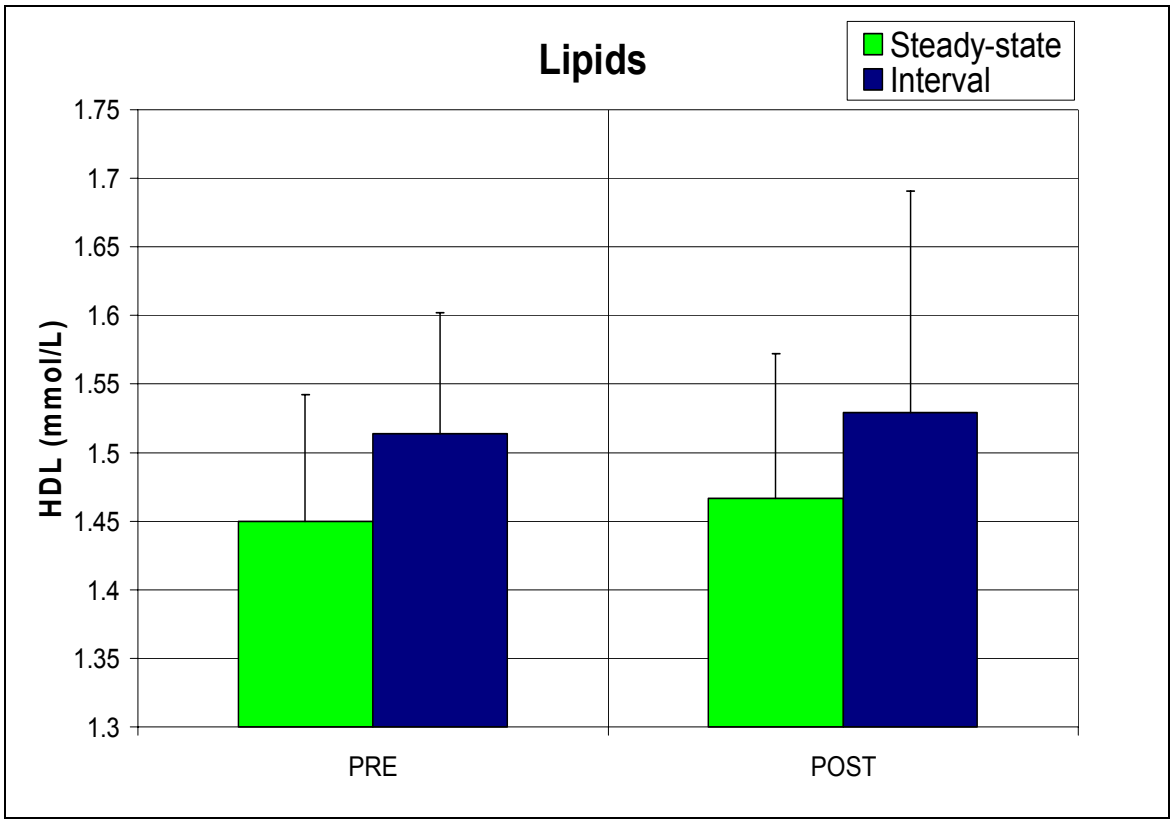

Figure 4-7: HDL levels at baseline and post-intervention for the SS group (n = 12) and the INT group (n = 11).

4.4.3.4 Low Density Lipoprotein

Statistical analysis showed that LDL levels were not significantly different between the two groups (t = 1.863, *P* = 0.076) at baseline, however LDL levels were outside the normal range for the INT group. Post-intervention results showed that LDL levels were reduced by 15.32% in the INT group and by 12.11% in the SS group, resulting in normal values for both groups. This change was significant for the main effects of time (F = 12.368, *P* = 0.002; ES = 0.33 for both groups). Conversely, there was no significant group effect (F = 2.952, *P* = 0.100) or interaction effect (F = 0.951, *P* = 0.340). Results are shown in Figure 4.8.

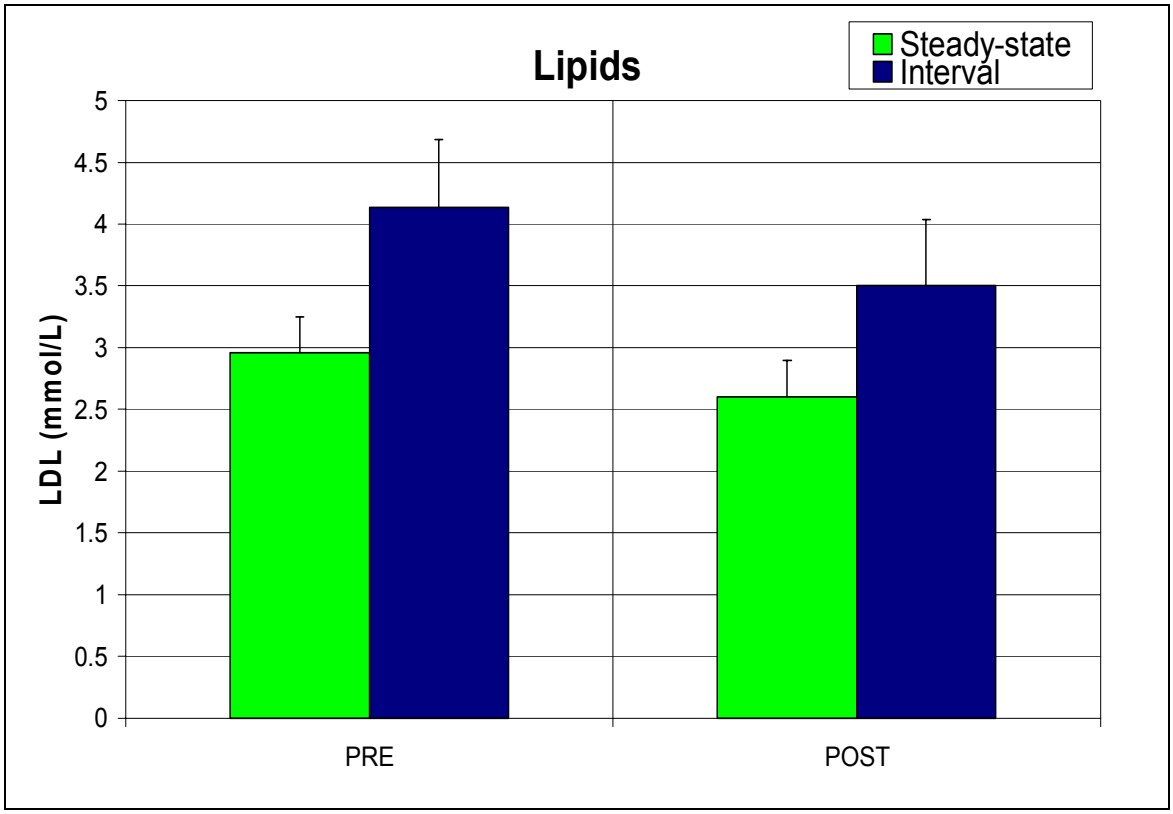

Figure 4-8: LDL levels at baseline and post-intervention for the SS group (n = 12) and the INT group (n = 12).

4.4.3.5 Very Low Density Lipoprotein

Baseline values for VLDL in the two groups were normal before the exercise programme. Additionally, baseline values were similar between the two groups (t = 1.283, $P = 0.222$). The main effect for time (F = 12.045, $P = 0.004$) and the interaction between time and group (F = 7.415, $P = 0.017$) were significant, however the main effect for group was not significant (F = 0.408, $P = 0.534$). Analysis of post-intervention results showed that VLDL levels decreased by 43.28% in the INT group and by 12.29% in the SS group. *Post-hoc* analysis revealed a significant difference over time in the INT group (t = 3.190, $P = 0.019$, ES = 1.026), but not in the SS group (t = 0.935, $P = 0.381$, ES = 0.088). At post-intervention, values for the two groups were not significantly different (t = -0.141, $P = 0.890$). Results are shown in Figure 4.9.

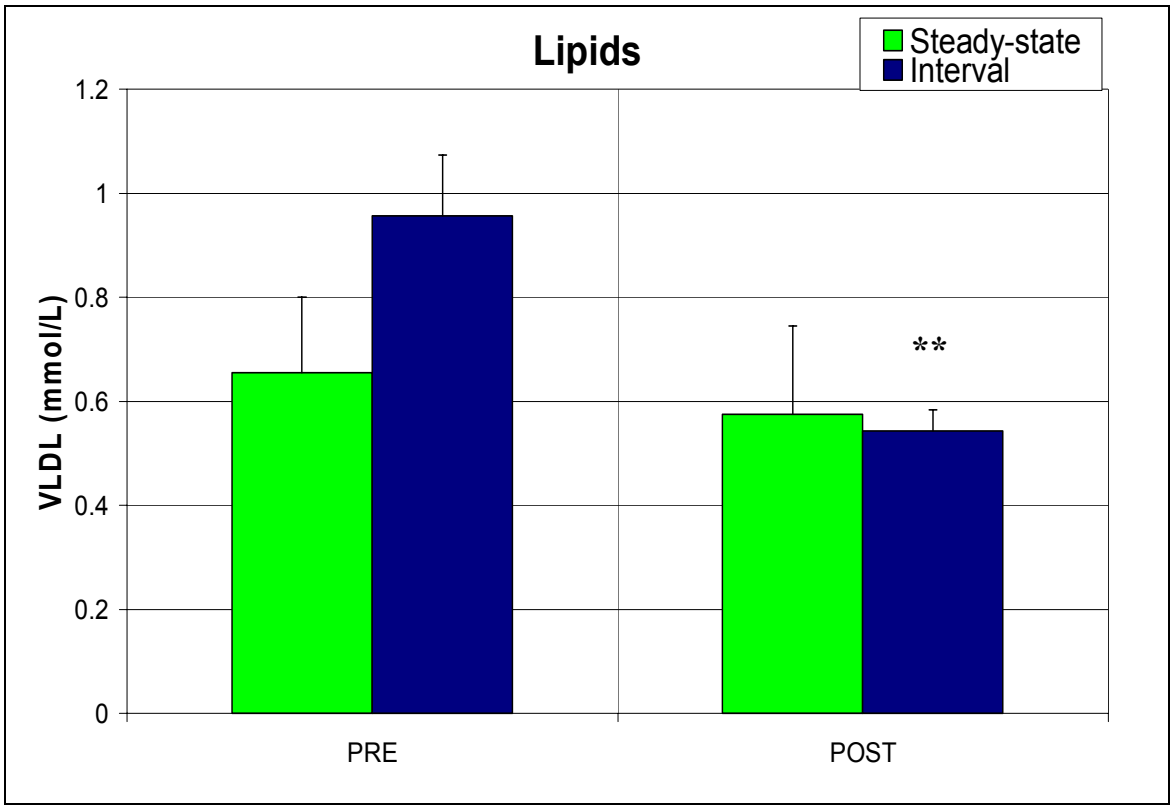

Figure 4-9: VLDL levels at baseline and post-intervention for the SS group (n = 8) and the INT group (n = 7).
** $P < 0.05$ significantly different over time compared to baseline in the INT group.

4.4.3.6 Coronary Risk Ratio

Prior to the participants starting their intervention, both groups were similar in terms of coronary risk ratio (t = 1.508, *P* = 0.146). Only the main effect for time was significant (F = 16.323, *P* = 0.001; ES = 0.58 and 0.38 in the INT and SS groups, respectively), as the main effect for group (F = 1.336, *P* = 0.260) and the interaction of time and group (F = 1.586, *P* = 0.221) were not significant. Upon completion of the exercise interventions, the INT group reduced their coronary risk ratio by 18.70%, whereas the SS group reduced their risk ratio by 11.96%. Results are shown in Figure 4.10.

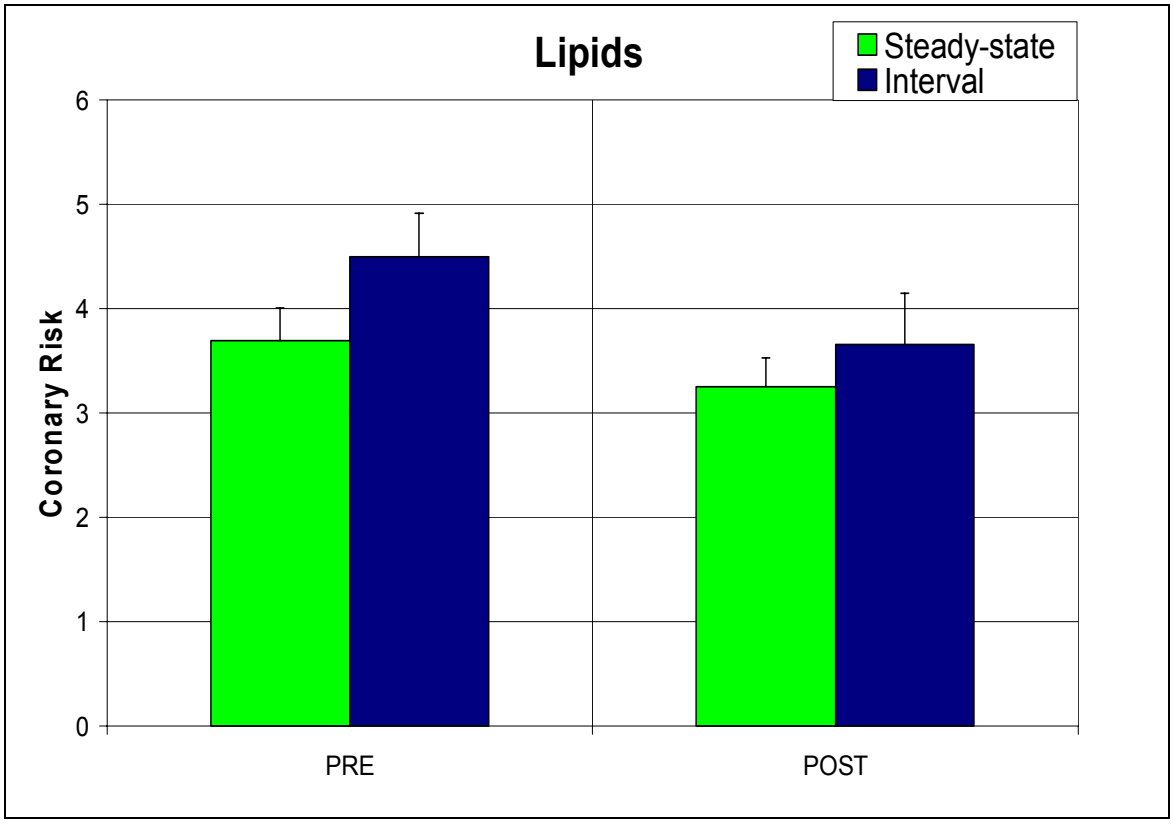

Figure 4-10: Coronary risk levels at baseline and post-intervention for the SS group (n = 14 and n = 12, respectively) and the INT group (n = 12).

4.4.4 Additional Tests

4.4.4.1 C-Peptides

At baseline, mean values for c-peptides were within an acceptable range, with no significant difference being shown between the two exercise groups (t = -1.890, *P* = 0.384). The level of c-peptide in the blood decreased after the interventions, as demonstrated by an 8.82% decrease in the INT group and a 9.23% decrease in the SS group. The main effect for time (F = 0.514, *P* = 0.482), group (F = 1.039, *P* = 0.321) and interaction (F = 0.014, *P* = 0.906) were all not significant. Results are shown in Figure 4.11.

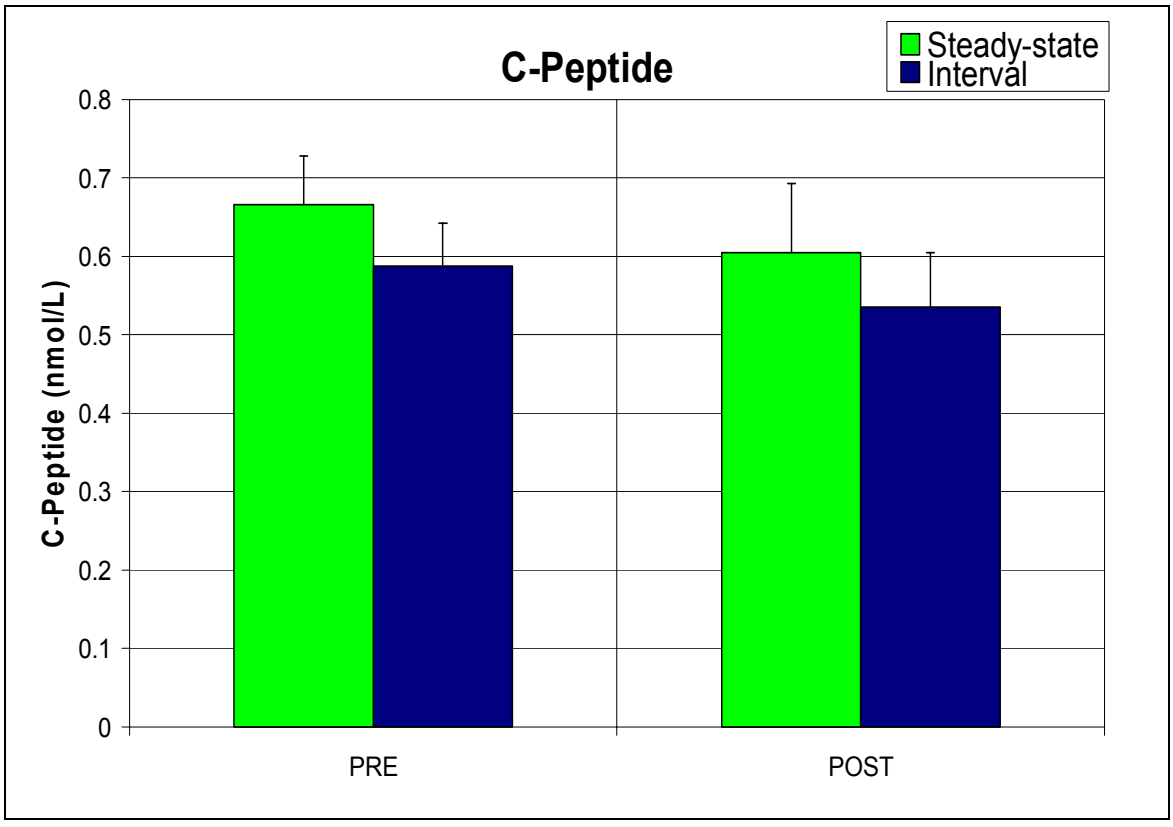

Figure 4-11: C-peptide levels at baseline and post-intervention for the SS group (n = 11) and the INT group (n = 11).

4.4.4.2 Haemoglobin A1c (HbA1c)

Mean baseline values for haemoglobin A1c (HbA1c) were within normal range for both groups. Further to this, baseline HbA1c levels did not differ significantly between groups (t = 0.494, *P* = 0.626). Upon completion of the intervention, HbA1c levels were reduced by 2.89% in the INT group and by 2.04% in the SS group. Statistical analysis showed that the main effect for time approached significance (F = 4.011, *P* = 0.059; ES = 0.25 and 0.30 in the INT and SS groups, respectively), however there was no significant difference for the main effect of group (F = 0.207, *P* = 0.654) or for the interaction of time and group (F = 0.130, *P* = 0.722). Results are shown in Figure 4.12.

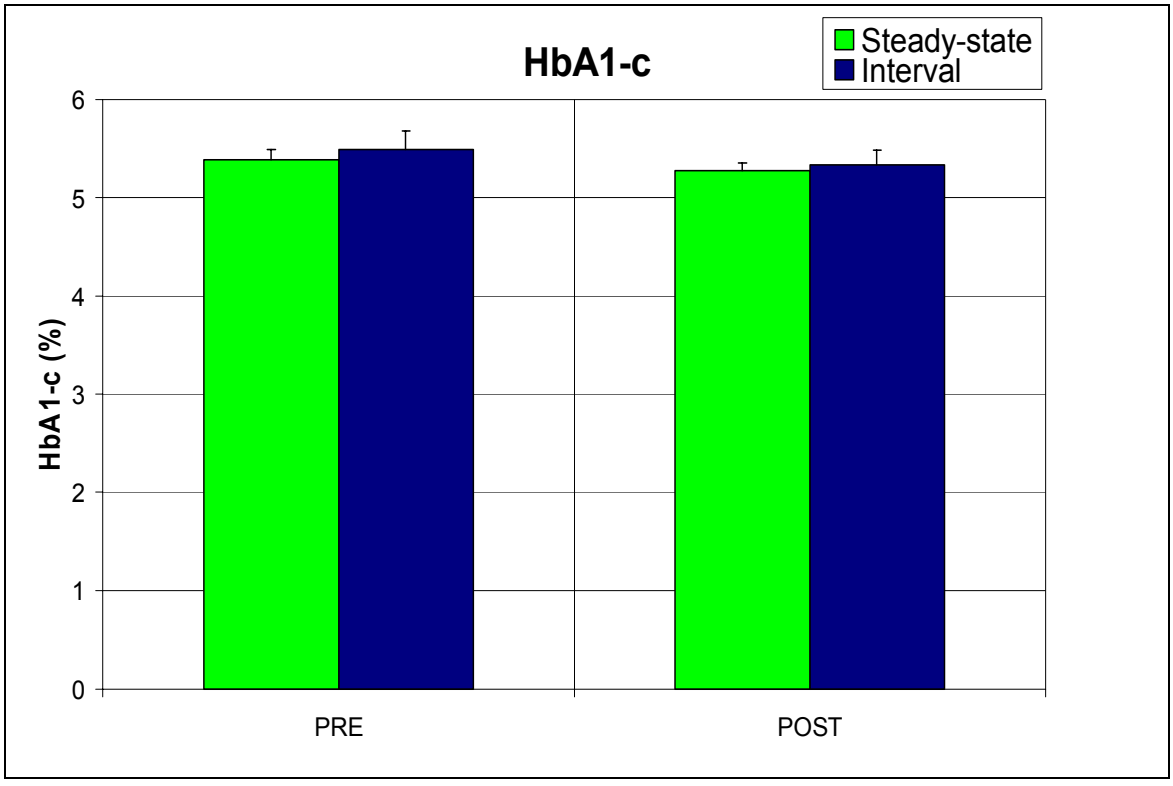

Figure 4-12: Haemoglobin A1c levels at baseline and post-intervention for the SS group (n = 10) and the INT group (n = 12).

4.4.4.3 Insulin-like Growth Factor

Mean insulin-like growth factor (IGF-1) levels were normal at baseline for both groups. Additionally, there was a significant difference between the two groups at baseline (t = 2.276, P = 0.034). Upon completion of the interventions, IGF-1 values decreased in the INT group by 1.82%, yet increased in the SS group by 42.75%. There was a significant main effect for time (F = 4.668, P = 0.044) and for the interaction of time by group (F = 8.799, P = 0.008). Conversely, the main effect for group was not significant (F = 0.097, P = 0.759). *Post-hoc* analysis showed that only IGF-1 values in the SS group significantly changed over time (t = -3.163, P = 0.010, ES = 1.812), whereas values in the INT group did not differ significantly (t = 0.732, P = 0.483, ES = 0.233). Additionally, *post-hoc* analysis also revealed that neither the INT nor the SS groups were significantly different to each other at post-intervention (t = -0.953, P = 0.352). Results are shown in Figure 4.13.

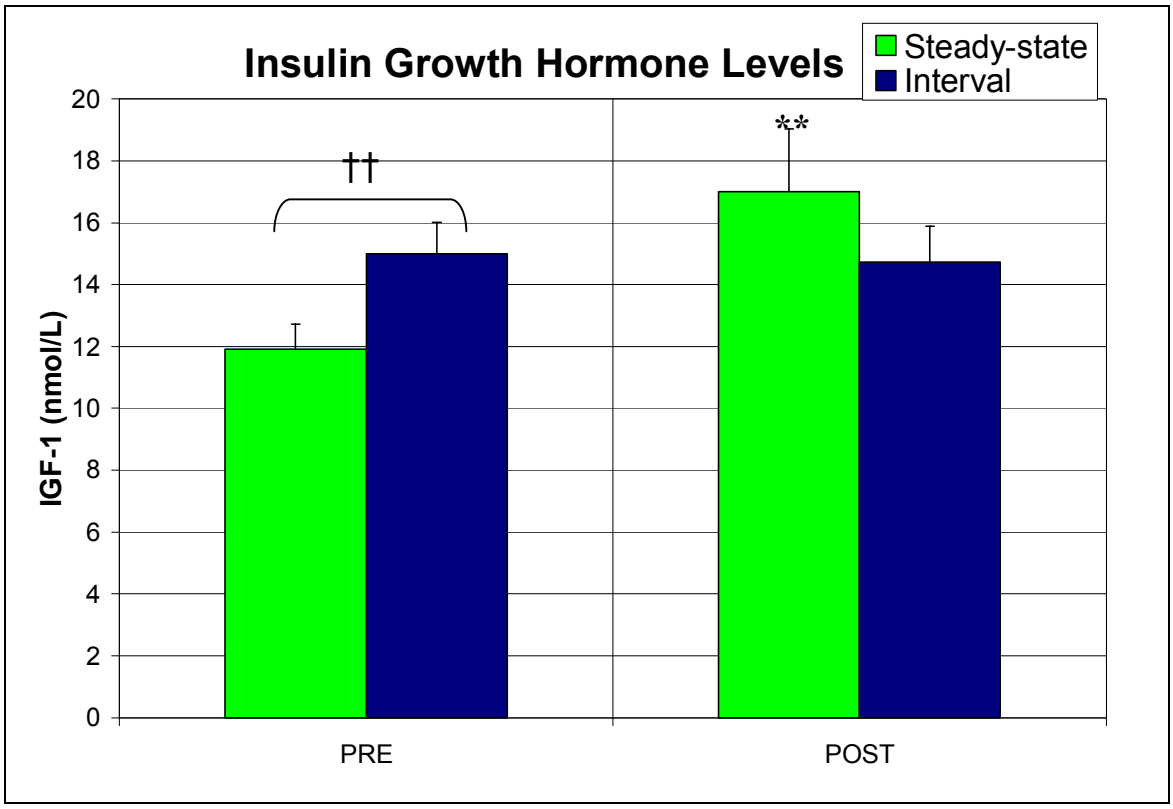

Figure 4-13: IGF-1 levels at baseline and post-intervention for the SS group (n = 11) and the INT group (n = 11).
†† $P < 0.05$ significant group difference at baseline between the SS and INT groups; ** $P < 0.05$ significantly different over time compared to baseline in the SS group.

4.4.4.4 High Sensitivity C-Reactive Protein

While there was no significant difference between the two groups at baseline for high sensitivity c-reactive protein (t = -1.769, $P = 0.091$), values for the SS group were outside the normal range. Analyses of post-intervention results showed a 14.34% decrease in levels of high sensitivity c-reactive protein in the INT group, while the SS group experienced a 28.77% decline in this variable. However, even with this large decline in high sensitivity c-reactive protein levels in the SS group, results still were outside the normal range. No significant main effect occurred for the interaction of time by group (F = 1.211, $P = 0.284$). Conversely, the effects of time (F = 3.267, $P = 0.085$ ES = 0.30 for both groups), as well as group (F = 3.256, $P = 0.086$) both approached significance. Results are shown in Figure 4.14.

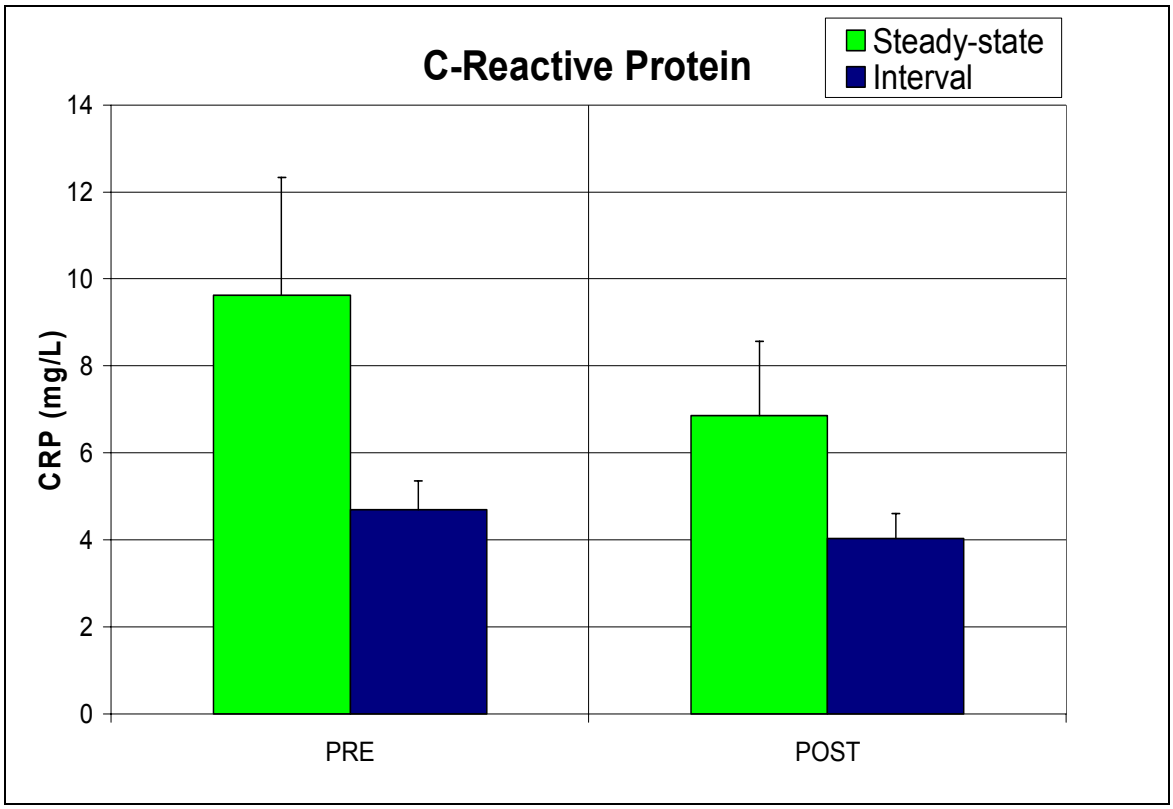

Figure 4-14: High sensitivity c-reactive protein levels at baseline and post-intervention for the SS group (n = 11) and the INT group (n = 12).

4.4.4.5 Fasting Insulin

Baseline scores for fasting insulin levels were within an acceptable range and were similar between the two groups (t = -0.428, *P* = 0.673). Upon completion of the intervention, results showed that both groups had reduced their fasting insulin levels with the INT group recording a 29.72% decrease, while the SS group recorded a 3.84% decrease. The main effect of time approached significance (F = 4.257, *P* = 0.052; ES = 0.81 and 0.10 in the INT and SS groups, respectively), however the main effect of group was not significant (F = 2.457, *P* = 0.133). Finally, results for the interaction of time and group were also not significant (F = 2.523, *P* = 0.128). Results are shown in Figure 4.15.

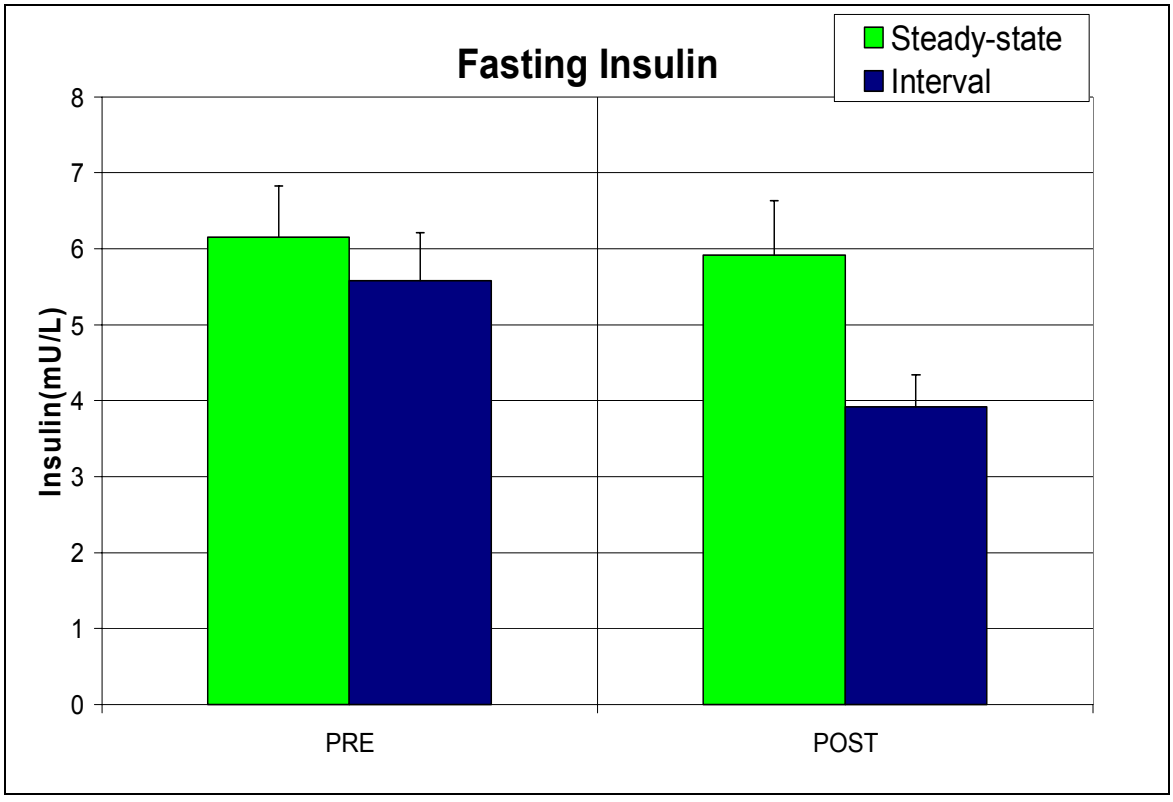

Figure 4-15: Fasting insulin levels at baseline and post-intervention for the SS group (n = 11) and the INT group (n = 11).

4.5 Metabolism

Data collected from metabolic testing included RMR (expressed as total daily kcal), RQ, percentage of CHO and lipids oxidised during the RMR test, as well as resting oxygen consumption levels.

4.5.1 Resting Metabolic Rate

Resting metabolic rate values were expressed as kcal/day^{-1}. There was no significant difference in RMR values between either group prior to the intervention (t = 0.788, P = 0.438). Post-intervention results revealed a 3.64% reduction in RMR values in the INT group, whereas the SS group recorded a 3.35% increase in these values over this time. No significance difference occurred for the main effect of time (F = 0.003, P = 0.954), group (F = 0.335, P = 0.568), or for the interaction of group and time (F = 0.544, P = 0.468). Results are shown in Figure 4.16.

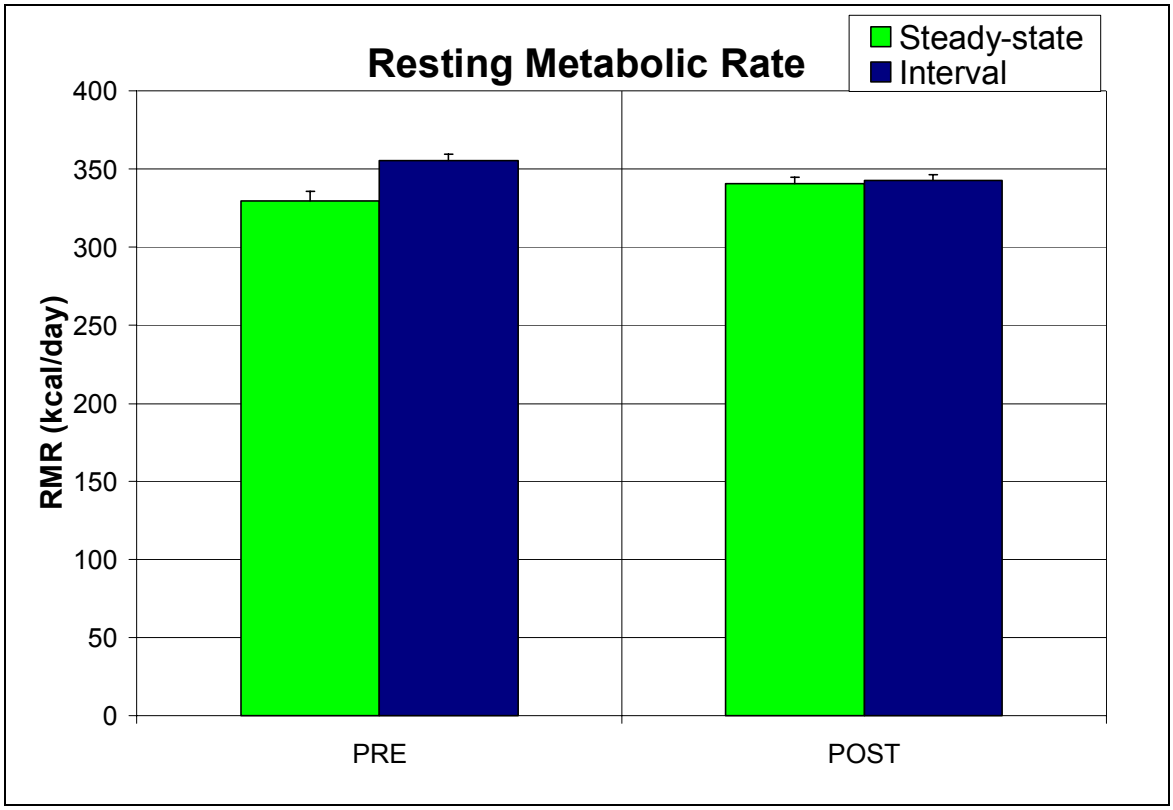

Figure 4-16: BMR values prior to and after the 12-week intervention for the SS group (n = 14) and the INT group (n = 12).

4.5.2 Respiratory Quotient (RQ)

Baseline RQ values were similar between the two intervention groups (t = 1.276, *P* = 0.214). After the completion of the intervention, a 5.71% increase occurred in RQ values in the INT group, while a 2.87% increase occurred in the SS group. The main effect for group (F = 4.778, *P* = 0.039) was significant, whereas the main effect for time approached significance (F = 3.904, *P* = 0.060; ES = 0.50 and 0.29 in the INT and SS groups, respectively). However, the main effect for the interaction of time by group (F = 0.492, *P* = 0.490) was not significant. Results are shown in Figure 4.17.

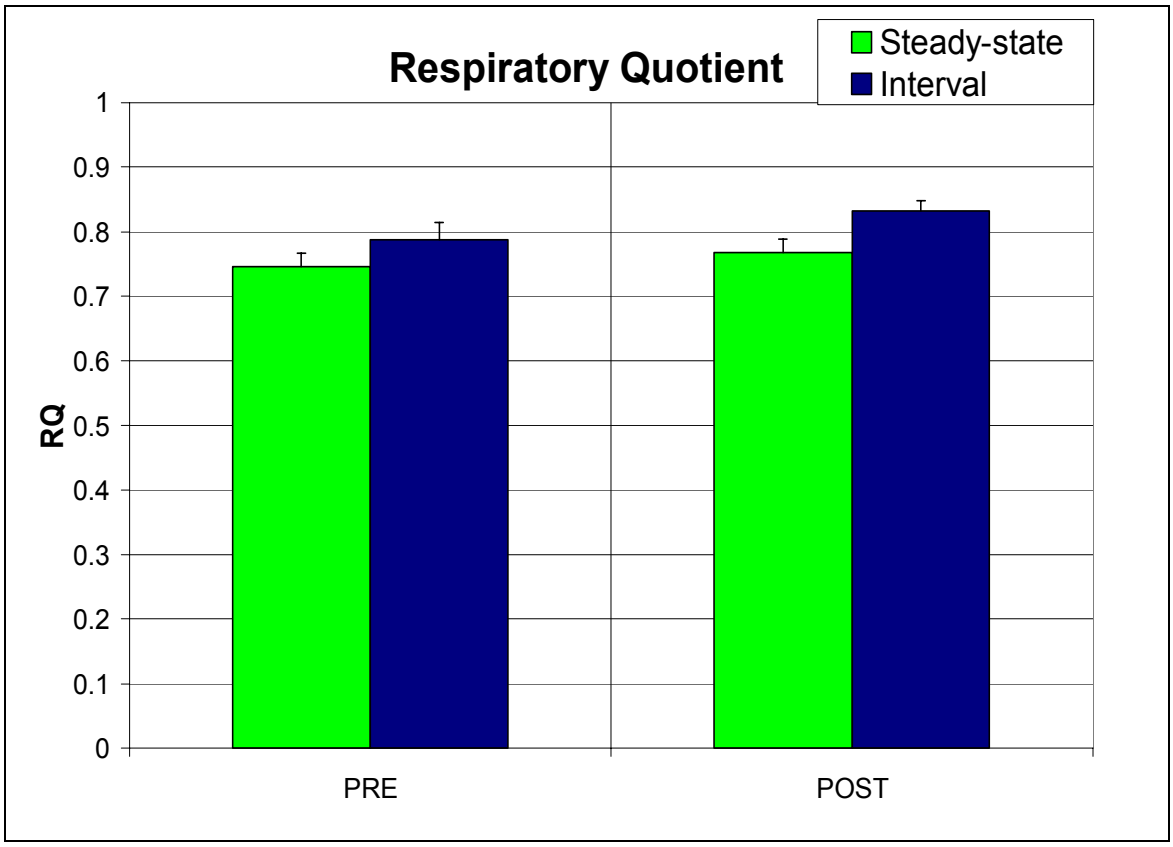

Figure 4-17: RQ values prior to and after the 12-week intervention for the SS group (n = 14) and the interval group (n = 12).

4.5.3 Percentage of Carbohydrate and Lipids Oxidised at Rest

The percentage of CHO and lipids oxidised at rest did not significantly differ between either of the groups at baseline (t = 1.342, *P* = 0.192). The percentage of CHO oxidised at rest increased after the intervention for both groups (INT group = 44.10% and SS group = 36.34%). Conversely, the percentage of lipids oxidised at rest decreased by 19.65% in the INT group and by 7.84% in the SS group. For both CHO and lipids, the main effect for group was significant (F = 4.922, *P* = 0.036), while the main effect for time approached significance (F = 3.668, *P* = 0.067; ES = 0.49 and 0.30 in the INT and SS groups, respectively). However, the interaction for time and group was not significant (F = 0.466, *P* = 0.501). Statistical results are the same for both CHO and lipids as these variables are inversely related. Results are shown in Figure 4.18.

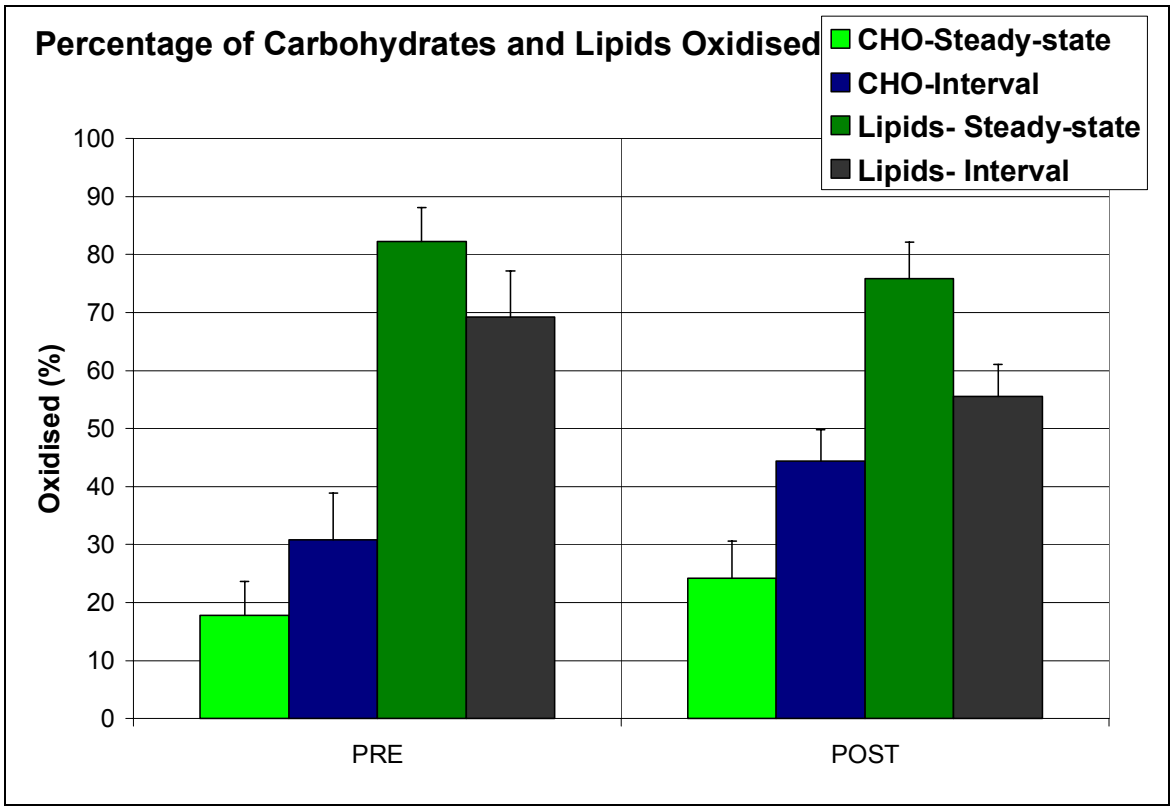

Figure 4-18: Percentage of CHO and lipids oxidized at rest prior to and after the 12-week intervention for the SS group (n = 14) and INT group (n = 12).

4.5.4 Resting Oxygen Consumption

Baseline values for resting oxygen consumption were similar between the two groups (t = 0.634, *P* = 0.532). Upon completion of the intervention, resting oxygen consumption levels decreased in the INT group (3.11%), but increased in the SS group (2.84%). Statistical analyses revealed no significant difference for the main effect of time (F = 0.002, *P* = 0.961), or for group (F = 0.199, *P* = 0.659), as well as for the interaction of group and time (F = 0.413, *P* = 0.527). Results are shown in Figure 4.19.

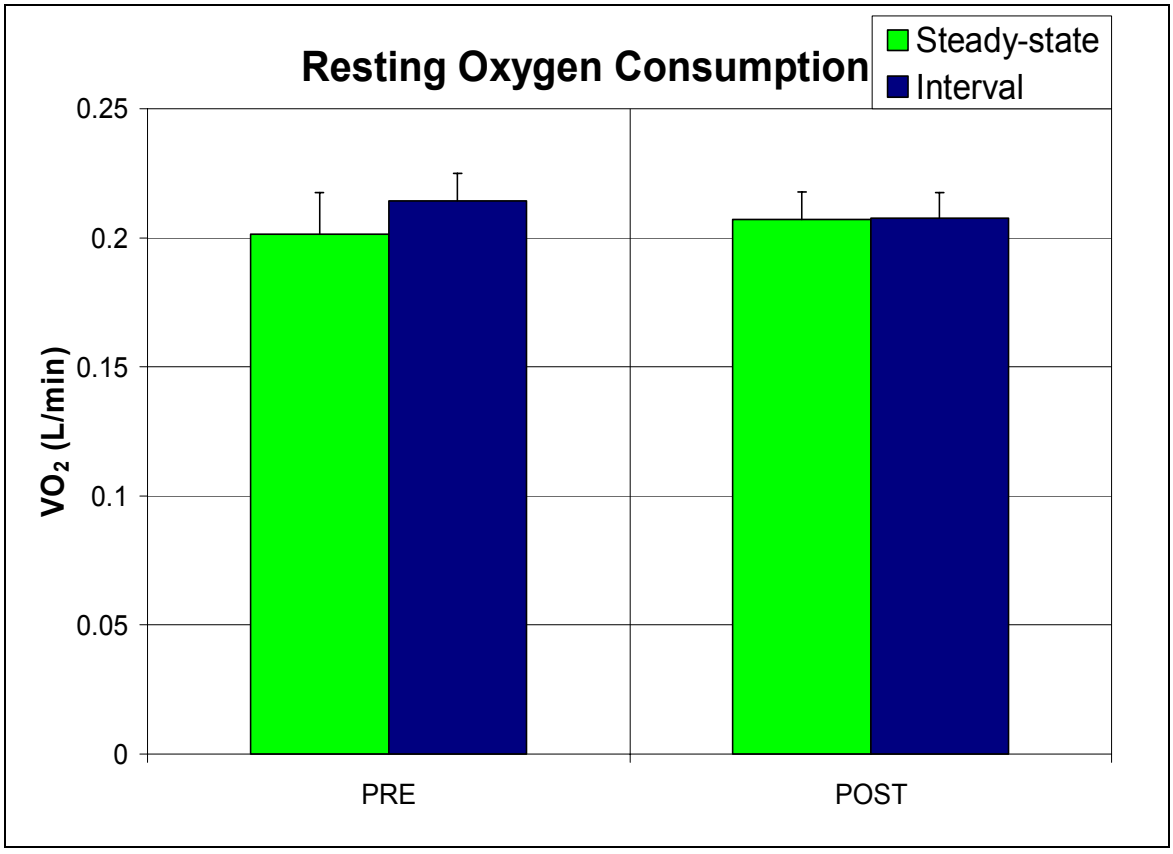

Figure 4-19: Resting oxygen consumption at rest prior to and after the 12-week intervention for the SS group (n = 14) and INT group (n = 12).

4.6 Body Composition

Results are shown below for body composition. These results include values for the following: BMI; body mass; fat mass; lean tissue; percentage of body fat and segmental body fat distribution.

4.6.1 Body Mass Index

Statistical analysis revealed no significant difference in BMI between the two groups at baseline (t = -0.824, $P = 0.418$). However, statistical analysis performed upon the completion of the interventions revealed a significant main effect for time (F = 71.142, $P < 0.001$; ES = 0.84 and 0.58 for the INT and SS groups, respectively), but no significant main effect for group (F = 0.881, $P = 0.357$) or for the interaction of group by time (F = 0.102, $P = 0.753$). Body mass index values in the INT group decreased by 7.08% ($P < 0.001$) and by 8.58% in the SS group ($P < 0.001$). Results are shown in Figure 4.20.

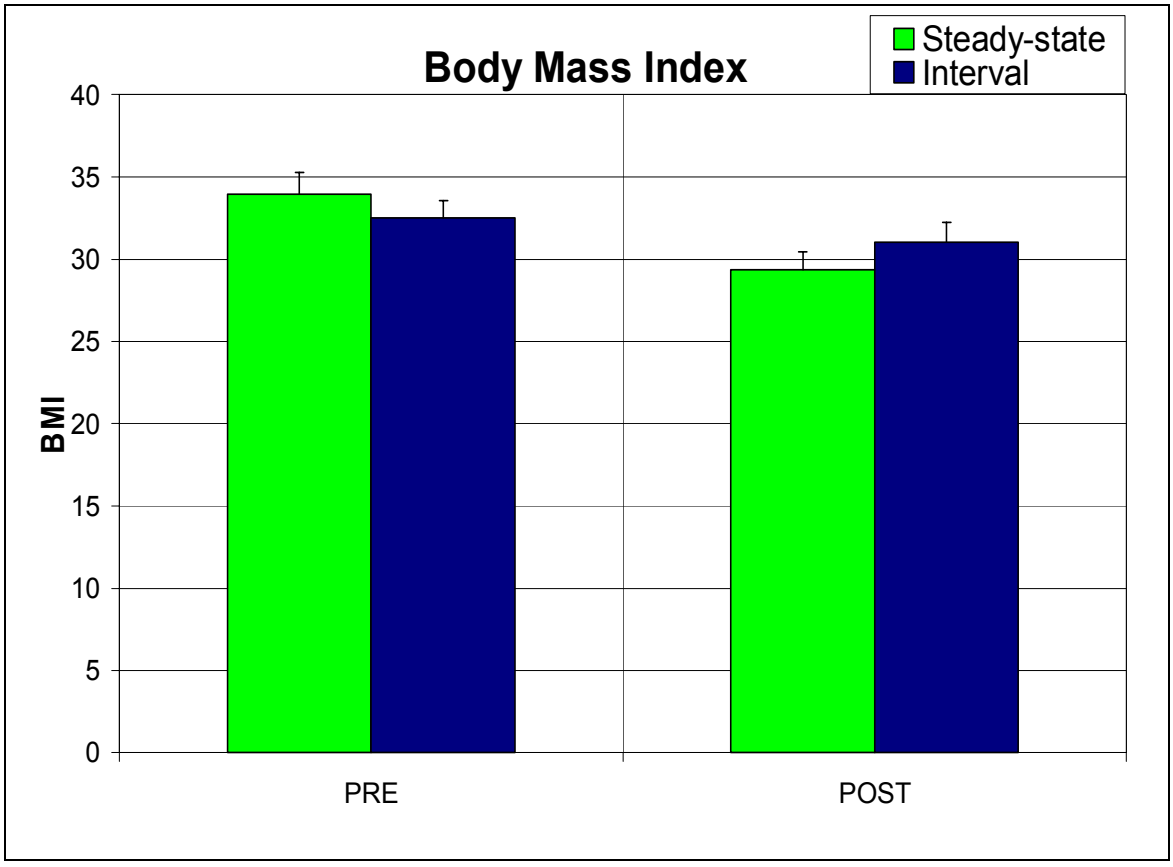

Figure 4-20: BMI at baseline and post-intervention for the SS group (n = 14) and the INT group (n = 12).

4.6.2 Body Mass

At baseline, body mass values were similar between the two groups (t = -0.945, P = 0.354). Upon completion of the interventions, statistical analyses revealed a significant main effect for time (F = 74.951, $P < 0.001$; ES = 0.79 and 0.43 for the INT and SS groups, respectively). However, there was no significant main effect for group (F = 1.059, P = 0.314), or for the interaction of group and time (F = 0.156, P = 0.696). Both groups reduced their body mass, with values decreasing by 9.61% in the INT group, and by 8.25% in the SS group. Results are shown in Figure 4.21.

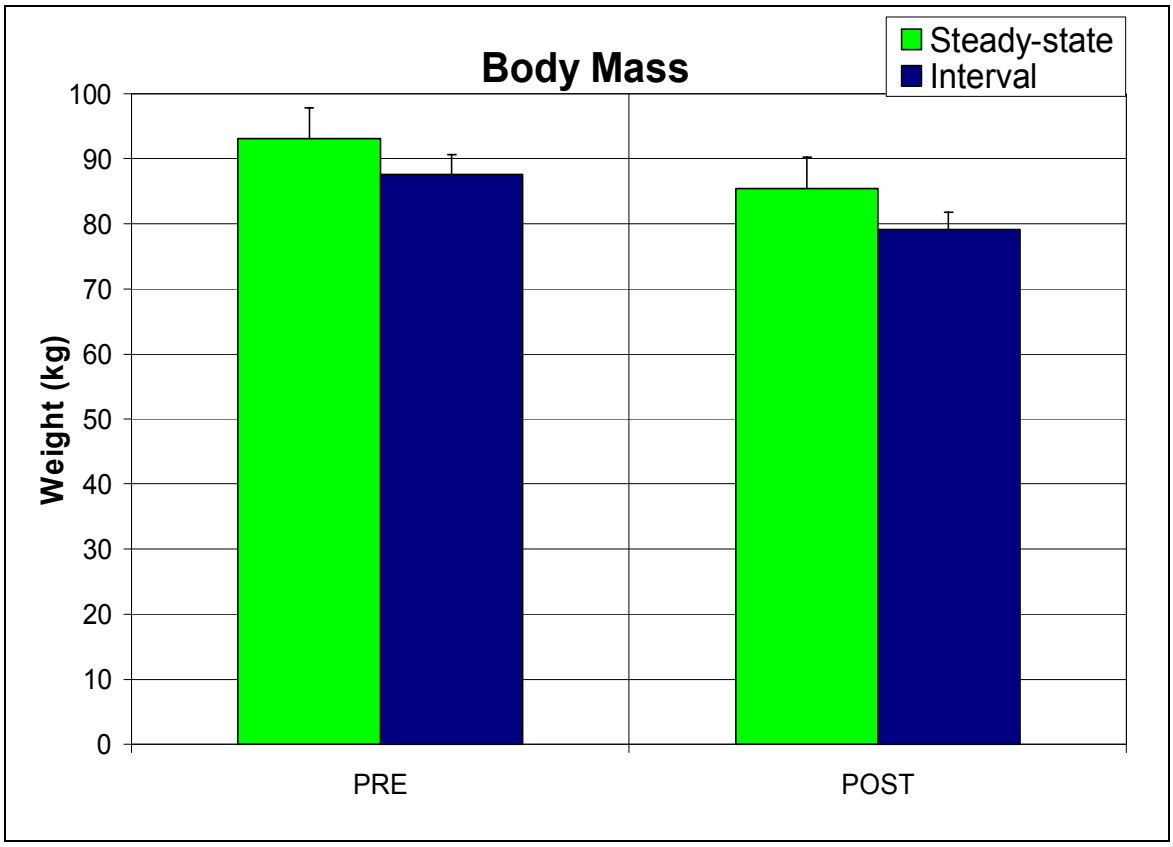

Figure 4-21: Body mass values at baseline and post-intervention for the SS group (n = 14) and the INT group (n = 12).

4.6.3 Fat Mass

Data analysis showed that there was no statistically significant difference in the amount of body fat between the two groups at baseline (t = -1.292, $P = 0.209$). Upon completion of the intervention, there was a significant main effect for time (F = 114.883, $P < 0.001$; ES = 1.10 and 0.92 in the INT and SS groups, respectively), but not for group (F = 2.268, $P = 0.145$), or for the interaction of group and time (F = 0.690, $P = 0.414$). Fat mass decreased in both the INT group and the SS group (22.56% and 17.47% respectively, $P < 0.001$). Results are shown in Figure 4.22.

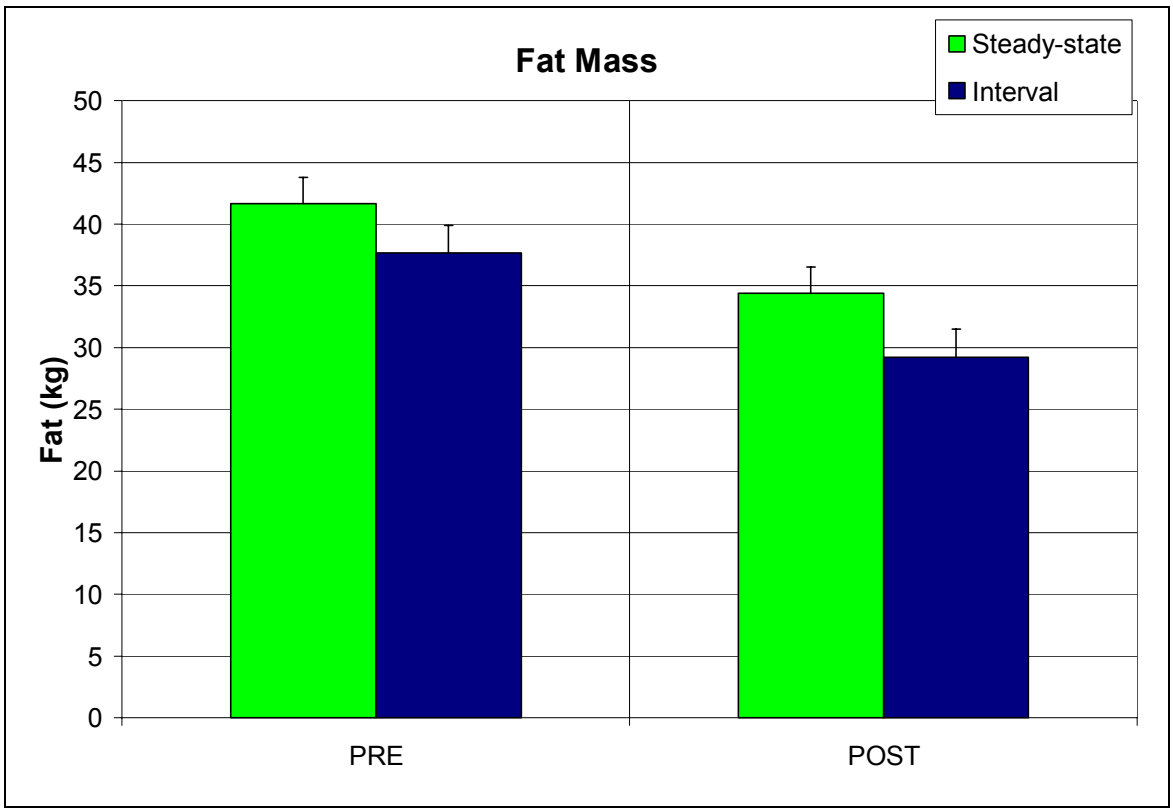

Figure 4-22: Fat mass values at baseline and post-intervention for the SS group (n = 14) and the INT group (n = 12).

4.6.4 Lean Tissue

There was no significant difference between the two groups at baseline for lean tissue mass (t = -0.073, *P* = 0.943). On completion of the 12-week intervention, results showed that the INT group experienced a 0.05% decrease in lean tissue mass, while the SS group also experienced a 0.35% decrease in lean tissue mass. There were no significant main effects for time (F = 0.064, *P* = 0.803), or for group (F = 0.003, *P* = 0.956). Additionally, there was no significant interaction effect (F = 0.034, *P* = 0.855). Results are shown in Figure 4.23.

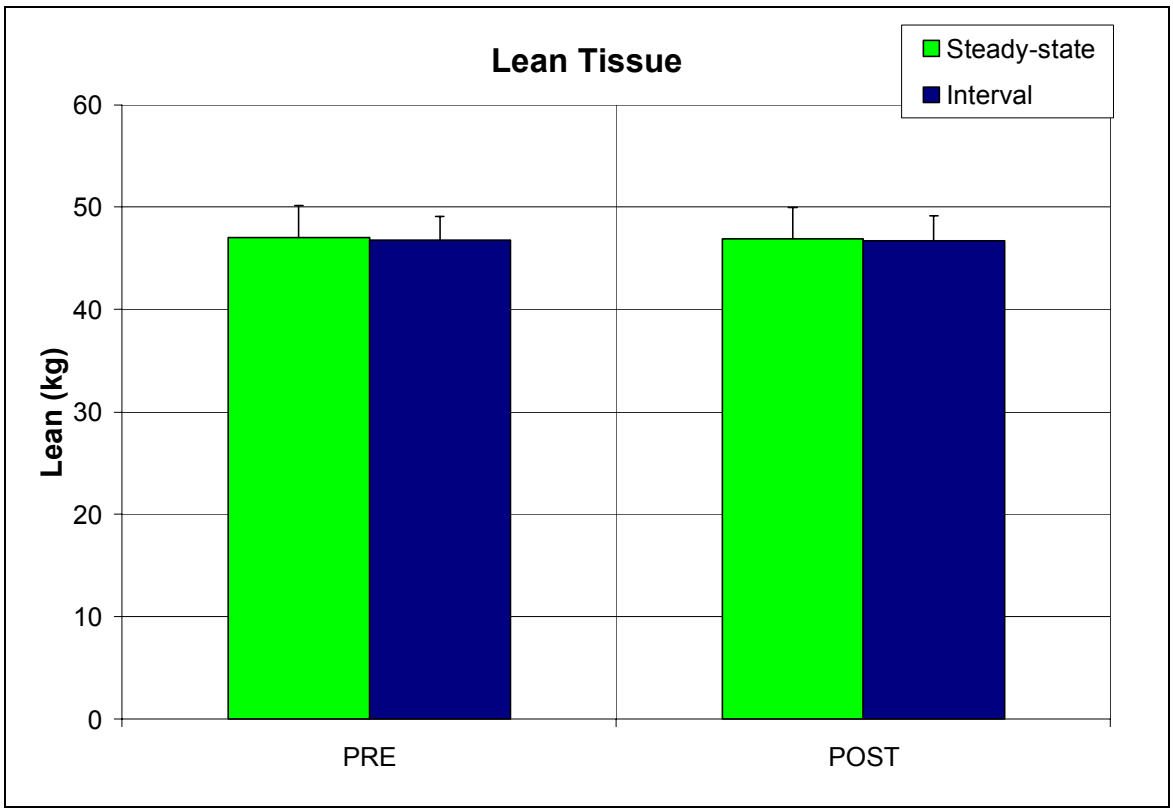

Figure 4-23: Lean tissue values at baseline and post-intervention for the SS group (n = 14) and the INT group (n = 12).

4.6.5 Percentage of Body Fat

Percentage of body fat between groups at baseline was similar (t = -1.203, P = 0.241). Post-intervention statistical analyses revealed a significant main effect for time (F = 98.417, $P < 0.001$; ES = 0.88 and 1.10 in the INT and SS groups, respectively), but not for group (F = 1.913, $P = 0.179$), nor was there an interaction effect (F = 1.325, P = 0.261). Post-intervention results showed that the percentage of body fat decreased by 14.05% in the INT group ($P < 0.001$) and by 10.47% in the SS group ($P < 0.001$). Results are shown in Figure 4.24.

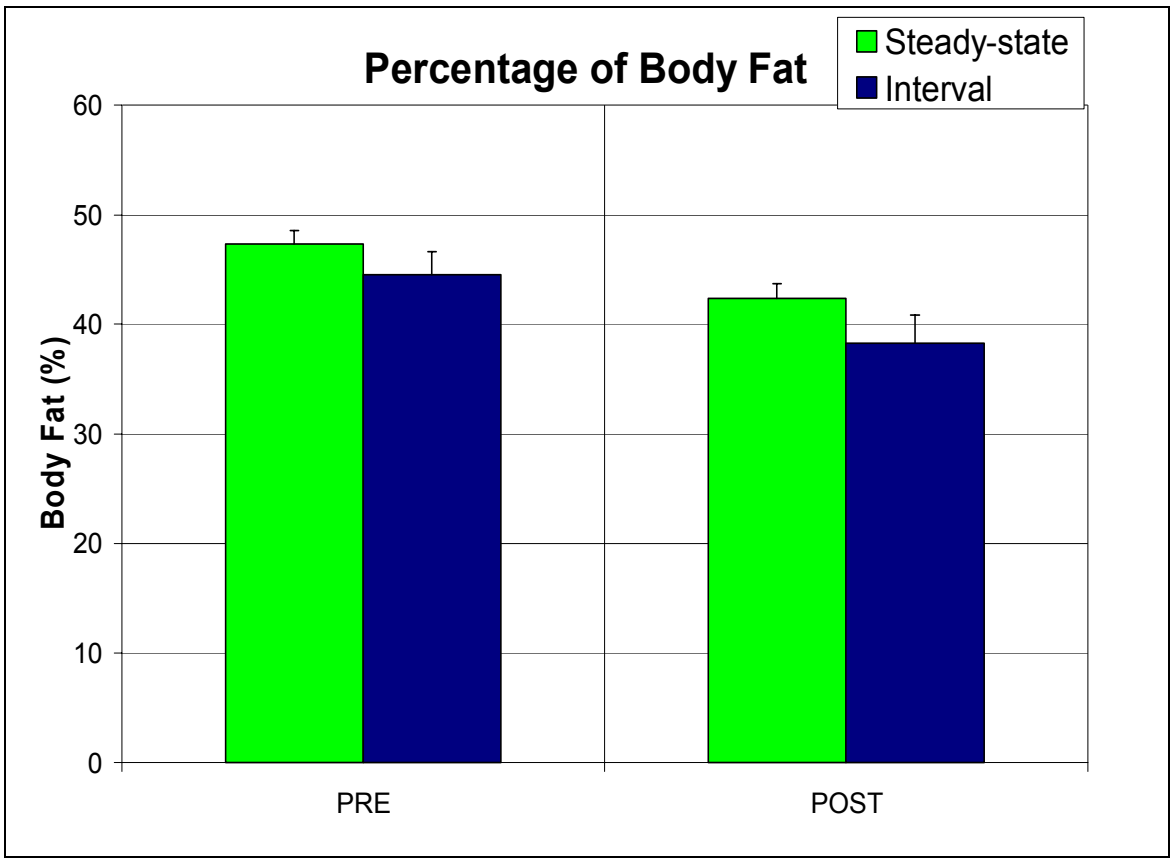

Figure 4-24: Percentage of body fat at baseline and post-intervention for the SS group (n = 14) and the INT group (n = 12).

4.6.6 Segmental Fat Distribution

Segmental fat for android and gynoid distribution was calculated by the DEXA software.

4.6.6.1 Android

Results for the android distribution of body fat did not differ significantly between the INT and SS groups at baseline (t = -1.133, P = 0.269). Statistical analysis performed after the interventions revealed that there was no significant main effects for time (F = 0.310, P = 0.583), or for group (F = 0.769, P = 0.389), nor was there an interaction effect (F = 1.126, P = 0.299). Nonetheless, post-intervention results showed that fat mass around the abdominal region (android obesity) decreased by 14.51% and 12.20% in the INT and SS groups, respectively. Results are shown in Figure 4.25.

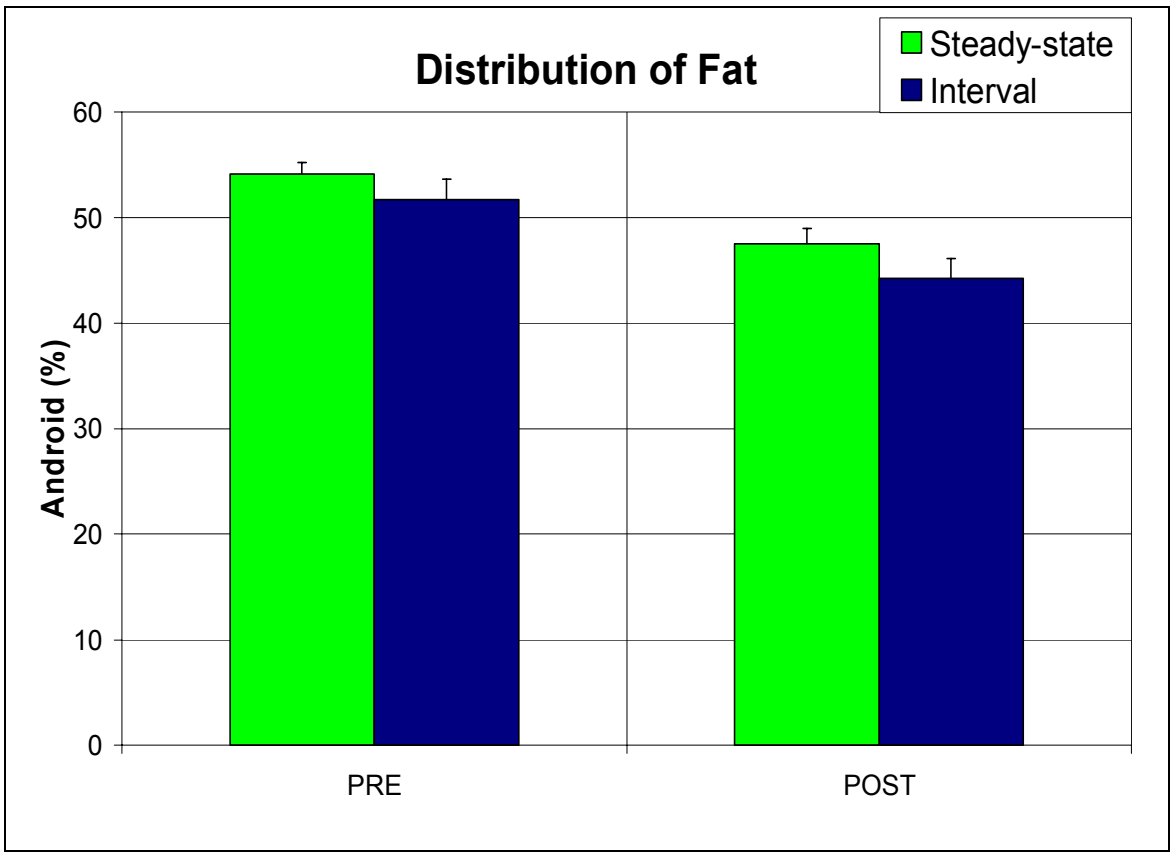

Figure 4-25: Android obesity at baseline and post-intervention for the SS group (n = 14) and the INT group (n = 12).

4.6.6.2 Gynoid

There was no significant difference between groups with regard to gynoid fat distribution at baseline (t = -0.693, P = 0.495). However, upon completion of the intervention, analyses revealed a significant main effect for time (F = 98.965, $P < 0.001$; ES = 0.65 and 0.70 in the INT and SS groups, respectively) but not for group (F = 0.749, P = 0.395). While there was no significant interaction main effect (F = 1.706, P = 0.204), post-intervention results showed that gynoid obesity was reduced in the two groups, as demonstrated by fat mass decreases of 10.60% in the INT group and 7.84% in the SS group. Results are shown in Figure 4.26.

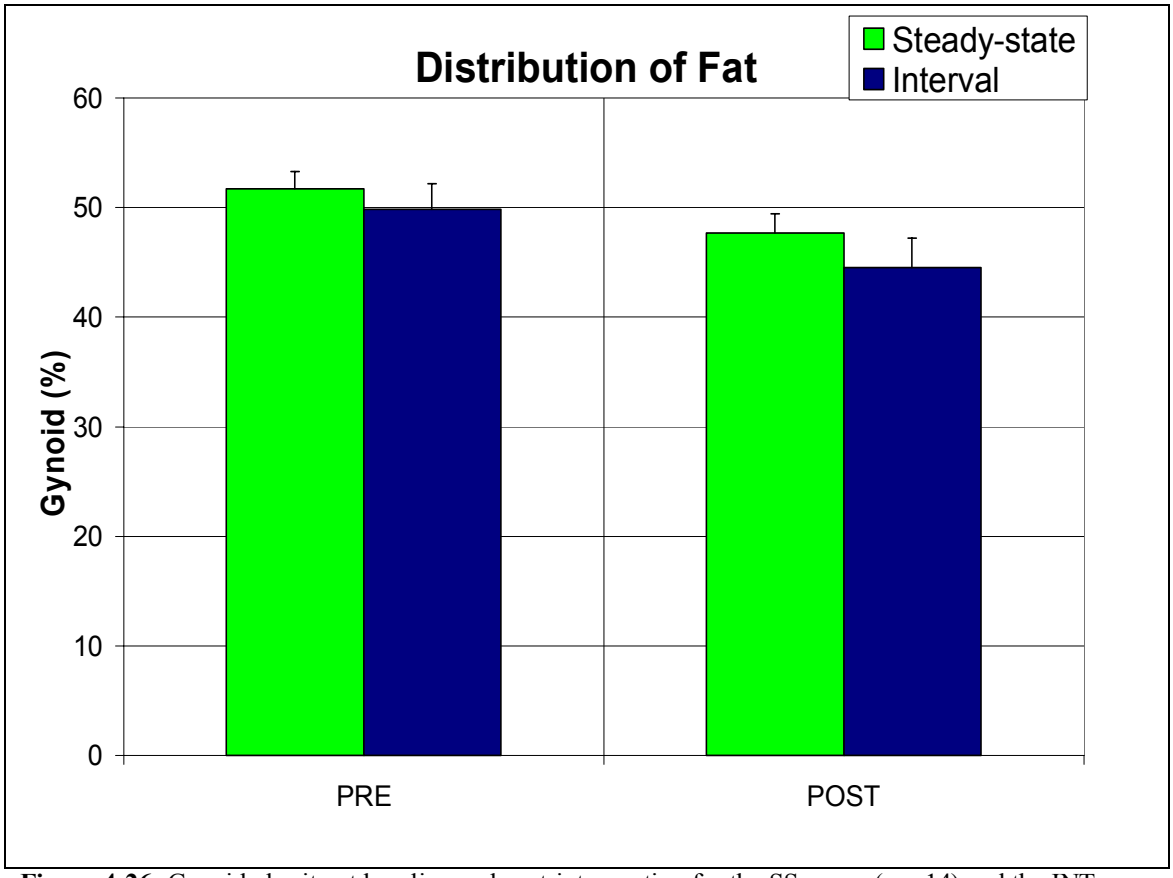

Figure 4-26: Gynoid obesity at baseline and post-intervention for the SS group (n = 14) and the INT group (n = 12).

4.6.7 Girth Measurements

Girth measurements included waist circumference, hip circumference and the waist to hip ratio. Results are shown below.

4.6.7.1 Waist Circumference

There was no statistical difference between the mean waist circumferences for both of the exercise groups prior to beginning the interventions (t = -1.019, $P = 0.318$). Post-testing results showed that the INT group reduced their waist circumference scores by 7.90%, while waist circumference scores also decreased in the SS group by 5.74%. Statistical analyses showed a significant main effect for time (F = 47.027, $P < 0.001$; ES = 1.10 and 0.47 for the INT and SS groups, respectively), but not for group (F = 1.583, $P = 0.220$) nor for the interaction of group by time (F = 0.892, $P = 0.354$). Results are shown in Figure 4.27.

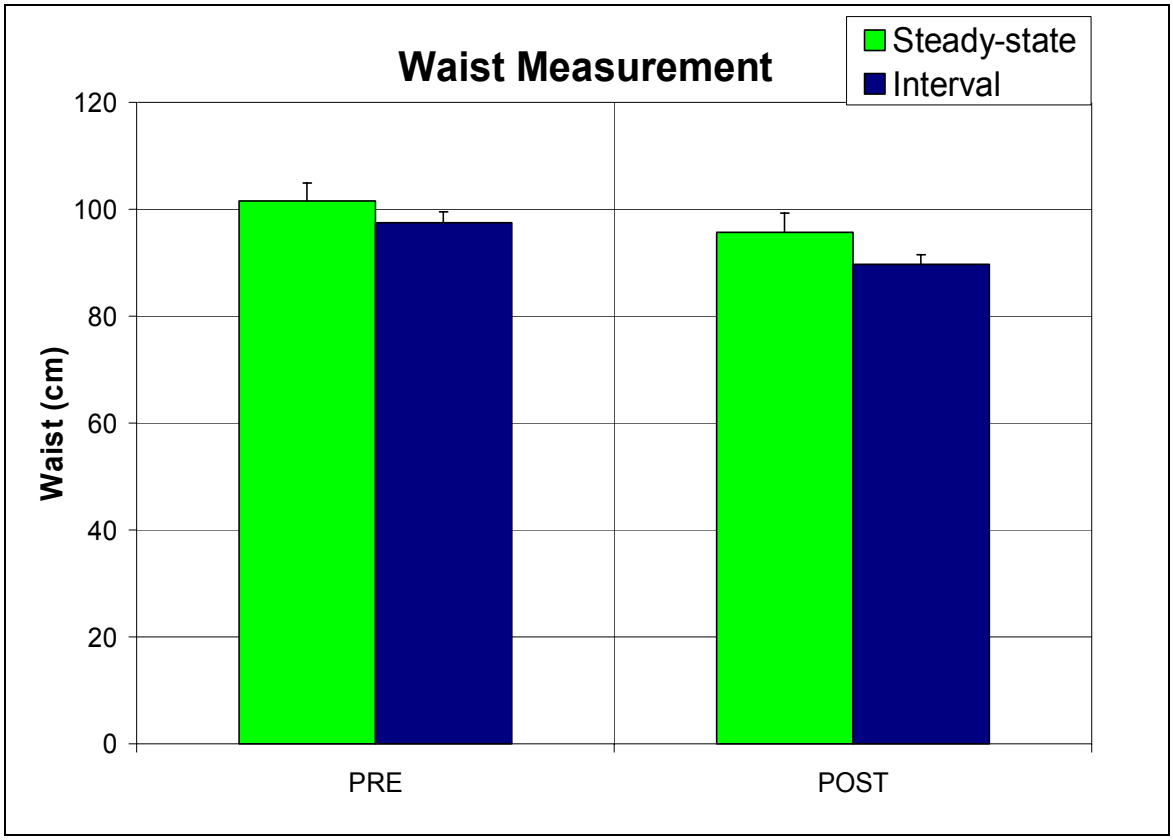

Figure 4-27: Waist circumference for the SS group (n = 14) and the INT group (n = 12) at baseline and after a 12-week intervention.

4.6.7.2 Hip Circumference

Hip circumference in both the INT and SS groups was similar at baseline measurements (t = -1.116, $P = 0.275$). As with waist circumference, hip circumference decreased post-intervention in the INT group by 6.00% and by 6.02% in the SS group. There was a significant main effect for time (F = 86.103, $P < 0.001$; ES = 0.86 and 0.82 in the INT and SS groups, respectively), but not for group (F = 1.219, $P = 0.280$). There was no significant interaction effect (F = 0.027, $P = 0.870$). Results are shown in Figure 4.28.

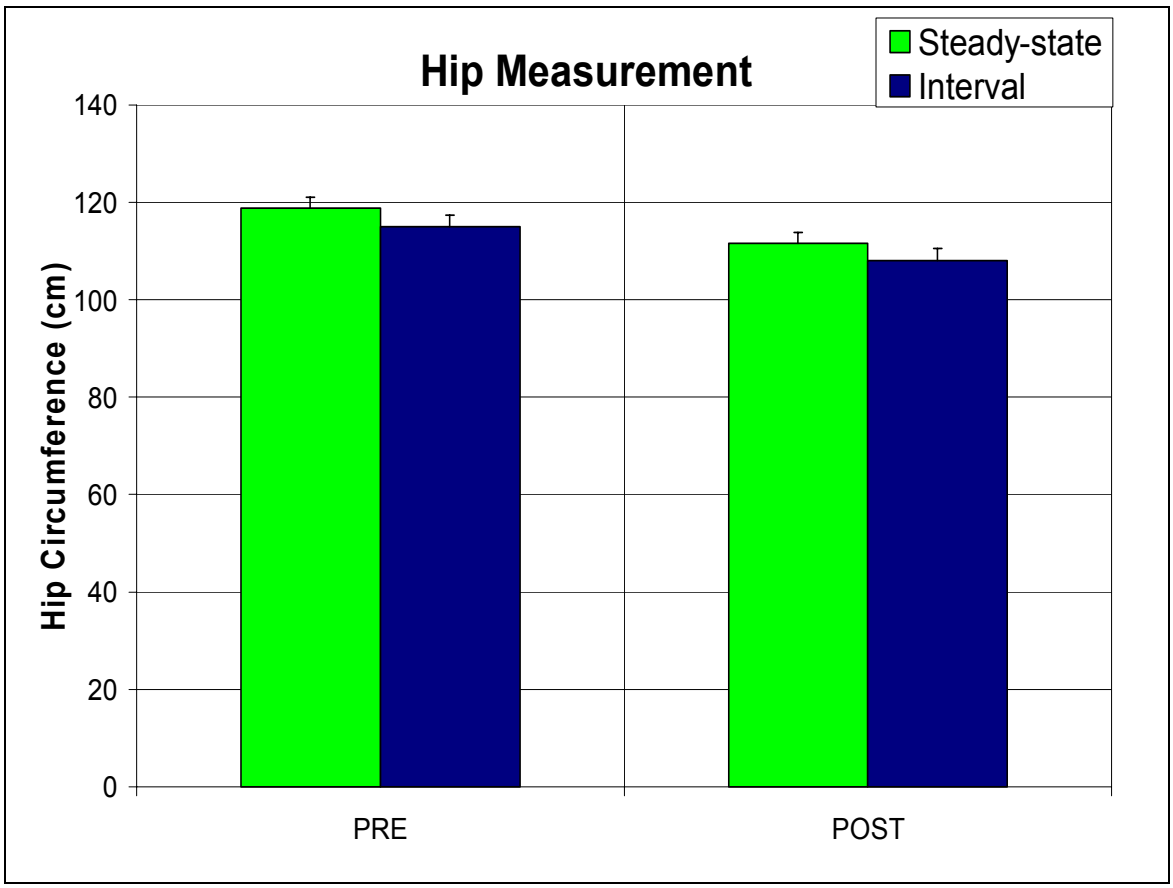

Figure 4-28: Hip circumference for the SS group (n = 14) and the INT group (n = 12) at baseline and after a 12-week intervention.

4.6.7.3 Waist to Hip Ratio

Waist and hip girth measurements were taken in order to calculate the waist/hip ratio for each participant. There was no significant difference between groups at baseline with regard to hip to waist ratio (t = -0.239, *P* = 0.813). Upon completion of the 12-week intervention period, hip to waist ratio was reduced in the INT group by 1.95%, however the SS group showed a slight increase of 0.09%. Statistical analyses revealed that there were no significant effects for group (F = 1.281, *P* = 0.269) or for time (F = 0.369, *P* = 0.549), nor for the interaction of time and group (F = 1.527, *P* = 0.228). Results are shown in Figure 4.29.

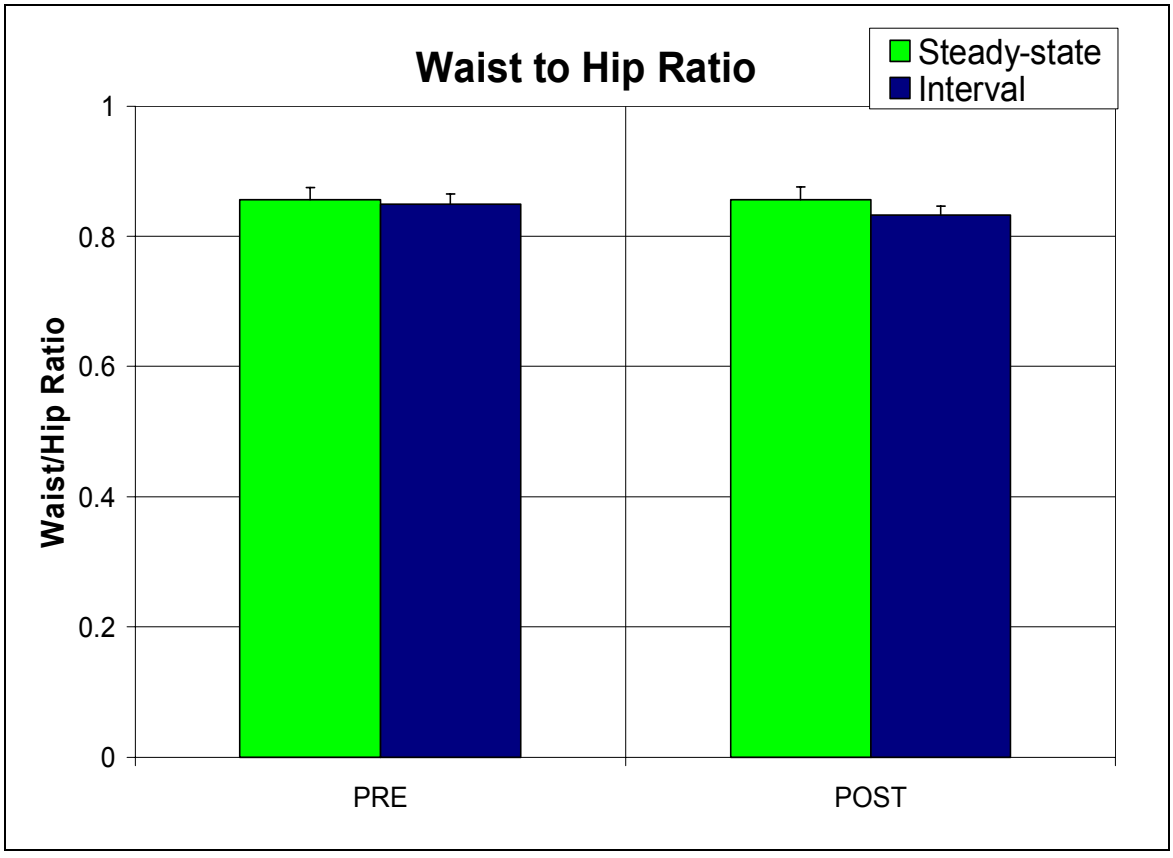

Figure 4-29: Ratio of waist to hip circumference for the SS group (n = 14) and INT group (n = 12) at baseline and after a 12-week intervention.

4.6.8 Correlation of Fat Mass with Hip and Waist Girth

At baseline, there was a strong relationship between DEXA measurements of fat mass and both waist ($r = 0.595$, $P < 0.001$) and hip girth ($r = 0.903$, $P < 0.001$). The correlation was also significant after the completion of the 12-week intervention with fat mass still significantly correlating with waist ($r = 0.703$, $P < 0.001$) and hip girth ($r = 0.913$, $P < 0.001$).

4.7 Vascular Function

Several calculations were performed to determine the measurements of diameter and blood flow through the brachial artery during FMD and GTN administration. Relevant data are presented in the following section.

4.7.1 Five Minute Flow Mediated Dilation

4.7.1.1 Percentage of Five Minute Flow Mediated Dilation

The Levene's Test for equality of variance revealed that equal variance was not assumed. Statistical analysis also revealed that there was no significant difference between the two groups at baseline (t = 0.277, P = 0.793). Assessment of five minute flow mediated dilation (5FMD) performed after the 12-week intervention period revealed that the percentage of FMD had decreased in the INT group, as well as in the SS group by 1.07% and 14.52%, respectively. No significant effect occurred for time (F = 0.118, P = 0.738) or for group (F = 0.635, P = 0.442). Additionally, there was no significant main effect for the interaction of time and group (F = 0.085, P = 0.776). Results are shown in Figure 4.30.

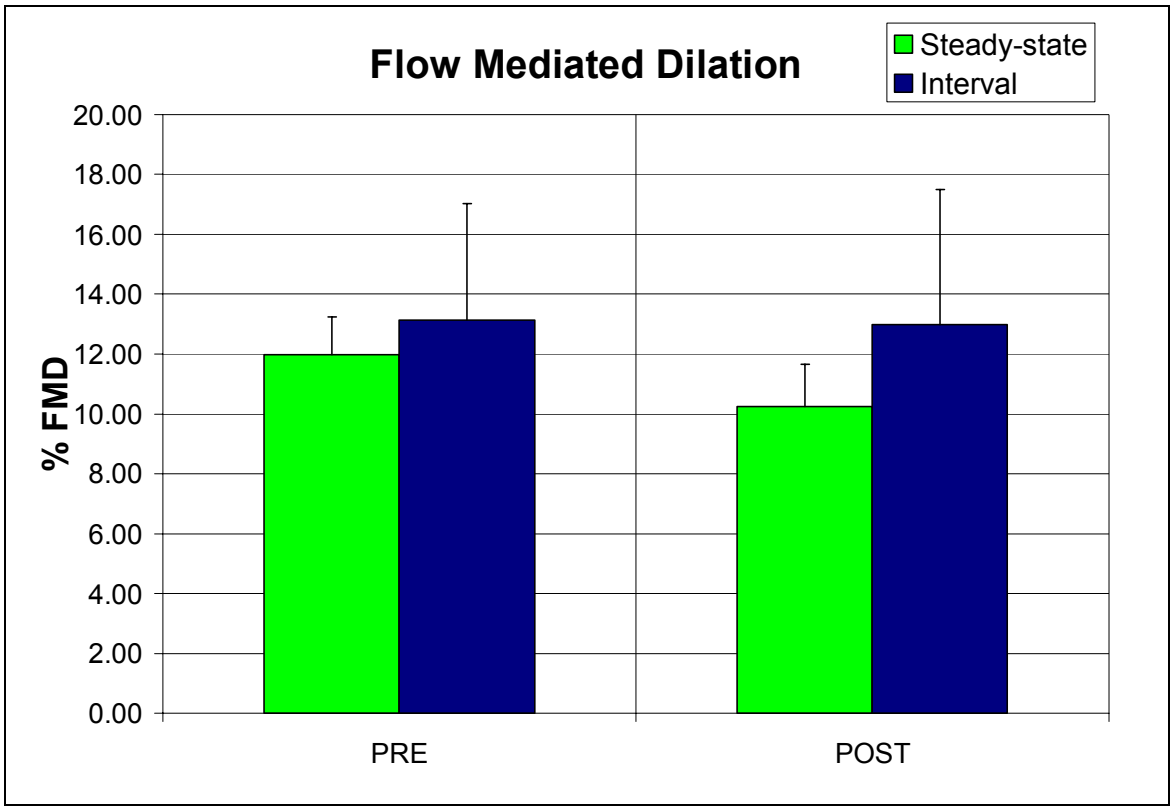

Figure 4-30: Percentage of FMD at baseline and post-intervention for the SS group (n = 8) and the interval group (n = 5).

4.7.2 Glyceride Trinitrate

4.7.2.1 Percentage of Glycerol Trinitrate

At baseline, the INT and the SS groups were similar in respect to GTN values (t = 0.287, *P* = 0.780). However, the percentage of GTN differed significantly after the interventions were complete. An increase of 27.39% and a reduction of 8.11% of GTN were seen in the INT and SS groups, respectively. The main effects for time (F = 0.557, *P* = 0.473), group (F = 2.468, *P* = 0.147) and interaction of time by group (F = 1.773, *P* = 0.213) were all not significant. Results are shown in Figure 4.33.

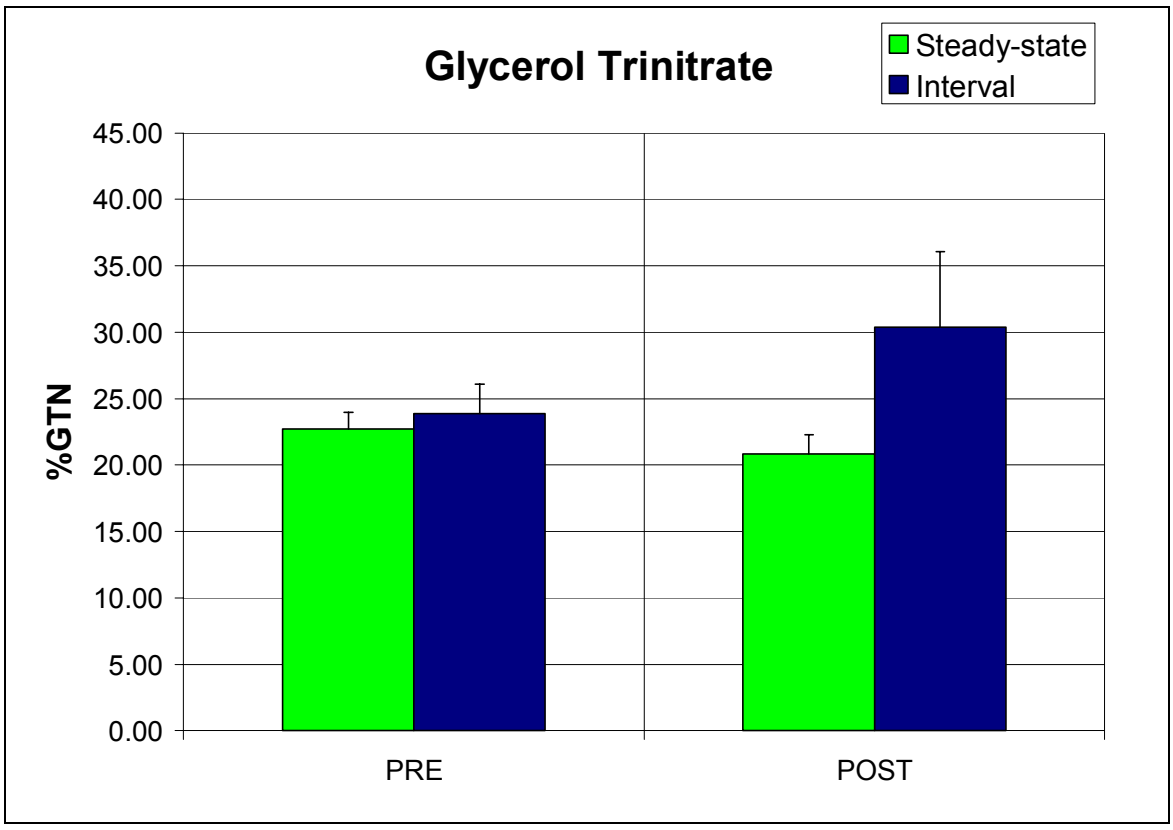

Figure 4-31: Percentage of GTN at baseline and post-training for the SS group (n = 7) and the INT group (n = 5).

4.8 Quality of Life Questionnaires

Three questionnaires were administered in this study. These were the SF-36, the HADS and the OA-ESI.

4.8.1 SF-36

The SF-36 is a self-report questionnaire that provides an indicator across eight sub-sections of health and wellbeing. These sub-sections include: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health. Each response category has a score value expressed from 0-100 with a higher number indicating a better state of health or wellbeing.

There was no significant difference between the two groups for any SF-36 variable assessed at baseline, except for mental health ($t = 2.713$, $P = 0.012$). Statistical analyses performed on baseline and post-intervention results revealed a significant difference for the main effect for time for all variables assessed except for 'role limitations due to emotional problems', which approached significance ($F = 3.156$, $P = 0.088$). Statistical results for the variables that showed a significant main effect for time are as follows: physical functioning ($F = 30.327$, $P < 0.001$; ES = 0.75 and 1.14 for the INT and SS group, respectively); general health ($F = 23.693$, $P < 0.001$; ES = 0.54 and 1.10 for the INT and SS group, respectively); physical health ($F = 9.127$, $P = 0.006$; ES = 0.60 and 0.94 for the INT and SS group, respectively); bodily pain ($F = 9.006$, $P = 0.006$; ES = 0.35 and 0.80 for the INT and SS group, respectively); vitality ($F = 21.341$, $P < 0.001$; ES = 0.54 and 1.36 for the INT and SS group, respectively); social function ($F = 9.336$, $P = 0.005$; ES = 0.31 and 0.77 for the INT and SS group, respectively); and mental health ($F = 10.088$, $P = 0.004$). Additionally, the main effect for group approached significance for social function ($F = 3.169$, $P = 0.088$) and mental health ($F = 4.221$, $P = 0.051$). The interaction of group and time also approached significance only for mental health ($F = 4.085$, $P = 0.055$). *Post-hoc* analysis revealed that scores for mental health in the SS group significantly improved over time ($t = -3.396$, $P = 0.005$, ES = 0.75), whereas scores in the INT group did not significantly change from baseline to post-intervention ($t = -0.952$, $P = 0.361$, ES = 0.26). Additionally, post-intervention scores for mental health were not significantly different between the two groups (t =

0.980, $P = 0.337$). All other main effects were not significant. Results are shown in Table 4.5.

Table 4-5: SF-36 Questionnaire. Baseline and post-intervention results for the SS group (n = 14) and the INT group (n = 12).

	SS Group (n = 14)		**INT Group (n = 12)**	
	BASELINE	**POST INTERVENTION**	**BASELINE**	**POST INTERVENTION**
Physical Function	67.1 ± 20.7	90.7 ± 6.5	70.4 ± 27.3	90.8 ± 11.0
Role Physical	66.1 ± 30.4	94.6 ± 20.0	81.3 ± 24.1	95.8 ± 9.7
Bodily Pain	66.0 ± 22.7	84.1 ± 14.4	67.3 ± 24.8	75.9 ± 16.5
General Health	62.7 ± 15.2	79.4 ± 13.6	68.5 ± 22.9	80.8 ± 16.1
Vitality	43.9 ± 20.0	71.1 ± 18.3	56.8 ± 26.9	71.3 ± 18.5
Social Function	67.9 ± 26.7	88.4 ± 14.3	81.0 ± 17.5	86.5 ± 18.8
Role Emotional	61.9 ± 34.3	78.4 ± 33.5	72.9 ± 31.2	85.0 ± 26.2
Mental Health	65.1 ± 16.0 ††	77.1 ± 16.4 **	79.7 ± 10.2 ††	82.3 ± 8.8

†† $P < 0.05$ significant group difference at baseline between the SS and INT groups; ** $P < 0.05$ significantly different over time compared to baseline in the SS group.

4.8.2 Hospital Anxiety and Depression Scale

4.8.2.1 Anxiety

Analysis at baseline revealed that there was no significant difference between the two groups for levels of anxiety as assessed by HADS (t = -1.027, *P* = 0.315). Baseline anxiety levels in the SS group were considered to be 'borderline abnormal', while scores in the INT group were within 'normal' range. Upon completion of the 12-week intervention period, statistical analyses showed a significant main effect for time (F = 6.716, *P* = 0.016; ES = 0.23 and 0.54 in the INT and SS groups, respectively), yet the group and the interaction effects were not significant (F = 0.268, *P* = 0.609 and F = 2.324, *P* = 0.140, respectively). Additionally, post-intervention results showed a 10.26% decrease in anxiety scores in the INT group, while the SS group experienced a 31.58% decrease in scores. This decrease in post-intervention scores in the SS group resulted in a normal rating for anxiety in this group. Results can be found in Figure 4.36.

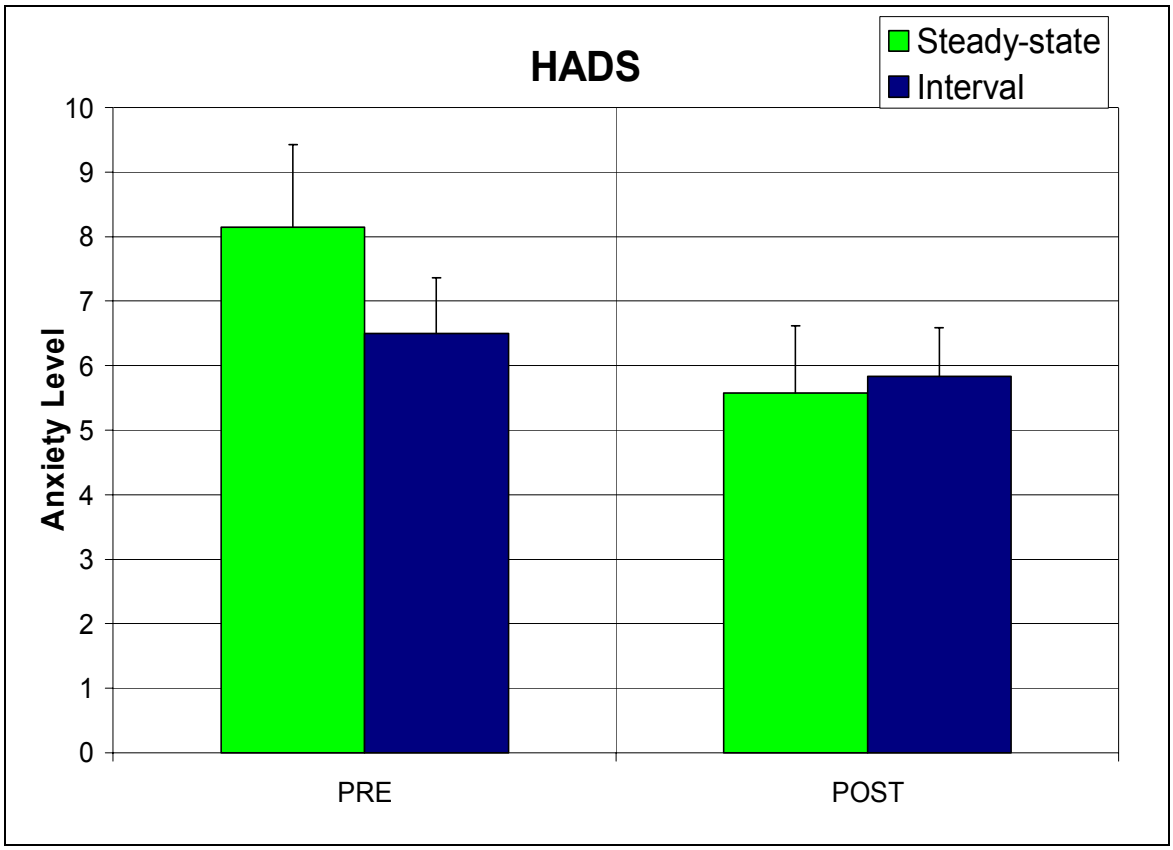

Figure 4-32: Anxiety levels for the SS group (n = 14) and the INT group (n = 12) before and after a 12-week intervention.

4.8.2.2 Depression

Baseline scores for depression were similar between the two groups (t = -0.705, P = 0.488) and were considered to be within 'normal' range. Further assessment performed upon the completion of the intervention showed that depression scores had fallen by 50.00% and 71.79% in the INT and SS groups, respectively. This resulted in a significant main effect for time (F = 21.771, P < 0.001; ES = 0.65 and 0.96 for the INT and SS groups, respectively), but not for group (F = 0.040, P = 0.844), or for the interaction of group and time (F = 1.707, P = 0.204), which were not significant. Results can be found in Figure 4.37.

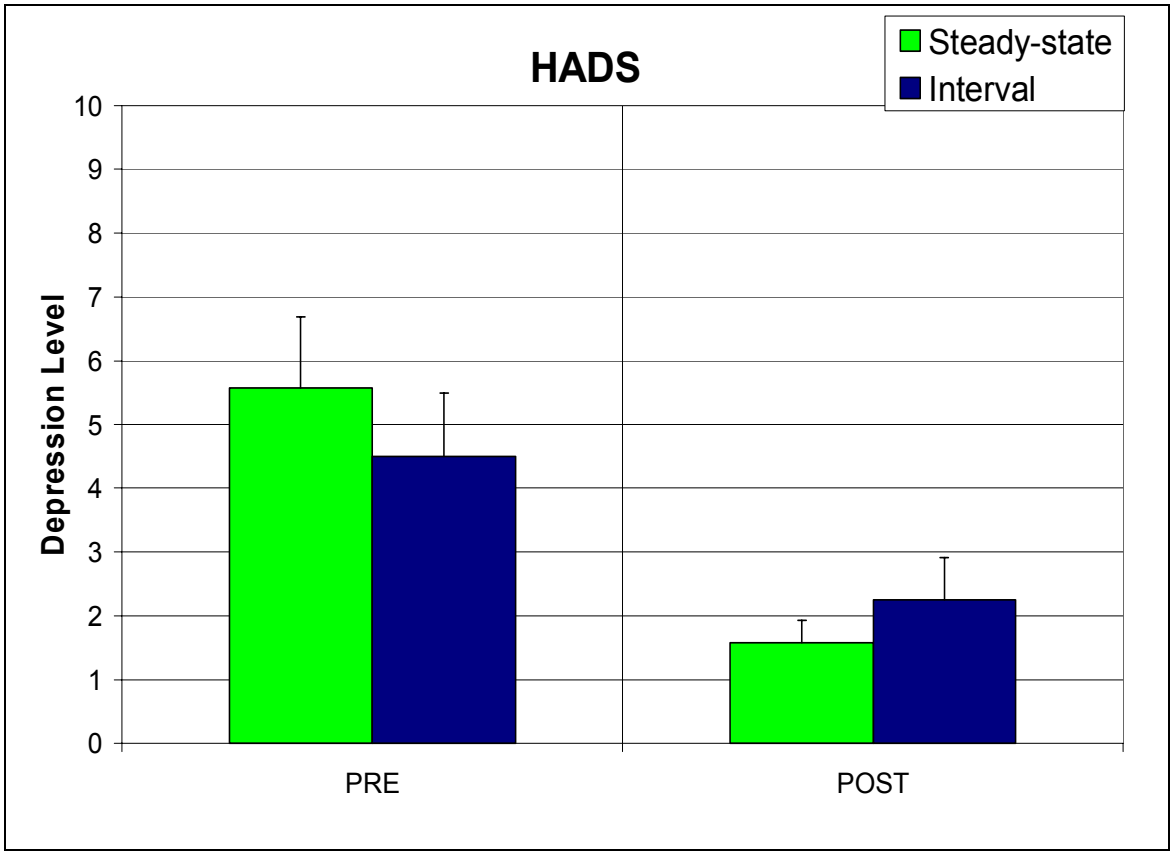

Figure 4-33: Depression levels for the SS group (n = 14) and the INT group (n = 12) before and after a 12-week intervention.

4.9 Activity Levels

4.9.1 Older Adult-Exercise Status Inventory

Activity levels were assessed by use of a self-report questionnaire (OA-ESI), which was administered during week 1 and week 12 of the interventions.

4.9.1.1 Overall Activity Levels

There was no significant difference between the two groups for weekly activity levels assessed during week 1 of the intervention (t = 0.032, P = 0.975). Statistical analyses performed on week 12 results revealed no significant difference for the main effect of time (F = 1.404, P = 0.250), group (F = 0.592, P = 0.451) or the interaction of group by time (F = 1.415, P = 0.248). Overall activity levels decreased in the INT group by 58.12%, whereas activity levels increased slightly in the SS group by 0.11%. Results are shown in Figure 4.38.

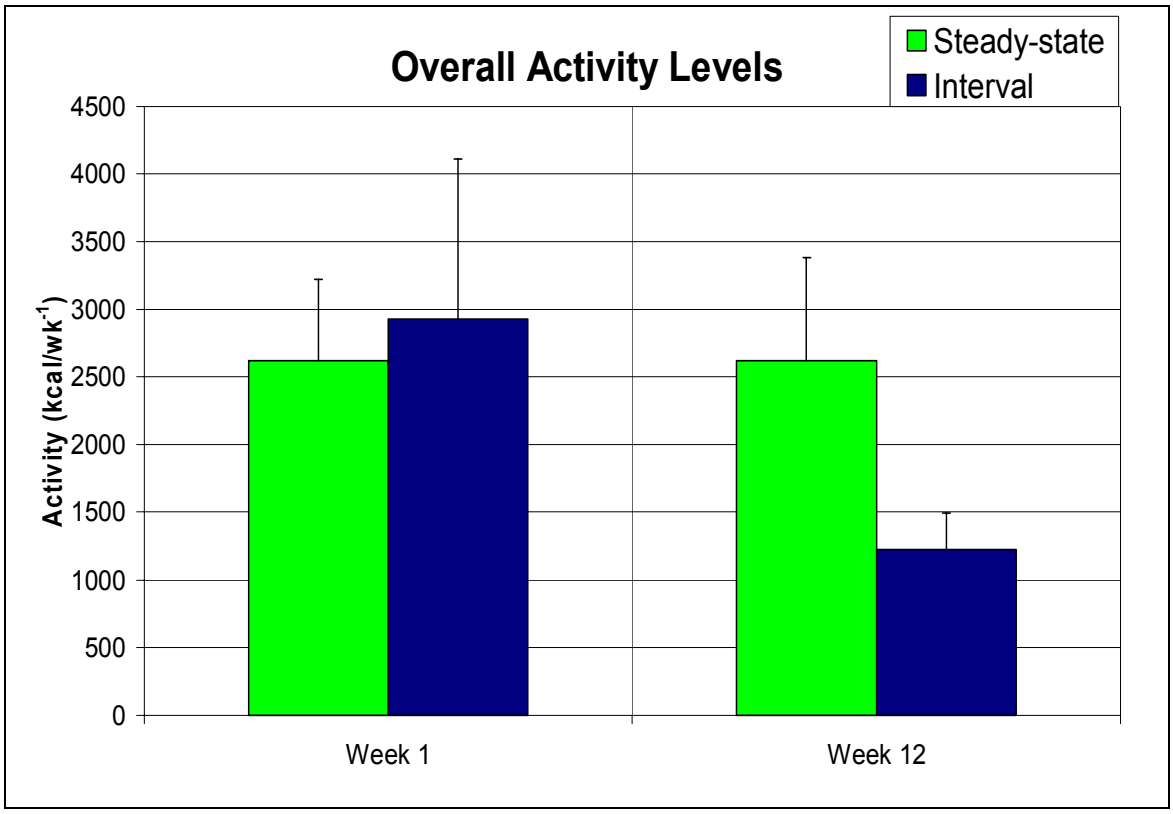

Figure 4-34: Overall activity levels for the SS group (n = 13) and the INT group (n = 11 and n = 12) during week 1 and week 12 of the intervention.

4.9.2 Pedometer

4.9.2.1 Total Daily Steps

No significant difference was found between the two groups at baseline for the total number of steps taken daily (t = 1.000, *P* = 0.329). Upon completion of the interventions, the total amount of steps increased by 8.89% and 14.86% in the INT and SS groups, respectively. Statistical analyses revealed no significant main effects for time (F = 1.608, *P* = 0.220), group (F = 0.126, *P* = 0.727), or the interaction of time and group (F = 0.593, *P* = 0.451). Results are shown in Table 4.6.

4.9.2.2 Exercise Steps

Statistical analysis revealed no significant difference between the two groups for total exercise steps taken during baseline assessment (t = 1.084, *P* = 0.291). Analyses of results recorded upon completion of the interventions revealed that the amount of steps taken during exercise increased by 8.83% in the INT group and by 7.33% in the SS group. Statistical analysis revealed that the main effect for time (F = 3.914, *P* = 0.065; ES = 1.02 and 0.37 in the INT and SS groups) and group (F = 3.333, *P* = 0.087) approached significance. However, there was no significant interaction effect for time by group (F = 0.105, *P* = 0.750). Results are shown in Table 4.6.

4.9.2.3 Incidental Steps

At baseline, results for incidental steps between the INT and SS groups were similar (t = 0.844, *P* = 0.409). Upon completion of the interventions, both the INT group and the SS group increased the amount of incidental steps taken by 8.89% and 18.08%, respectively. Statistical analysis revealed a non-significant main effect for time (F = 2.311, *P* = 0.148), group (F = 0.860, *P* = 0.367) and the interaction of time and group (F = 0.122, *P* = 0.731). Results are shown in Table 4.6.

Table 4-6: Pedometer data comparing week 1 values with week 12 values (per day) for the SS group and INT group.

	SS Group (n = 10)		INT Group (n = 8)	
	Week 1	**Week 12**	**Week 1**	**Week 12**
Total Steps	9567 ± 2362	10989 ± 4482	11743 ± 4425	12787 ± 3992
Exercise Steps	3803 ± 755	4082 ± 598	4392 ± 1164	4780 ± 746
Incidental Steps	6850 ± 2142	8072 ± 4359	8608 ± 4293	9373 ± 3888

4.9.3 Accelerometer

Due to only one participant wearing the accelerometer in the SS group, a group comparison was not completed. Instead all data was pooled and baseline and post-intervention data was compared using paired t-tests.

4.9.3.1 Energy Expenditure

The total amount of energy ($kcal/d^{-1}$) expended during post-intervention assessment revealed a 23.79% decrease when compared to baseline data. This change was not significant (t = 1.058, $P = 0.350$). Results are shown in Table 4.7.

4.9.3.2 Total Steps

Total steps taken per day for a week, from week 1 to week 12, decreased by 20.17%. This result was statistically not significant (t = 1.715, $P = 0.162$). Results are shown in Table 4.7.

4.9.3.3 Activity Levels

The amount of time spent in activities that were considered to be light increased minimally from week 1 to week 12 by 0.22% (t = -0.266, $P = 0.804$; NS). Time spent

in moderate activities decreased from week 1 to week 12 by 3.32%, with this change being non-significant (t = 0.138, *P* = 0.897). Minutes spent in activities that were considered to be hard fell by 50.00% in week 12 compared to week 1 (t = 0.828, *P* = 0.454; NS), while time spent completing very hard activities reduced from week 1 to week 12 by 33.33%. This change was also not significant (t = 1.000, *P* = 0.374). Results for the various activity levels are shown in Table 4.7.

Table 4-7: Accelerometer data comparing week 1 values with week 12 values (n = 6).

	Week 1 (n = 6)	**Week 12 (n = 6)**
Energy Expenditure (kcal per day)	384.0 ± 212.4	292.7 ± 216.9
Step Count (per day)	12565.0 ± 1366.9	10030.2 ± 3424.0
Activity Levels:		
Light (minutes per day)	1394.0 ± 24.7	1397.0 ± 34.6
Moderate (minutes per day)	42.2 ± 24.9	40.8 ± 33.8
Hard (minutes per day)	2.8 ± 3.0	1.4 ± 1.3
Very Hard (minutes per day)	0.6 ± 1.3	0.4 ± 0.9

4.9.4 Correlation of Activity Levels

Data analysis performed at baseline revealed no significant correlation between any of the three measurements of activity; OA-ESI with pedometer (r = -0.267, *P* = 0.230); OA-ESI with accelerometer (r = 0.097, *P* = 0.876); pedometer with accelerometer (r = 0.800, *P* = 0.104). Correlation of results at week 12 revealed no significant correlation for OA-ESI with pedometer (r = 0.248, *P* = 0.266) or OA-ESI with accelerometer (r = -0.060, *P* = 0.924). However, the correlation post-intervention for pedometer with accelerometer was significant (r = 0.989, *P* = 0.011).

4.10 Food Diary

A food diary was used to determine the energy value (kcal) of participant's food intake, as well as the percentage of carbohydrates, lipids and protein ingested by participants.

4.10.1 Energy Intake

Energy intake between the two groups was not significantly different during baseline measurements (t = -0.385, *P* = 0.704). However, upon completion of the interventions, results showed that the amount of energy consumed increased by 24.99% in the INT group, whereas energy intake increased by 6.76% in the SS group. Statistical analyses revealed no significant differences for the main effects of time (F = 1.482, *P* = 0.238) or group (F = 1.093, *P* = 0.309), however the interaction of time and group was significant (F = 4.662, *P* = 0.044). *Post-hoc* testing did not reveal a significant difference in either the INT or SS groups over time (t = -1.730, *P* = 0.118, ES = 1.505 and t = 1.327, *P* = 0.214, ES = 0.1654, respectively). Further to this, no significant difference was revealed between the two groups at week 12 (t = 1.367, *P* = 0.197). Results are shown in Table 4.8.

4.10.2 Protein

The daily intake of protein (grams per day) was not significantly different between the two groups prior to the intervention (t = 0.455, *P* = 0.654). Statistical analysis of post-intervention results revealed a non-significant main effect for time (F = 0.320, *P* = 0.578), as well as for group (F = 1.709, *P* = 0.207). Conversely, the main interaction effect of time by group (F = 8.247, *P* = 0.010) was significant. The amount of protein consumed in week 12 by the INT group increased by 12.60%, while values decreased by 8.96 % in the SS group, when compared to week one. *Post-hoc* examination showed that protein intake by the INT group significantly increased over time (t = -2.398, *P* = 0.040, ES = 0.651), however the change over time was not significantly different in the SS group (t = 1.657, *P* = 0.129, ES = 0.244). The difference between the INT and SS groups for protein intake post-intervention, approached a significant value (t = 1.813, *P* = 0.085). Results are shown in Table 4.8.

4.10.3 Carbohydrates

The kcal intake of CHO was not significantly different between the two groups at the start of the intervention (t = -0.394, *P* = 0.698). Post-intervention statistical analyses revealed a non-significant main effect for group (F = 0.407, *P* = 0.531) and for the interaction of time and group (F = 1.714, *P* = 0.206), however the main effect for time was significant (F = 4.983, *P* = 0.038; ES = 1.45 and 0.42 for the INT and SS groups, respectively). Upon completing the interventions, results showed that CHO consumption increased in the INT group by 39.65%, as well as in the SS group by 9.96%. Results are shown in Table 4.8.

4.10.4 Lipids

Lipid intake (grams per day) was not significantly different between the INT and SS groups during baseline measurements (t = -0.659, *P* = 0.518). Post-intervention analysis showed a 15.52% increase in lipid dietary intake by the INT group, however the SS group decreased their lipid consumption by 20.95%. The main effect for the interaction of time by group was significant (F = 5.236, *P* = 0.034), whereas there was a non-significant main effect for time (F = 0.182, *P* = 0.675) and group (F = 0.590, *P* = 0.452). *Post-hoc* examination revealed a significant decrease in lipid intake over time for the SS group (t = 2.552, *P* = 0.029, ES = 0.767), but no significant change over time occurred in the INT group (t = -1.068, *P* = 0.313, ES = 0.610). Post-intervention values for lipid intake also showed that there was no significant group difference (t = 1.327, *P* = 0.206). Results are shown in Table 4.8.

4.10.5 Cholesterol

At baseline, cholesterol intakes (grams per day) for the two groups were not significantly different (t = -0.521, *P* = 0.609). Upon completion of the intervention, the amount of cholesterol consumption decreased by 3.54% in the INT group and by 9.92% in the SS group. The main effects for group (F = 0.133, *P* = 0.719), time (F = 1.134, *P* = 0.300) and interaction of time and group (F = 0.291, *P* = 0.596) were all not significant. Results are shown in Table 4.8.

Table 4-8: Diet information comparing week 1 values with week 12 values in the steady-state (n = 11) and interval (n = 10) group.

	SS Group (n = 11)		**INT Group (n = 10)**	
	Week 1	**Week 12**	**Week 1**	**Week 12**
Energy Intake (kcal/day^{-1})	1056.1 ± 62.2	984.7 ± 51.9	1024.1 ± 53.8	1280.0 ± 192.0
Protein (g/day^{-1})	70.5 ± 25.9	64.2 ± 23.6 †	74.8 ± 14.4	84.2 ± 22.1 †/**
Carbohydrates (g/day^{-1})	75.2 ± 17.9	82.7 ± 27.4	72.5 ±12.9	101.2 ± 59.2
Lipids (g/day^{-1})	48.0 ± 13.1	38.0 ± 11.5 **	44.5 ± 11.3	51.4 ± 27.4
Cholesterol (mg/day^{-1})	302.8 ±130.0	272.8 ± 99.1	277.5 ± 86.3	267.6 ± 96.4

† $P < 0.1$ significantly different between groups for the SS and INT groups post-intervention; ** $P < 0.05$ significantly different over time compared to baseline.

CHAPTER 5

Discussion

5.1 Introduction

Obesity is a major problem in the world today, particularly in terms of financial costs, reduction in quality of life, as well as mortality risks. Therefore, every effort is necessary to reduce the incidence of being overweight or obese. While diet programmes have been extensively used by the overweight and obese in order to reduce body mass, research has shown that the most effective strategy for weight loss involves the combination of diet and exercise (Blair, 1993; Buemann & Tremblay, 1999; Hill et al., 1993; NIH Technology Assessment Conference Panel, 1993; Pavlou et al., 1989). To date, steady-state aerobic exercise has been commonly used as an exercise modality in an overweight population, yet greater health and weight loss benefits may be associated with the use of interval exercise, which involves a higher intensity exercise component. Consequently, this study compared two different exercise programmes (interval exercise versus steady-state exercise), in order to see which was the most effective in relation to fat loss and health benefits.

5.2 Attrition and Adherence

In the present study the attrition rate was 40.9%, with only 26 of the original 44 participants completing the study. Although this seems like a high withdrawal rate, other studies have reported that 50% or more of adults who begin an exercise programme will drop out within a few months (Dishman, 2001; Jakicic & Gallagher, 2003; Morgan, 2001). The lower attrition rates demonstrated in this study may be due to the use of intermittent exercise and a home based exercise programme. Intermittent exercise partly addresses the most frequently given reason for discontinuing an exercise programme, ie. lack of time (Dishman, 2001; Morgan, 2001), while a home based walking programme avoids issues relating to travel and costs associated with equipment and gyms. Further to this, higher dropout rates and non-compliance are often associated with high-intensity activity (Skinner, 2005). This was demonstrated in the present

study, with the SS group experiencing a higher adherence rate than the INT group (92.9% and 87.7%, respectively). Similar adherence levels have also been reported by other researchers, with Murphy and colleagues (2002) reporting adherence levels of 88.2 ± 1.1% and 91.3 ± 4.1% associated with high and low intensity exercise protocols, respectively, during a 12-week cross-over intervention design. The higher attrition level associated with interval exercise in this study was unexpected, as it was assumed that the interval training protocol would provide more variety in training, and that this in turn would reduce withdrawal rates. This proved not to be the case.

5.3 Aerobic Fitness

While most overweight individuals participate in exercise and diet interventions in order to lose body mass, a more important outcome of participation in exercise relates to associated improvements that exercise has on health (i.e. improved lipid profile, improved vascular function, etc). This is of critical importance due to the high level of morbidity, and even mortality, associated with being overweight (Gaesser, 2004; Grundy et al., 1999; Wei et al., 1999). Typically, many overweight and obese individuals are also sedentary (Hu et al., 2003). This is pertinent as low cardiorespiratory fitness has been shown to be a powerful predictor of mortality from coronary heart disease (Gibbons, Mitchell, Wei, Blair & Cooper, 2000; Jakicic & Gallagher, 2003; Myers et al., 2002; Wei et al., 1999), with mortality risk being greatly reduced with an improvement in fitness (Lee, Blair & Jackson, 1999; Myers et al., 2002). Consequently, it was expected that both the INT and the SS groups would significantly improve their aerobic fitness measures over the 12-week intervention. This hypothesis was accepted, as a significant main effect for time was demonstrated for both $\dot{V}O_{2peak}$ values and exercise time to exhaustion on a GXT. Peak oxygen uptake increased by 27.29ml/kg^{-1}/min^{-1} to 31.49ml/kg^{-1}/min^{-1} in the INT group and from 25.54ml/kg^{-1}/min^{-1} to 29.22ml/kg^{-1}/min^{-1}in the SS group. Exercise time to exhaustion also increased by 5 minutes 08 seconds in the INT group and by 4 minutes 59 seconds in the SS group. This improvement is of vital importance, as a one minute increase in treadmill exercise time has been reported to result in a 7.9% reduction in mortality (Blair et al., 1995). Of interest, RPE scores recorded at the end of the GXT during post-intervention testing were not maximal for 15 participants, suggesting that aerobic fitness scores could have been higher in these individuals.

Previous research has shown that exercise completed at an intensity of 75% of $\dot{V}O_{2max}$ is capable of increasing cardiorespiratory fitness by 20% in sedentary individuals regardless of their age, gender, race or initial fitness levels (Skinner et al., 2001). Although participants in the present study did not experience a 20% improvement in their fitness levels, the INT group did improve by 15.36% compared to a 14.40% improvement in the SS group. These lower values are most likely a result of the lower exercise intensities undertaken in this study, which were employed in an effort to make the exercise interventions more achievable in an overweight and presumably sedentary population. Nonetheless, the results from this study are very encouraging.

Improvements reported in this present study for aerobic fitness are likely to play an important role in improving an individual's health and lifestyle. Lee and co-workers (1999) conducted a study involving 21,925 men and observed a direct relationship between aerobic fitness and mortality, with physically fit obese men decreasing their mortality risk. The authors concluded that fit men had greater longevity regardless of body composition and therefore recommended that obese men engage in regular exercise in order to increase their fitness levels, which should result in health benefits even if they remained overweight (Lee et al., 1999). This was further supported in a study by Jakicic (2003), which showed that overweight adults who had high levels of fitness had a lower risk of cardiovascular disease when compared with normal weight individuals who were unfit.

Of relevance to the conclusions made by Lee et al. (1999) and Jakicic et al. (2003) are fitness rankings ascribed to participants in this study, as defined by a cardiovascular fitness table developed by McArdle, Katch and Katch (2001) (see Appendix N). According to rankings from this table, individuals participating in this study had 'fair' to 'average' fitness values prior to undertaking the exercise interventions. Specifically, four participants in the INT group were classified as having 'fair' fitness levels, while seven were placed in the 'average' category. Similarly, eight participants in the SS groups were classed as having 'fair' fitness levels, with the remaining five being ranked as 'average'. After the 12-week exercise interventions, all participants increased their $\dot{V}O_{2max}$ scores by an average of 14.85% (26.348 ± 4.60

ml/kg^{-1}/min^{-1} to 30.260 ± 5.38 ml/kg^{-1}/min^{-1}). In the INT group, this resulted in one participant being classified as 'fair', nine were considered to be 'average', while one participant's fitness levels was ranked as 'good'. In regard to the SS group, two participants were rated as 'fair', ten as 'average' and one as 'good'.

Exercise can often result in lower SBP and DBP. This is supported in a study by Moreau and colleagues (2001), which investigated postmenopausal women with borderline hypertension. Results showed that a 12-week walking programme, equivalent to a distance of three kilometres per day, was effective in lowering SBP and mean arterial BP, which translates to a lower risk of cardiovascular disease and stroke. This is important as hypertension is the most potent risk factor for coronary disease (Mann, 1974). In the present study, while there were no significant changes in BP scores, SBP decreased by 4.21% in the INT group and increased by 1.77% in the SS group, whereas DBP decreased by 6.61% in the INT group, with this score approaching significance. Lack of significant differences for BP may be due to the fact that BP values were all within a healthy range prior to the interventions (SBP = 123.6 ± 18.8 mmHg and 112.8 ± 13.3 mmHg for the INT and SS groups, respectively; DBP = 81.7 ± 7.6 mmHg and 81.7 ± 12.6 mmHg for the INT and SS groups, respectively). If hypertensive, non-medicated individuals had have been recruited into the study, greater changes may have resulted.

The present study further hypothesised that aerobic fitness would be significantly higher in the INT group after the 12-week intervention period. This was expected due to the greater load being place on the cardiorespiratory system from the high intensity exercise component of the interval training. Even when total energy cost was equal between interventions, previous studies have reported higher $\dot{V}O_{2peak}$ values associated with high intensity compared to lower intensity exercise (Duncan et al., 1991; Kraus et al., 2002; O'Donovan et al., 2005), with this difference being reported to be equal to a 16% improvement in $\dot{V}O_{2peak}$ values compared to only a 4% increase with low intensity exercise in $\dot{V}O_{2peak}$ values (Duncan et al., 1991).

While the INT group demonstrated a superior improvement in $\dot{V}O_{2max}$ on completion of the intervention, the difference between the two groups was not significant. Additionally, no other measures associated with aerobic fitness, i.e. time to exhaustion on a GXT, BP or RHR were significantly more improved in the INT group compared to the SS group post-intervention, reflecting the lack of change in peak oxygen uptake.

This result was unexpected, as noted earlier, previous studies have reported a significant increase in aerobic capacity associated with high intensity exercise when compared to lower intensity exercise. Adeniran (1988) reported that interval training (running at 90% of HR_{max} for 4 minutes followed by 4 minutes relief), performed three times per week over an eight-week period in normal weight, healthy young girls, resulted in a 11.5% increase in aerobic fitness compared to a 10.2% increase in a group participating in steady-state exercise (jogging at 80 – 85% HR_{max}). A further study by Sokmen, Beam, Witchey and Adams (2002), also reported greater improvements in $\dot{V}O_{2max}$ and exercise time to exhaustion after an interval exercise programme compared to steady-state exercise programme in a non-athletic population ($P < 0.01$). Another study by King, Broeder and Panton (2001), reported that eight-weeks of interval and steady-state exercise in an obese population resulted in a significant increase in $\dot{V}O_{2max}$ in the interval group compared to the steady-state group. Oxygen uptake in the interval group increased from 25.2 ± 4.2 $ml/kg^{-1}/min^{-1}$ to 28.5 ± 5.1 $ml/kg^{-1}/min^{-1}$ ($P < 0.03$) equating to a 13.1% increase after the interval exercise programme compared to no change seen in the SS group (King et al., 2002). A possible reason for the discrepancy in $\dot{V}O_{2peak}$ values in the study by King et al. (2001) and the present study, most likely relates to the higher intensity exercise used by King et al. (2001) during the interval training protocol (i.e. 95% of $\dot{V}O_{2max}$), which would have resulted in a greater load and hence adaptation to the cardiovascular system. Again, the greater improvement in the interval group in the study by Sokmen et al. (2002) most likely relates to the use of higher intensity exercise compared to the steady-state exercise (120-150% $\dot{V}O_{2max}$ versus 70-80% $\dot{V}O_{2max,}$ respectively). Of importance, is that the study by King et al. (2001) suggests that the use of exercise intensities higher than those used in the current study, is achievable in an obese population. Consequently, further research is needed in this area.

Lack of significant differences between the two groups post-intervention for aerobic fitness are most likely due to the employment of exercise intensities in the INT group that were not high enough to elicit the anticipated improvements, as well as the fact that both groups significantly improved their $\dot{V}O_{2peak}$ over the course of the 12-week intervention. Additionally, as the cohort size was small in the present study, large individual variations were likely to have a greater impact on overall results**.** For example, one participant in the INT group went against the trend and actually reported a decrease in their $\dot{V}O_{2peak}$ from baseline to post-intervention (30.45 to 26.55 $ml.kg^{-1}.min^{-1}$), therefore affecting overall results. Perhaps also, a longer intervention period may have produced greater differences between the two groups, while the length of the work bouts may have needed to be longer, as work bouts of 2-3 minutes have been recommended for optimal changes in the aerobic energy system (Astrand, Astrand, Christensen & Hedman, 1960).

5.4 Blood Profile

An individual's blood profile, in particular blood lipids, is an important issue in an overweight and obese population, as risk factors associated with diseases such as cardiovascular disease are increased when serum triglyceride levels, fasting glucose levels and serum cholesterol levels are above normal levels (Wei et al., 1999). To date, there have been a number of studies that have reported improved blood measures associated with both aerobic and anaerobic exercise (Ballantyne, Clark, Simpson & Ballantyne, 1982; Buemann & Tremblay, 1999; Durstine et al., 2001; Gill et al., 1998; Sugiura et al., 2002; Thompson et al., 1991; Widhalm, Maxa & Zyman, 1978). Consequently, it was hypothesised that the two exercise groups would both experience significant improvements in their blood profile over the course of the interventions. In this section, only the blood measures that were considered to be important are discussed. The variables that are not discussed did not significantly alter due to either intervention.

Prior to the intervention, assessment of baseline blood lipids revealed that values for total cholesterol and LDL were above normal levels in the INT group. On completion of the interventions, statistical analyses revealed that the majority of blood

measures assessed improved over time, resulting in the acceptance of the proposed hypothesis. These results also showed that values for cholesterol and LDL had returned to normal levels in the INT group. The only blood lipid variables that did not show a significant change over time was HDL. Of further interest, is that VLDL levels decreased significantly over time in the INT group only. This is of importance as increased amounts of VLDL are indicators of cardiovascular disease (Kraus et al., 2002) and therefore significantly lower levels of VLDL should result in an improved health status in this group. Additionally, other blood measures consisting of uric acid and IGF-1 significantly improved over time in the SS group.

Results from this study suggest that an individual's blood lipid profile can be positively altered through exercise (Buemann & Tremblay, 1999) and diet (Dattilo & Kris-Etherton, 1992; O'Donovan et al., 2005). Dattilo and Kris-Etherton (1992) conducted a meta-analysis to quantify the effects of weight loss by dieting on blood lipids. Results indicated that weight reduction through dieting caused a significant improvement in lipid levels. Consequently for every kilogram of body mass lost, cholesterol, LDL and triglyceride levels were reduced by 0.05mmol/L, 0.02mmol/L and 0.015mmol/L, respectively (Dattilo & Kris-Etherton, 1992). Several other studies demonstrated improvement in blood lipid levels after exercise (Ballantyne et al., 1982; Durstine et al., 2001; Gill et al., 1998; Sugiura et al., 2002; Thompson et al., 1991; Widhalm et al., 1978). In fact, according to Durstine (2001), exercise only needs to equate to an energy expenditure of 1200 kcal/wk in order for improvements in lipid and lipoprotein levels to occur. More specifically, a study by Brownell, Bachorik and Ayerle (1982) investigated the effects of moderate exercise on blood lipids, where participants completed 30 minutes of exercise on three days per week for a ten-week period. Post-intervention lipid responses were compared to baseline values, as well as between the male and female participants. Results showed a significant reduction in cholesterol (4.4%), LDL (6.0%) and triglycerides (9.5%), with an increase in HDL (5.1%) for the male participants, while results for the female participants showed a reduction in cholesterol (4.1%) and triglycerides (14.5%) with no change in HDL and LDL (Brownell et al., 1982). When comparing the response of lipids to exercise from the above study to the present study, the present study resulted in greater lipid improvements. This was most likely due to the inclusion of diet restriction in our study, however other factors may have also contributed, such as differences in the intervention

length (12 weeks versus 10 weeks), exercise duration (30 minutes versus 15-20 minutes), the higher frequency of exercise (5 days/wk versus 3 days/wk), and/or the intensity of the exercise (70-75% $\dot{V}O_{2max}$ versus 70% HR_{max}) between the two studies. Participants in the INT group of the present study also recorded above normal values for cholesterol and LDL prior to the intervention, therefore allowing more scope for improvement. Even so, the larger reduction of 12.24% in the INT group compared with 9.37% in the SS group seen in total cholesterol indicates the effectiveness of the interval protocol. Nonetheless, we cannot conclude that the improvements in lipids levels over time in the present study can be attributed solely to the effects of exercise, highlighting the importance in future studies of a diet alone control group who do not exercise.

Further to the above, Ryan and Nicklas (2004) investigated the effects of diet and exercise on overweight or obese, postmenopausal women and found that the six-month intervention resulted in a 16% increase in glucose utilization and insulin sensitivity. Of importance is that the present study, as well as the study by Brownell et al. (1982) and Ryan and Nicklas (2004), have demonstrated that an individual's blood profile can be improved through exercise and diet, which in turn can reduce the numerous risk factors that are statistically associated with obesity such as hyperlipemia and diabetes mellitus (Sullivan, 1976). Improving an individual's postprandial lipid and lipoprotein profile is vital as this can reduce the risk of developing coronary heart disease (Gill et al., 1998). Of further importance, the present study demonstrated that exercise and diet was associated with a reduction in the coronary risk ratio in both groups. This change has the potential to profoundly influence the participant's health and lifestyle in their future years and shows that diet and physical activity are significantly associated with several biochemical markers of obesity and cardiovascular disease (Fung et al., 2000). Additionally, success by participants in this present study in improving their blood profile, in particular their blood lipids over time, can be partly contributed to their commitment to their diet, which was shown not to change over the course of the interventions.

Additionally, it was hypothesised that the INT group would experience significantly greater improvements in their blood profile post-intervention when

compared to the SS group. This hypothesis was based on the assumption that higher intensity exercise performed by the INT group would result in greater improved aerobic fitness in this group compared to the SS group, which in turn would result in greater health benefits, in particular an improved blood profile. The benefits of high intensity exercise on blood profile has been reported by O'Donovan et al. (2005) who conducted a 24-week intervention using sedentary males, aged between 30 and 45 years. Post-intervention analysis of blood lipids demonstrated that the coronary risk factor decreased in the high intensity exercise group (80% of $\dot{V}O_{2max}$), but not in the moderate intensity group (60% of $\dot{V}O_{2max}$), nor in a control group (O'Donovan et al., 2005). Further to this, studies have shown that interval training (with high intensity exercise components) is associated with greater lipid utilization (Tremblay et al., 1994) and a decrease in plasma triglycerides, VLDL and LDL, as well as an increase in HDL (Perry et al., 1986). Additionally, Perry and colleagues (1986) reported a significant decrease in the cardiac risk index associated with interval training. However, results from the present study showed that post-intervention results were similar between the two groups for all blood variables assessed, resulting in the rejection of the hypothesis.

Lack of significant differences between the two groups may be due to both groups significantly improving in several blood measures over time, showing that exercise in general is enough to improve an individual's blood profile. This study did not have a control group and therefore it is unknown what effect diet was responsible for in altering the blood profiles. Additionally, food intake may have influenced results, as while no significant change was reported in lipid intake in the INT group, the SS group significantly reduced their lipid intake over the course of the intervention. Perhaps if the INT group had of also significantly reduced their lipid intake, this may have positively impacted their blood lipid results to a greater extent. Further to this, the expected greater improvement in aerobic fitness in the INT group, which was proposed to also result in greater improvement to individual's blood profiles, did not occur (see section 5.3). Additionally, the intervention period used in our study may not have been long enough, while the intensity levels used during interval training may not have been high enough, in order to elicit significant differences between the two groups. Lower LDL levels, as well as significantly higher levels of HDL were reported by Kraus and colleagues (2002), who employed a high intensity exercise protocol over a longer

intervention period of eight months. Finally, a larger cohort may also be necessary in order to reduce confounding results that may occur as a result of some participant's data.

5.5 Resting Metabolism

As RMR accounts for 60-75% of total daily energy expenditure, a small increase in this variable can have long-term benefits in an overweight and obese population (Byrne & Wilmore, 2001). It was proposed that both the INT and the SS group would significantly increase their RMR over the course of the intervention. Results showed that RMR did not significantly change from baseline levels in either group, although the SS group did show a minimal increase of 46.14 kcal/d^{-1} compared with a reduction of 54.15 kcal/d^{-1} in the INT group. Therefore, the hypothesis was rejected.

This finding was unexpected as previous literature has reported that RMR values increase in response to exercise training (Byrne & Wilmore, 2001; Hansen et al., 2005). This was demonstrated in a study by Poehlman and Danforth (1991), which reported a ten percent increase in RMR after an eight-week intervention of cycling performed three times per week between 60-85% of $\dot{V}O_{2max}$. According to McArdle, Katch and Katch (2001), certain types of exercise are known to increase lean mass, and this in turn will increase RMR. Further to this, men are reported to be at an advantage compared to women when weight loss is desired, as higher levels of testosterone increases amounts of lean mass, which in turn increases RMR (McArdle et al., 2001). Of further relevance is that exercise has been shown to increase testosterone levels in both men and women (McArdle et al., 1996).

Conversely, other research has reported similar outcomes to the present study. Wilmore and colleagues (1998) tested 77 people who participated in a 20-week endurance cycling programme performed at 55-75% of $\dot{V}O_{2max}$ on three days per week. Even though body fat and fat mass significantly decreased and lean mass and $\dot{V}O_{2max}$ significantly increased after the intervention, RMR values remained unchanged (6.54 ± 1.22 to 6.61 ± 1.23 MJ/day). The authors compared their study's design to previous

longitudinal studies that reported changes in RMR, only to find that no obvious reason was apparent for the differences (Wilmore et al., 1998). A similar age sample of both genders was used compared with the present study, however differences between the studies included intervention length (20 weeks versus 12 weeks), exercise duration (30-50 minutes versus 30 minutes), exercise intensity (55-75% $\dot{V}O_{2max}$ versus 40/70% $\dot{V}O_{2max}$ and 50% $\dot{V}O_{2max}$) and exercise frequency (3 sessions/wk versus 5 sessions/wk).

As noted in the literature review, caloric restriction can cause an immediate reduction in RMR levels (Byrne & Wilmore, 2001). Exercise, on the other hand, can preserve or even increase lean mass, which in turn can increase RMR (Hunter et al., 1998; Votruba, Horvitz & Schoeller, 2000). While the two exercise interventions used in this study negated significant falls in RMR, they obviously were not long enough or intense enough to actually increase RMR. This result is reflected by the lack of change that occurred after the interventions in lean mass in both groups. Bullough and colleagues (1995) suggest that high intensity and long duration exercise may produce prolonged elevations in RMR. The presence of a diet alone group in the present study, which was not within the scope of the resources or time available, would have indicated whether our exercise interventions prevented a diet-induced fall in RMR.

It was also hypothesised that RMR would be significantly higher in the INT group compared to the SS group upon completion of the interventions. This hypothesis was based on the assumption that the higher intensity exercise component of interval exercise would result in a greater physical load being placed on the cardiovascular system, which in turn would increase RMR. It was also thought that interval training would result in greater muscle mass in the INT group, which would further increase oxygen consumption and consequently RMR. Post-intervention results showed that RMR was similar between the two groups leading to the rejection of this hypothesis.

The exercise component of the interventions employed in the present study most likely counteracted the negative effects of dieting on RMR, resulting in the maintenance of original RMR values. Results showed a minimal increase in RMR in the SS group,

which reflected the slight increases in RQ and resting $\dot{V}O_2$ values recorded in this group upon completion of the intervention. The increase in resting $\dot{V}O_2$ was surprising since lean tissue mass had decreased slightly (165.36 g) in the SS group post-intervention. The higher resting oxygen uptake values in the SS group may consequently reflect hyperventilation occurring in some individuals from this group during RMR testing. Post-intervention RQ values were significantly higher in the INT group (reflecting significantly increased CHO oxidation), however this increase was offset by a marginal fall in resting $\dot{V}O_2$ values, resulting in a slightly lower RMR.

Differences in RMR may have become significant over a longer intervention period, or if the cohort for each intervention was larger. Additionally, changes in the intensity of the work to relief components of the interval exercise, as well as the duration of these bouts may have resulted in a higher RMR after training.

5.6 Body Composition

In the management of obesity, the assessment of body fat is a useful method for monitoring body composition changes in response to an intervention (American College of Sports Medicine, 2001). As previously stated, Wilmore and Costill (1999) reported that a body fat measurement equal to or greater than 25% for males and 32% for females classifies individuals as being obese. In the present study, all participants had a percentage of body fat that exceeded these values at baseline, placing all individuals into the obese category.

It was proposed that the exercise groups would significantly improve body composition measures over the course of the intervention. Results showed that average group results were significantly reduced over the course of the intervention for the majority of body composition measures assessed. These measures included decreases in BMI (7.08% and 8.58%), body mass (9.61% and 8.25%), fat mass (22.56% and 17.47%), percentage of body fat (14.05% and 10.47%), gynoid obesity (10.60% and 7.84%), waist circumference (7.90% and 5.74%) and hip circumference (6.00% and 6.02%) in the INT and SS groups, respectively. The only measures that did not

significantly change over time were lean tissue (25.51 g and 165.36 g decrease in the INT and SS groups, respectively), android obesity (14.51% and 12.20% decrease in the INT and SS groups, respectively) and waist to hip ratio (1.95% decrease and 0.09% increase in the INT and SS groups, respectively). Therefore, in general, these results would support the acceptance of the proposed hypothesis.

Improvements shown in this study for various measures of body composition are important, as Slentz (2005) has reported that short periods of physical inactivity can cause significant gains in visceral abdominal fat in sedentary middle-aged overweight adults. Visceral fat is a powerful predictor for several metabolic disturbances and cardiovascular risk factors (Bosello & Zamboni, 2000) and therefore interventions that result in reductions of both visceral adipose tissue and liver fat are vital to an individual's health. Further to this, Hansen and colleagues (2005) reported that any exercise will increase fat utilisation compared to sedentary counterparts. This makes exercise an important component of a weight loss intervention, as exercise increases both the energy demand and macronutrient oxidation needed to meet this demands (Hansen et al., 2005). Of importance, is that the findings in this present study are superior to those reported in a number of similar studies. Schmidt and colleagues (2001), employed a 12-week intervention that consisted of 2 x 15 minutes of aerobic exercise bouts performed at 75% of HRR on three to five days per week. Results from Schmidt's study showed a significant body mass loss of 2.96 ± 1.3 kg, with a reduction in BMI consisting of 1.1 ± 0.4 kg/m^2 in overweight female college students. This compares to the present study which resulted in body mass losses of 8.42 kg and 7.68 kg and BMI reductions of 3.13 kg/m^2 and 2.92 kg/m^2 in the INT and SS groups, respectively. Differences in results are most likely due to the greater volume of exercise performed in the present study, along with the inclusion of diet restriction. Additionally, a study by Volek and colleagues (2002) that employed an exercise and diet intervention reported body mass losses of 4.3 ± 3.4 kg and 4.7 ± 3.1 kg in female and male participants, respectively. The lower losses compared to our study are most likely due to the shorter intervention period of only eight weeks. Another study by King and colleagues (2001), reported only a 4.9% decrease in body fat percent (45.0 ± 8.4 to 42.8 ± 7.2%) in an interval exercise group (P = 0.08), while a second group that participated in steady-state exercise reported no change in body fat percent (40.4 ± 3.4 to 40.9 ± 3.0%; NS). However, again the study by King et al. (2001) had an

intervention period of only eight-weeks, while exercise frequency was only three times per week. Most importantly, diet restriction was not included in the intervention protocol (King, Panton, Broeder, Browder et al., 2001). In fact, when body mass loss is desired, the Schmidt et al. (2001) and King et al. (2001) studies highlight the importance of diet restriction.

Of importance, the present study showed that lean mass was not significantly altered over the courses of the interventions. The loss of lean mass is undesirable in any intervention, as muscle plays an important role in force production and metabolism (Kraemer et al., 1999). Minimal change in lean mass has been previously associated with exercise interventions, whereas interventions that employed diet alone can result in significant losses to lean mass. This is demonstrated in a 12-month study by Pritchard, Nowson and Wark (1997) who compared interventions consisting of diet or exercise in 58 overweight, middle aged men. The dieting group reduced their body mass by 6.4 ± 3.3 kg, whereas the exercise group only experienced a body mass loss of 2.6 ± 3.0 kg. Nevertheless, the DEXA scan revealed that the dieting group actually lost 40% of lean tissue, whereas the exercise group's lean tissue loss comprised of less than 20%, with maintenance of limb lean tissue (Pritchard et al., 1997). As noted previously, lean tissue loss is undesirable in a weight loss programme due to the implications that these losses have on RMR. Consequently, this study further demonstrates that diet and exercise is a superior intervention compared to diet alone.

Lack of significant changes found in android fat distribution and waist to hip ratio values between the two groups at the end of the interventions may have been due to the majority of participants being female and the propensity for females to store more fat in the lower body regions (He et al., 2004). Nonetheless, participants from both groups experienced a loss in android fat mass, as well as a change in their waist to hip ratio (14.51% versus 12.20% decrease and 1.95% decrease versus 0.09% increase in the INT and SS groups, respectively). These changes are important as greater risk of disease is associated with android obesity and high waist to hip ratios (Van Pelt et al., 2002). Consequently, fat reduction in this region could have a vital effect on the individual's health status. Of relevance, five of the six male participants and nineteen of

the twenty female participants had waist measurements at baseline that exceeded recommended levels (102 cm in males and 88 cm in females, American College of Sports Medicine, 2001). After the 12-week intervention, waist circumference was within normal range for three male and six female participants. Reductions in waist girth, as well as hip girth, as a result of exercise training, have been demonstrated in a variety of populations (Watts et al., 2006).

It was also hypothesised that the INT group would experience greater improvement in body composition (i.e. reduction in fat mass, android and gynoid fat, BMI, and waist to hip ratio), compared with the SS group. This proposal was based on the assumption that the higher intensity component of the interval exercise session would result in greater overall energy expenditure and a higher RMR, which would lead to these body composition changes. This conjecture is supported by a study by King et al. (2001) that reported a significant difference in body composition in overweight participants as a result of an interval exercise protocol compared to no change from steady-state aerobic exercise, as shown above. The authors proposed that a possible reason for this body fat percent change between the two groups may have been attributed to the significant decrease in fat mass found only in the interval group (5.3% decrease versus 1.9% increase), which may have occurred as a result of an acute RMR increase of 4.4% in this group (King, Panton, Broeder & Browder, 2001).

Results from the present study revealed that none of the body composition variables assessed were significantly different between the two groups resulting in the rejection of this hypothesis. However, of interest was that the percentage of change experienced in body mass, fat mass, percentage of body fat, gynoid obesity, android obesity and waist circumference, were somewhat higher in the INT group. This result is further supported by a study by O'Donovan and colleagues (2005) that showed a greater fat loss after 24 weeks of higher intensity exercise compared to moderate intensity exercise (1.5% versus 0.3% loss).

Similarities in the changes in body composition between the two exercise groups are most likely due to a lack of significant difference between the two groups in resting metabolism (see section 5.5), which may have been due to the inadequate length of the intervention protocol. Additionally, exercise intensities employed by the INT group may not have been high or long enough in order to elicit significant differences in metabolism (resting or post exercise) and hence body composition. These results suggest that further research is required into the optimal amount of exercise duration and intensity that will elicit the greatest changes in body composition.

Additionally, a significant, positive correlation was shown between DEXA fat mass and both waist and hip girth at baseline. This outcome is further supported by Watts and colleagues (2006) who reported a strong relationship between DEXA fat mass and waist girth ($r = 0.75$, $P < 0.001$) and hip girth ($r = 0.83$, $P < 0.001$) in obese adolescents. Therefore girth measurements play an important role in assessing body composition and can supply relevant information in relation to fat mass when DEXA scanning is unavailable.

In summary, neither exercise intervention was superior to the other in causing improvements in body composition, however the fact that both groups significantly improved measures of body composition, including BMI, body mass, fat mass, percentage of body fat, gynoid obesity and waist circumference, as well as hip circumference is very encouraging and shows that aerobic exercise in the obese explicates vital benefits. However, inclusion of a control group would have provided more insight into these outcomes.

5.7 Vascular Function

Impaired vascular function is often seen in the obese (Watts, Beye, Siafarikas, Davis et al., 2004; Watts, Beye, Siafarikas, O'Driscoll et al., 2004), as well as those with heart failure (Maiorana et al., 2000; Walsh et al., 2003) and type II diabetes (Maiorana et al., 2001). Research has reported that FMD is linked to endothelial nitric oxide (NO)-dependent pathways, and therefore an impaired FMD in certain risk groups may reflect

an abnormality in these pathways (Mullen et al., 2001). As diet and exercise is known to improve body composition, cardiorespiratory fitness and lipid profile, it may also play a vital role in improving endothelial functioning, further leading to reduced mortality and morbidity. It was therefore hypothesised that vascular function would significantly improve after both the INT and SS interventions. It was further proposed that vascular function would improve significantly more in the INT group compared to the SS group post-intervention. This was proposed as it was thought that greater shear stress would be placed on the arterial wall by the high intensity components of the interval exercise, which in turn would induce improvements in conduit vessel function due to changes in the resistance of vessel function. However, results showed that FMD responses did not differ between groups and the change over time also did not differ. Similarly, the GTN responses, which reflect vascular smooth muscle sensitivity to NO, did not significantly differ between groups, pre or post-training.

The results reported in the present study do not conform to previous literature as numerous studies have reported improved vascular function after exercise training. Exercise training has been reported to increase peak vasodilator function in healthy adults (Green et al., 1994; Green et al., 1996; Green et al., 1997), as well as improve endothelium-dependent and independent NO function in cardiovascular disease patients (Maiorana et al., 2001; Maiorana et al., 2000; Walsh et al., 1999). This is likely to occur as a consequence of exercise training, because of the increased flow and shear stress on the endothelium, which directly effects vascular function and structure (Maiorana et al., 2001; Niebauer et al., 1997; Sessa, Pritchard, Seyedi, Wang & Hintze, 1994; Watts, Beye, Siafarikas, O'Driscoll et al., 2004; Watts et al., 2005). The effects of exercise on improving vascular function are supported in a study by Watts and coworkers (2004), which showed FMD to increase from 6.00 ± 0.69% to 7.35 ± 0.99% after eight-weeks of exercise training in obese children. Similar results were seen in cardiovascular disease patients, with a significant increase in FMD (3.0 ± 0.8% to 5.7 ± 1.1%) and a non-significant increase in GTN (14.5 ± 1.9% to 12.1 ± 1.4%), after eight-weeks of aerobic and resistance exercise training (Walsh et al., 2003). Another study also showed improvement in FMD (1.7 ± 0.5% to 5.0 ± 0.4%; $P < 0.001$) after eight-weeks of whole body aerobic and resistance exercises, however GTN caused no significant difference in endothelium-independent vasodilation (13.1 ± 1.5% to 13.7 ±

2.0%; $P = 0.7$) in type II diabetics (Maiorana et al., 2001). These results are contrary to what was found in the present study, as FMD responses decreased in both groups whereas GTN responses increased by 27.39% in the INT group but decreased by 8.11% in the SS group. Interestingly, an improvement of only 1-2% in FMD results in significant benefits to the individual (Sorensen et al., 1995). Additionally, 12-weeks of moderate exercise (50% $\dot{V}O_{2max}$), consisting of 30 minutes performed on five to seven days per week in healthy subjects, increased endothelium-dependent vasodilation through increased production and release of NO (Goto et al., 2003).

A possible explanation for why results did not support previous research for vascular functioning might be that both groups experienced normal endothelial function pre-training. As previous studies have demonstrated an association between abnormal vascular function and obesity (Watts, Beye, Siafarikas, Davis et al., 2004; Watts, Beye, Siafarikas, O'Driscoll et al., 2004), it could be concluded that the participants in this present study may not have been representative of a typically obese population. Small cohort sizes may have also played a role in this outcome. Alternatively, the exercise may not have been at a sufficient intensity to cause significant stress on the endothelium walls. Higher intensity exercise may have resulted in improved vascular functioning.

5.8 Quality of Life Perceptions

The SF-36 questionnaire was designed to provide information on general health and wellbeing. It was first developed to establish population-based benchmarks for Australians. Normative data gathered from the Australian population, showed that mean SF-36 scores for overweight individuals were slightly below those of normal weight people. The obese expressed the lowest scores across all dimensions, particularly for physical health and wellbeing, whereas generally active individuals record the highest SF-36 scores across all dimensions (Australian Bureau of Statistics, 1997) (see appendix N). Therefore, it was proposed that both exercise interventions would significantly improve quality of life measures over the 12-week interventions.

Of interest, baseline results showed that scores for all measures of the SF-36 questionnaire were lower in the SS group when compared to the norms for those in an obese and sedentary population, demonstrating that participants in this group reported that they had an extremely poor quality of life. A similar conclusion was drawn for the INT group, although some measures were higher than expected. Upon completion of the interventions, scores for seven of the eight measures on the SF-36 questionnaire, as well as anxiety and depression scores on the HADS questionnaire, showed a significant effect for time that reflected an improvement in these variables. The only measure that did not significantly improve over time was 'role limitations due to emotional problems', which approached a significant level. Additionally, mental health significantly improved over time in the SS group, but not in the INT group. This may be due to the SS group demonstrating lower mental health scores at baseline, which consequently provided a greater range for improvement. These results are supported by research that has shown that exercise can improve quality of life (Stephens, 1988). This is further supported by results on the HADS questionnaire, where ratings for anxiety scores in the SS group changed from borderline 'abnormal' at baseline to a 'normal' rating at the end of the intervention (see scoring table for HADS in appendix P). Overall, these results would support the acceptance of the proposed hypothesis.

It was also hypothesised that quality of life scores would show greater improvement in the INT group compared to the SS group upon completion of the intervention. This proposal was based on the assumption that the INT group would experience a greater improvement in aerobic fitness and that this would translate into superior improvements in quality of life compared with the SS group. Additionally, due to the relief periods of the interval training, it was thought that this might reduce joint pain on the body and therefore improve several measures on the SF-36 questionnaire compared to the SS group. However, this was not the case as results showed no significant differences between groups for any variable assessed. Therefore, this particular hypothesis was rejected. The percentage differences between baseline and post-intervention scores were slightly higher in the SS group for all SF-36 measures, and an explanation for this may be that the SS group reported lower values for each of these variables at baseline and therefore had a greater range to improve.

Previous research supports the use of aerobic exercise to improve anxiety and depression levels. This is supported by a study by Stocks (1977) that investigated the effects of different exercise programmes on anxiety and depression levels. For 12-weeks, 40 obese, female adolescents were randomised into four groups comprising of aerobic training (three sessions per week for 40 - 60 minutes of ergometric cycling), interval training (three sessions per week for 40 – 60 minutes of interval ergometric cycling; 30 seconds work/180 seconds active recovery), leisure (one session per week for 60 mins of games and exercise) or control (no exercise, one session per week of nutrition guideline). Only the aerobic group significantly reduced their depression score (18.9 ± 9.33 to 10.6 ± 9.56; $P = 0.01$). Therefore, aerobic exercise may be the most effective modality for reducing depression than other programmes. No significant difference was reported in anxiety levels for either of the exercise groups (Stocks, 1977).

Lack of significant difference between the two groups may reflect similar aerobic fitness values recorded post-intervention for both groups. Perhaps if a significant group difference had of occurred in aerobic fitness, or even in body mass losses in the INT group at the end of the 12-weeks, then this would have resulted in the INT group feeling happier, healthier and fitter, which may have resulted in a concomitant increase in quality of life scores. However, it appears that the interventions were not different enough to cause a statistical difference between the two exercise groups for quality of life measures.

5.9 Activity Levels

It was proposed that physical activity levels would significantly increase over time in both the INT and the SS groups. It was expected that overall activity times would increase due to expected improvements in health and fitness levels. Physical activity levels were assessed in this study using a number of different measures. Firstly, all participants needed to record their weekly activity levels in a self-report questionnaire (OA-ESI). Results showed no significant change in activity levels in either group over time or between the two groups. This was unexpected, especially

considering the improvement by both groups in aerobic fitness. Lack of significance was possibly due to inaccuracy in recording.

An alternative way of assessing physical activity is to assess the number of daily steps taken each day using a pedometer. Assessment of post-intervention pedometer results showed that no significant difference was seen for overall activity, total daily steps or incidental daily steps over the 12-week intervention.

Nonetheless, step count taken whilst exercising by the INT group increased by 31.38% compared to an 8.84% in the SS group. Of relevance, it has been previously estimated that for the general population, a 30 minute walk should equate to a step count of 3,800 to 4,000 steps (Pate et al., 1995; U.S. Department of Health and Human Services, 1996; Welk et al., 2000). Participants in the present study reported an exercise step count at baseline (equalling 30 minutes) of 4,392 and 3,803 steps for the INT and the SS groups, respectively. As noted above, both groups did increase their step count during the exercise sessions assessed during week 12 of the intervention, with the INT group recording 4,780 steps, whereas the SS group only took an average of 4,082 steps. Consequently, at the end of the intervention, both groups had a step count above the normal average for the general population, supporting an increase in fitness levels.

Further to this, the total amount of daily steps increased by 8.89% and 14.86% in the INT and SS groups, respectively. This increase, while insignificant, was pertinent as guidelines have been produced that rank individuals according to how many steps they take per day, i.e.: (i) less than 5,000 steps per day is considered a 'sedentary' status; (ii) 5,000 to 7,499 steps per day represents a 'low activity' status; (iii) 7,500 to 9,999 steps per day is a 'somewhat active' status; while (iv) greater than 10000 steps per day is ranked as an 'active' status (Tudor-Locke & Bassett, 2004). Based on these figures, the activity status for participants in the current study at baseline ranged from 'low activity' to an 'active activity' status. Further to this, while the optimal number of steps that should be completed for health benefits per day is unknown (McCormack et al., 2003), several studies have reported that health benefits may result from performing

10,000 steps or more per day (Tudor-Locke & Bassett, 2004; Wilde, Sidman & Corbin, 2001). Additionally, increasing the amount of daily steps taken should result in improvements in an individual's health status (Moreau et al., 2001; Sugiura et al., 2002; Tudor-Locke, Myers, Bell, Harris & Rodger, 2002). In fact, an accumulation of 10,000 steps per day is thought to attain average BMI values in middle aged women (Thompson, Rakow & Perdue, 2004), with this level of activity being linked to lower BP (Moreau et al., 2001; Swartz, Strath et al., 2003), decreased body mass (Moreau et al., 2001) and improved glucose tolerance (Swartz, Strath et al., 2003) in previously inactive women. During week one of the intervention in the present study, an average of 11,743 and 9,567 steps were taken per day in the INT and the SS groups, respectively. This total daily step count increased to 12,787 in the INT group and to 10,989 in the SS group by week 12. Therefore the increased total step count per day seen in this study is presumed to be reflective of an improved health status by individuals in both groups.

Of interest, the OA-ESI self-report questionnaire did not support results from pedometer readings. According to information recorded on the OA-ESI, activity levels decreased over time in the INT group and conversely minimally increased in the SS group. A reason for this discrepancy may be due to the inaccuracy of self-recording, as over time the novelty of data entry may have worn off. Schoeller (1995) has reported inaccuracy (underestimates) in self-reporting dietary records for measuring change in dietary intake. This may also apply to self-report questionnaires and therefore caution needs to be taken when analysing results when data is reported by participants.

It was also expected that total daily steps, as measured by an accelerometer, would increase significantly in both exercise groups over the course of the intervention. For the six randomly selected participants who wore the accelerometer, the amount of steps recorded and hence calories expended actually decreased from week one to week 12. It is unknown why this difference occurred, however most likely the cohort was too small with individual differences having a profound impact on overall results. For example one participant, decreased their total daily step count from 13,422 to 6,691 based on accelerometer recordings.

Furthermore, it was proposed that post-intervention activity levels in the INT group would be significantly higher than those in the SS group. It was expected that this would occur as a result of the proposed superior aerobic fitness levels expected to be experienced by this group post-intervention, compared to the SS group, which presumably would result in the INT group becoming more active. Post-intervention results showed that whilst the INT group took the most steps in respect to total steps per day (12,787 ± 3,992 vs 10,989 ± 4,482) this was not significant, leading to the rejection of this hypothesis. Other indicators of physical activity levels (i.e. OA-ESI, accelerometer and additional pedometer readings) also showed no significant differences between the two groups for this measure.

Lack of significant difference between the two exercise groups may be due to the conjecture that for every intervention there will be responders and non-responders (American College of Sports Medicine, 2000). Differences exist in terms of how well individuals adapt to a new programme, with some individuals having difficulty adapting whilst others progress quickly. Therefore this leads to differences in the physiological responses to the programme (Skinner, 2005). As numbers in both groups were fairly small, it is possible that there were a number of non-responders in the INT group, which in turn could explain the lack of significant differences between the two groups. This emphasises the need for larger cohorts in intervention studies in order to reduce confounding factors.

CHAPTER 6

Summary, Conclusions and Recommendations for Future Study

6.1 Summary and Conclusions

Obesity has become a worldwide crisis, with millions of individuals classified as being either overweight or obese. Obesity is not only associated with severe health problems, but can also impact upon an individual's self image, social contact and quality of life. Of concern is that the incidence of obesity continues to increase at an alarming rate. Consequently, finding an effective intervention is crucial in the management of obesity. To date, the efficiency of interval training has not been well researched in an overweight population, yet various health and weight loss benefits are associated with this form of exercise. Therefore this study was designed to evaluate the effects of interval exercise on health and fitness variables in an overweight and obese population.

The present study randomised, matched participants into one of two different 12-week home based walking interventions; 1) intermittent interval exercise (INT) and 2) intermittent steady-state aerobic exercise (SS). Both groups followed the same dietary restrictions, while exercise consisted of two 15-minute sessions performed on five days of the week. The INT group incorporated low and high intensity exercise into their exercise sessions, whereas the SS group completed the exercise at one moderate pace. An attempt was made to keep total work performed per session the same between both groups.

It was hypothesised that interventions consisting of diet and exercise would result in significant positive changes to aerobic fitness, blood lipids, body composition, vascular function and quality of life. It was further hypothesised that an intervention of intermittent interval exercise and diet would produce significantly greater improvements

in all the variables measured when compared to the intervention of intermittent steady-state aerobic exercise and diet in an overweight and obese population. Interval training was expected to result in greater improvements than continuous steady-state exercise due to the greater overload that the higher intensity components of interval exercise placed on the cardiovascular system, which in turn was expected to result in greater improvements in aerobic fitness, as well as in other measures of health. Additionally, it was also presumed that the higher exercise components of interval exercise would result in an increase in metabolism (RMR and EPOC), which would lead to greater weight loss. Overall, these benefits were expected to also result in improvement in emotional status and wellbeing.

Upon completion of the interventions the following observations were made:

- Average results for both groups significantly improved over time in relation to $\dot{V}O_{2peak}$ and exercise time to exhaustion on a GXT.
- Average results for both groups significantly improved over time in relation to blood results consisting of PCV, RCDW, MCH, WCC, ESR, sodium and glucose.
- Average results for both groups significantly improved over time in relation to liver function blood tests consisting of GGT and ALT.
- Average results for both groups significantly improved over time in relation to blood lipid markers consisting of cholesterol, triglycerides, LDL, VLDL and coronary risk ratio.
- VLDL results significantly improved over the course of the intervention in the INT group.
- Average results for both groups significantly improved over time in relation to additional blood results consisting of, IGF-1.
- IGF-1 results significantly increased over time in the SS group.
- Uric acid results significantly improved over time in the SS group.

- Average results for both groups improved over time in relation to body composition measures consisting of BMI, body mass, fat mass, percentage of body fat, gynoid distribution, waist circumference and hip circumference.
- Lean tissue mass was preserved despite both groups being on a strict diet.
- DEXA fat mass and girth measurements were well correlated.
- No changes in FMD or GTN responses were evident in either group over time.
- Average results for both groups improved over time in relation to the following measures on the SF-36 questionnaire: physical function; role limitations due to physical health; bodily pain; general health; vitality; social function; and mental health.
- Mental health scores improved significantly over time in the SS group.
- Average results for both groups improved over time in relation to anxiety and depression as assessed by HADS.
- There was no significant correlation between any of the three measures of activity (i.e. pedometer, accelerometer or self-report activity questionnaire)

Consequently, results from the present study support the combination of diet and exercise in improving aerobic fitness, body composition and other related measures in an overweight and obese population, however results did not support interval exercise as being a superior intervention to steady-state aerobic exercise.

6.2 Directions for Future Research

Further research, of a larger scope than a 12-month MSc thesis, is necessary in order to develop an intervention that obese individuals can sustain over long periods of time. Below are some considerations and suggestions for future research.

1) Further research needs to include a diet only group in order to adequately analyse the separate effects of exercise and diet on the variables assessed.

2) Further research that included an exercise alone, without dietary restriction, would determine the independent effects of exercise.

3) Further research needs to be conducted on the effects of interval training in sub-sections of an overweight and obese population, particularly those related to gender, age, related co-morbidities, etc.

4) Future studies, of larger scope and funding, should recruit larger subject cohorts to increase the power for detection of differences between groups.

5) Further research is needed in order to design an interval training protocol that will elicit optimal results in an overweight population. Consideration needs to be given to the ratio of work to relief time periods and the percentage of $\dot{V}O_{2max}$ to be used during the work/relief intervals.

6) Further research is needed in order to assess the appropriate duration of interval training that would elicit the most optimal results in an overweight and obese population.

7) Interventions should look at the combination of interval training with resistance training, in an effort to increase lean mass, which may in turn lead to a higher BMR and greater weight loss.

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APPENDICES

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Proposed **Benefits** include:

- Reduced body fat - Weight loss - Improved health
- Improved fitness - Improved quality of life plus much more.

WANTED:

- **Overweight, sedentary individuals**
- **Aged between 18 to 65 years**
- **Individuals wishing to join SureSlim OR have joined within two weeks**
- **Motivated individuals who want to exercise regularly**
- **Individuals who want to lose weight**

Screening Process Questionnaire

Name: ……

Address: ……Post Code……..

Phone (Home): ……..... (Work): ……..……..…….……

(Mobile): …….…….…..… Email: ……

Date of Birth: ……...…. Age: ……..

Gender: Male Female

1) What is your height and weight?

Height: ……..cm Weight: ……kg BMI: ……

2) Have you started your SureSlim diet?

No **Yes**

If Yes, how long have you been on the diet?
……

3) Have you given birth within the past three months or are you planning on becoming pregnant in the next 12 weeks?

No **Yes**

4) Is there a possibility that you are pregnant?

No **Yes**

If yes, are you willing to take a pregnancy test to confirm that you are not pregnant?

No **Yes**

5) Have you recently undergone any medical/ radiological or nuclear medicine procedures?

No **Yes**

If yes, what did you have done?
……

6) Are you post menopausal?

No **Yes**

Are you taking HRT or cyclical HRT?

No **Yes**

7) Are you taking any medications?

No **Yes**

If yes, what are the names of each of the medication that you are taking and what are they for (if known)?

……
……
……

8) Has your doctor ever told you that you have Type II diabetes?

No **Yes**

9) Have you recently had your blood pressure assessed?

No **Yes**

If yes, is your blood pressure over 160/90?

No **Yes**

If yes, are you taking medication for your blood pressure?

No **Yes**

10) Are you currently participating in at least 20 minutes of exercise three or more times per week?

No **Yes**

11) Have you lost five kilograms or more in the last three months?

No **Yes**

12) Do you have musculoskeletal problems that prevent walking?

No **Yes**

13) Do you allow the researcher to have access to your blood lipid results?

No **Yes**

School of Human Movement and Exercise Science

The University of Western Australia
35 Stirling Highway, Crawley WA 6009
Phone: 0404 119 910
Email: campbl04@student.uwa.edu.au

Researcher: Leanne Campbell

The Effects Of Two Modes Of Exercise On Obesity

— Information Sheet —

Thank you for your interest in this study which is designed to investigate the effects of exercise when combined with diet. This study has been approved by the UWA Human Research Ethics Committee. Please read the following information thoroughly so you can make an informed decision about whether you wish to participate in this research study.

PURPOSE

The aim of this study is to determine what effect different forms of exercise have on body composition and aerobic fitness in overweight humans who are restricting their diet.

PROCEDURES

You will be required to undergo several screening processes and therefore may be excluded at any time during the preliminary stages. If you are deemed eligible to participate, the following procedures will be undertaken.

Preliminary Procedures:

1. Visit 1 –

   You will be asked to attend the University of Western Australia (UWA) exercise laboratory for approximately two hours.

   Several measurements will be recorded including:

   i) Height,

   ii) Weight,

   iii) Blood pressure,

   iv) Resting energy expenditure - to assess resting energy expenditure you will be required to rest on a bed for 40 minutes. For a proportion of this period, you will be exhaling into a bag, which collects pulmonary respiratory gases.

   v) Body composition - to assess body composition a scan will be made using dual energy X-ray absorptiometry (DEXA) machine. You will need to lie still on a scanning bed for approximately three to seven minutes. DEXA involves the use of very low dose X-rays, the effective dose from a total body scan being approximately 0.4 - 2.0µSv. The background radiation exposure from the sun in a normal day is around 8.0µSv and a DEXA scan is around 50 times less radiation than a standard chest X-ray. This low dose X-ray is equal to about one thousandth of the

background radiation you would receive in one year living in Perth. The total background radiation in Western Australia is about 2.0mSv per year. The radiation dose from cosmic rays from flying in a jet from Perth to London is approximately 0.1mSv (ie. 50 times more radiation than the highest DEXA dose).

Additionally, you will be required to fill out several questionnaires relating to your activity levels and health.

vii) Short Form-36 (SF-36) – SF-36 measures eight domains of health including physical functioning, role limitations due to physical health, bodily pain, general health perceptions, vitality, social functioning, role limitations due to emotional problems and mental health.

viii) Older Adult Exercise Status Inventory (OA-ESI) – OA-ESI is a seven day self-report inventory that assesses the duration, frequency and level of intensity of a broad range of work and physical activities.

ix) The Hospital Anxiety And Depression Scale (HADS) – HADS presents several questions relating to emotional feelings.

2. Visit 2 –

You will then be invited to attend Royal Perth Hospital (RPH) for approximately two hours. Once again you will be required to undergo several tests including:

x) A graded exercise test – this test is to insure that you are capable of completing programme requirements. During this test oxygen consumption, blood pressure and heart rate values will be recorded, along with a 12-lead electrocardiographic assessment while you exercise on a treadmill. The electrocardiogram (ECG) may involve shaving of a small section of the skin so that leads can be attached properly.

xi) Vascular function testing - blood vessel function and dimensions will be assessed using non-invasive high resolution scanning of the brachial artery.

xii) Cardiac function testing - measures of cardiac function and dimensions will be conducted using non-invasive ultrasound scanning of the heart at rest.

Please note that ultrasound is a safe, painless and proven technique with no known hazards or side effects.

Diet and Exercise Training Programme:

3. You will be required to undergo caloric restriction based on your SureSlim guidelines. Additionally, some participants will participate in two 15 minute bouts of walking performed on five days of the week for a 12 week period. The researcher will carefully explain to you what intensity you will be walking at. The walking intensity will be low to moderate and it will be insured that you are able to exercise at this intensity. You will be asked to accurately record all exercise information in the diaries provided. These diaries are to be submitted to the researcher on a regular basis. Exercise diaries will be discussed to make sure requirements are being met. Other participants will be asked to maintain their current activity levels for the 12 week period. Throughout the study, regular phone contact will be made with you in order to make sure that no problems are being encountered.

Final Procedures:

4. At the conclusion of the 12 week period, measures taken during the preliminary process will be reassessed. Therefore you will be required once again to attend the laboratory and hospital, for approximately two hours each session.

RISKS

There are no major risks associated with this study. The DEXA does involve the use of radiation, however exposure is low, equating to 50 times less than a standard chest scan and four times less than a normal day in the sun. The graded exercise test performed at RPH is desired to reduce the risks associated with exercise, as this test will assess your capability of performing the exercise programme. Data recorded from the graded exercise test will be used to carefully monitor the intensity of walking in the exercise programme, so that you are capable of completing all components.

BENEFITS

It is possible that this study will produce health benefits for participants, particularly in those who undertake exercise. Some of these benefits may include reduction in body fat, blood pressure and fasting insulin levels, as well as improvement in aerobic fitness, quality of life, cholesterol level, vascular and cardiac function. In those participants randomised into the diet only group, it is possible that benefits in terms of body fat, blood pressure, fasting insulin levels, cholesterol level and quality of life will occur. You will be receiving all of the medical tests free of charge and on completion of the study an information session will be conducted regarding your individualised results.

Reimbursements

You will be reimbursed for parking expenses when attending either UWA or RPH for testing. Please keep your parking tickets and return these to the researcher on completion of the study for your reimbursement. Please note that all equipment including heart rate monitor, pedometers and diaries must be returned before reimbursements will be issued. Please take care of the equipment supplied to you.

SUBJECT RIGHTS

Results of the research study

All personal information and test results recorded from this study will remain confidential and will not be used for any other purposes other than in this study. Results from this study will be reported in the researcher's thesis. Any results that are reported including in the thesis, at conferences and in publications will not include any information that identifies any participants. At the conclusion of this study, you will receive a report showing your personal results and individual benefits, as well as the overall findings of the study.

Voluntary participation / Withdrawing consent to participate

Participation in this study is voluntary and you are not obliged to participate. If you choose not to participate, no penalty or prejudice will be held against you. You are free to withdraw at any stage throughout the study, and you do not need to justify your decision. If you withdraw and you are an employee or student at the University of Western Australia (UWA) this will not prejudice your status and rights as employee or student of

UWA. If you withdraw from the study and are a patient recruited from one of the affiliated clinics your treatment will not be prejudiced or affected in any way. All information and data collected, that is personal to you, will be withdrawn from the project, unless consent is given. Your participation in this study does not prejudice any right to compensation, which you may have under statute or common law.

Questions and/or further information

If you have any questions or require any further information about the research project, please do not hesitate to contact:

Researcher: Leanne Campbell BSc. (Masters Candidate)

School of Human Movement and Exercise Science

The University of Western Australia

35 Stirling Highway, Crawley WA 6009

Mobile: 0404 119 910

Email: campbl04@student.uwa.edu.au

Supervisor: Dr. Karen Wallman

School of Human Movement and Exercise Science

The University of Western Australia

35 Stirling Highway, Crawley WA 6009

Phone: (08) 6488 2304

Email: kwallman@cyllene.uwa.edu.au

Independent contact person:

The Human Research Ethics Committee at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the researcher or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009 (telephone number 6488-3703). All study participants will be provided with a copy of the Information Sheet and Consent Form for their personal records.

This research study has been approved by The Human Research Ethics Committee at the University of Western Australia.

RA/4/1/1172

School of Human Movement and Exercise Science

Researcher: Leanne Campbell

The University of Western Australia
35 Stirling Highway, Crawley WA 6009
Phone: 0404 119 910
Email: campbl04@student.uwa.edu.au

The Effects Of Two Modes Of Exercise On Obesity

— Informed Consent Document —

Please read the following information carefully and if in agreement with all the information provided, please sign at the bottom of this document.

I _____ (the participant) have been provided with a copy of the information sheet explaining the research study and have read and understood all the information provided. The opportunity has been given for me to ask any questions and these questions have been answered to my satisfaction. I am aware that if I have any additional questions I can contact the research team who will be happy to help with any queries.

I agree to participate in this study, realising that I may withdraw at any time without reason and without prejudice or without prejudice to my future medical treatment. I am willing to participate in all testing and intervention procedures outlined in the information sheet to the best of my ability, including data collection, exercise intervention and SureSlim diet requirements.

I understand that all information provided is treated as strictly confidential and will not be released by the researcher unless required to by law. I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research. I agree that the research data gathered for this study may be published provided my name or other identifying information are not used.

I therefore freely agree to participate in this study.

_____ _____

Participant Date

The Human Research Ethics Committee at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the researcher or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009 (telephone number 6488-3703). All study participants will be provided with a copy of the Information Sheet and Consent Form for their personal records.

This research study has been approved by The Human Research Ethics Committee at the University of Western Australia.

RA/4/1/1172

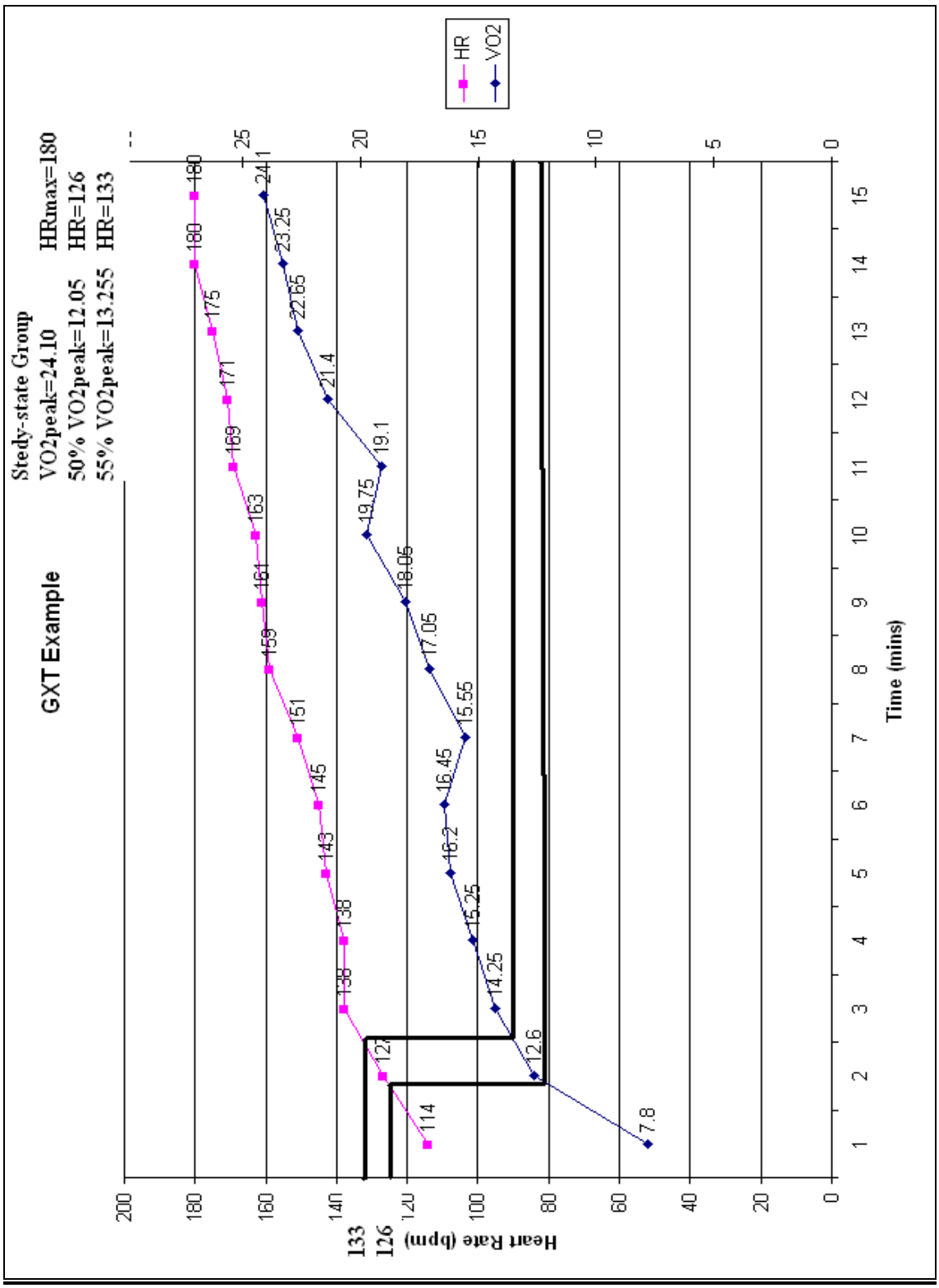
Appendix E: GXT, Graph and ECG Printout

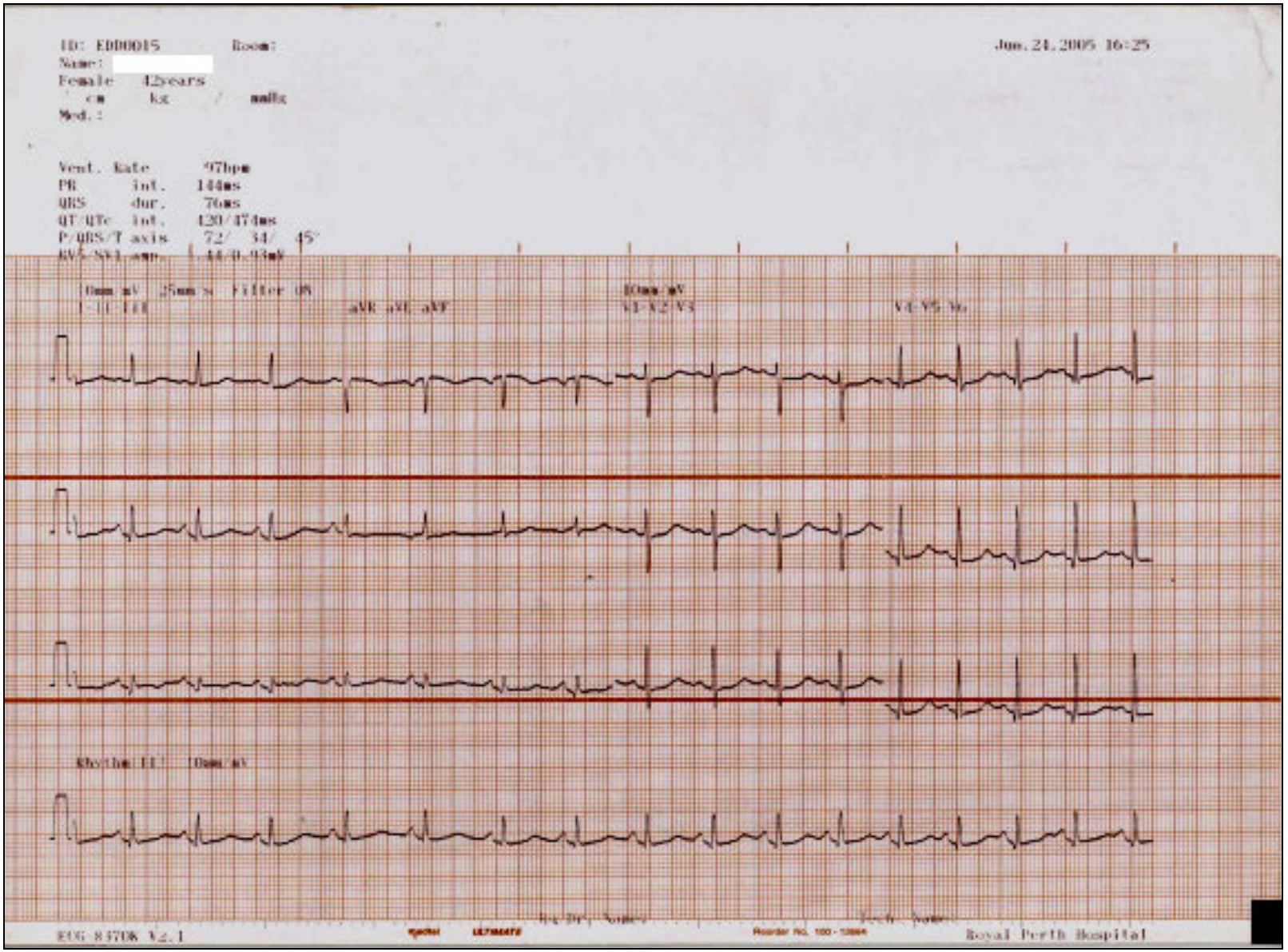
Royal Perth Hospital
Cardiac Transplant Unit

Date: 06/24/05
Metabolic Edit --- - EDDO015

Time Min	RQ	RPE 1		SpO2 %	RPE 2	VO2/kg mL/kg/min		SBP mmHg	DBP mmHg	VE(STPD) L/min		HR BPM
Min												
Test Stage - Baseline												
0.0	0.66					3.1				7.0		
0.3	0.65	0.655				3.4	3.25			7.0	7.0	
0.7	0.64					3.0				5.7		
1.0	0.64	0.665				3.3				6.5	5.85	
1.3	0.66					2.6				5.2		
1.7	0.66					2.2	3.0			4.4		
2.0	0.67	0.685				3.8				8.4		
2.7	0.70					4.3	4.05			8.2	8.3	
Test Stage - Exercise												
Stage 3.0	0.75					3.4				7.3		
3.3	0.79	0.77				4.5	7.8			9.8	16.8	
1 3.7	0.74					6.5				15.2		
4.0	0.72					9.1				18.4		
4.3	0.66					10.7				19.1	21.0	114
4.7	0.64	0.65				12.3	12.6			20.8		
5.0	0.65					12.9				21.2		
5.3	0.67					14.7				23.8	24.8	127
5.7	0.71	0.715				13.3	14.25			22.8		
6.0	0.72					15.2				26.8		
6.3	0.75		11			13.0		130	70	23.5		138
6.7	0.70	0.725	11			13.9	15.25			23.4	26.05	
7.0	0.74		11			16.6				28.7		
2 7.3	0.76		11			14.6		130	70	26.3		138
7.7	0.76	0.775	11			17.8	16.2			31.5	29.55	
8.0	0.79		11			14.5				27.6		
8.3	0.81		11			17.1		130	70	32.4		143
8.7	0.82	0.825	11			15.8	16.45			30.7	31.55	
9.0	0.83		11			14.2				28.7		
9.4	0.80		12			16.9		140	80	32.2		145
9.7	0.81	0.805	12			14.2	15.55			27.4	29.8	
10.0	0.78		12			16.6				30.0		
3 10.3	0.83		12			17.0		140	80	32.6		151
10.7	0.86	0.85	12			15.1	17.05			30.8	34.4	
11.0	0.84		12			19.0				38.0		
11.3	0.87		12			14.6		140	80	30.6		159
11.7	0.86	0.865	12			17.7	18.05			35.0	36.1	
12.0	0.87		12			18.4				37.2		
12.3	0.86		13			18.2		135	80	36.2		161
12.7	0.85	0.855	13			19.1	19.75			38.1	39.05	
13.0	0.85		13			20.4				40.0		
13.3	0.87		13			17.5		135	80	35.8		163
4 13.7	0.87	0.89	13			18.9	19.1			39.1	39.95	
14.0	0.91		13			19.3				40.8		
14.3	0.93		13			22.5		135	80	49.3		169
14.7	0.94	0.935	13			21.2	21.85			47.5	48.4	
15.0	0.92		13			21.6				46.7		
15.3	0.93		15			22.2		150	70	51.0		171
15.7	0.91	0.92	15			22.6	22.65			50.7	50.85	
5 16.0	0.93		15			22.7				50.3		
16.3	0.98		15			22.9		150	70	52.7		175
16.7	1.05	1.04	15			23.6	23.25			55.7	54.2	
17.0	1.03		15			20.1				47.9		
17.3	1.00		15			20.1		150	70	47.0		180
17.7	1.02	1.55	15			23.6	24.1			58.0	63.75	
18.0	1.09		15			24.6				69.5		
18.3	1.09		15			8.0				21.4		
Test Stage -Recovery												
18.7	1.09		15			0.2				0.5		

Page 1


GXT Example
Stedy-state Group
VO2peak=24.10
50% VO2peak=12.05
55% VO2peak=13.255
HRmax=180
HR=126
HR=133
HR
VO2
Heart Rate (bpm)
Time (mins)
133
126


ID: ED00015
Name:
Female 42years
Med.:
Jun.24.2005 16:25
Vent. Rate 97bpm
PR int. 144ms
QRS dur. 76ms
QT/QTc int. 420/474ms
P/QRS/T axis 72/ 34/ 45
25mm/s Filter Off
aVR aVL aVF
V1 V2 V3
V4 V5 V6
Rhythm II 10mm/mV
EUG 8470K V2.1
Royal Perth Hospital

Appendix F: DEXA Printout

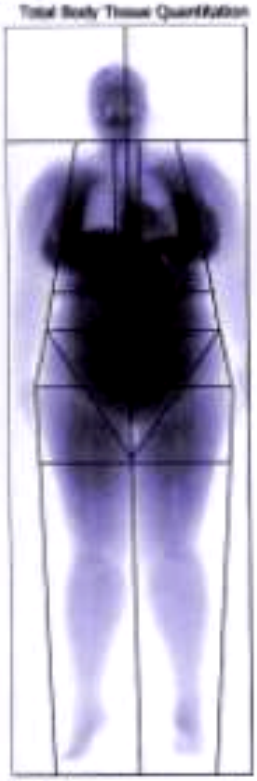
School of Human Movement and Exercise Science

The University of Western Australia

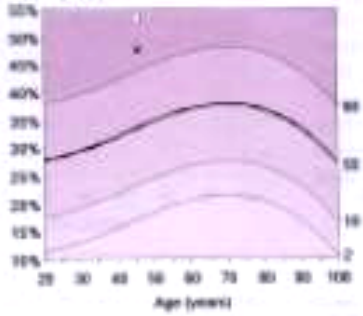
CRAWLEY 6009

Patient ID:	EDDO042	**Facility ID:**	
Birth Date:	2/09/1960 45.5 years	**Physician:**	Leanne
Height / Weight:	163.0 cm 118.0 kg	**Measured:**	8/03/2006 9:51:28 AM (8.50)
Sex / Ethnic:	Female	**Analyzed:**	8/03/2006 9:56:32 AM (8.50)

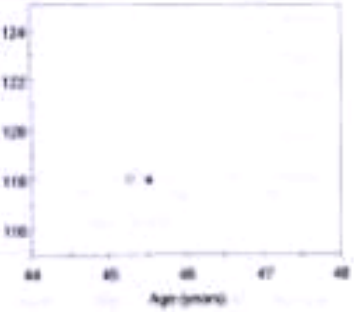
Total Body Tissue Quantification



Composition Reference: Total



Trend Weight: Total



Region	Tissue (%Fat)	Centile [2,3]	T.Mass (kg)	Fat (g)	Lean (g)	BMC (g)
Legs	53.4	-	-	18,192	15,877	1,368
Trunk	44.8	-	-	21,209	26,181	913
Android	50.8	-	-	3,983	3,859	65
Gynoid	53.7	-	-	8,348	7,198	370
Total	47.7	96	100.2	46,173	50,698	3,295

COMMENTS:

Trend: Total

Measured Date	Age (years)	Tissue (%Fat)	Centile [2,3]	T.Mass (kg)	Fat (g)	Lean (g)
8/03/2006	45.5	47.7	96	100.2	46,173	50,698
9/12/2005	45.2	53.3	99	110.4	57,158	50,056

Image not for diagnosis

2 -Australia (Lunar), Total Body Reference Population

3 -Matched for Age, Weight (females 25-100 kg), Ethnic

GE Medical Systems
LUNAR

SF-36 HEALTH SURVEY

INSTRUCTIONS: This questionnaire asks for your views about your health, how you feel and how well you are able to do your usual activities. Answer every question by marking the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

1. In general, would you say your health is:

Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

2. Compared to one year ago, how would you rate your health in general now?

Much better now than one year ago	1
Somewhat better now than one year ago	2
About the same as one year ago	3
Somewhat worse now than one year ago	4
Much worse now than one year ago	5

3. The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

ACTIVITIES	**Yes, Limited A Lot**	**Yes, Limited A Little**	**No, Not Limited At All**
a. **Vigorous activities**, such as running, lifting heavy objects, participating in strenuous sports	1	2	3
b. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	1	2	3
c. Lifting or carrying groceries	1	2	3
d. Climbing **several** flights of stairs	1	2	3
e. Climbing **one** flight of stairs	1	2	3
f. Bending, kneeling or stooping	1	2	3
g. Walking **more than one kilometre**	1	2	3
h. Walking **half a kilometre**	1	2	3
i. Walking **100 metres**	1	2	3
j. Bathing or dressing yourself	1	2	3

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

	YES	NO
a. Cut down on the **amount of time** you spent on work or other activities	1	2
b. **Accomplished less** than you would like	1	2
c. Were limited in the **kind** of work or other activities	1	2
d. Had **difficulty** performing the work or other activities (for example, it took extra effort)	1	2

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	YES	NO
a. Cut down on the **amount of time** you spent on work or other activities	1	2
b. **Accomplished less** than you would like	1	2
c. Didn't do work or other activities as **carefully** as usual	1	2

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups?

Not at all	1
Slightly	2
Moderately	3
Quite a bit	4
Extremely	5

7. How much bodily pain have you had during the past 4 weeks?

No bodily pain	1
Very mild	2
Mild	3
Moderate	4
Severe	5
Very severe	6

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Not at all	1
Slightly	2
Moderately	3
Quite a bit	4
Extremely	5

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks -

	All of the Time	Most of the Time	A Good Bit of the Time	Some of the Time	A Little of the Time	None of the Time
a. Did you feel full of life?	1	2	3	4	5	6
b. Have you been a very nervous person?	1	2	3	4	5	6
c. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
d. Have you felt calm and peaceful?	1	2	3	4	5	6
e. Did you have a lot of energy?	1	2	3	4	5	6
f. Have you felt down?	1	2	3	4	5	6
g. Did you feel worn out?	1	2	3	4	5	6
h. Have you been a happy person?	1	2	3	4	5	6
i. Did you feel tired?	1	2	3	4	5	6

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

All of the time	1
Most of the time	2
Some of the time	3
A little of the time	4
None of the time	5

11. How TRUE or FALSE is each of the following statements for you?

	Definitely True	Mostly True	Don't Know	Mostly False	Definitely False
a. I seem to get sick a little easier than other people	1	2	3	4	5
b. I am as healthy as anybody I know	1	2	3	4	5
c. I expect my health to get worse	1	2	3	4	5
d. My health is excellent	1	2	3	4	5

Hospital Anxiety and Depression Scale (HADS)

Name: _____ Date: _____

Instructions: Read each item and tick the box which is the closest to how you have been feeling in the past week. Don't take too long over your replies; your immediate reaction to each item will probably be more accurate than a long thought out response.

1) I feel tense or 'wound up':

Most of the time ☐ A lot of the time ☐

From time to time, occasionally ☐ Not at all ☐

2) I still enjoy the things I used to enjoy:

Definitely as much ☐ Not quite so much ☐

Only a little ☐ Hardly at all ☐

3) I get a sort of frightened feeling as if something awful is about to happen:

Very definitely and quite badly ☐ Yes, but not too badly ☐

A little, but it doesn't worry me ☐ Not at all ☐

4) I can laugh and see the funny side of things:

As much as I always could ☐ Not quite so much now ☐

Definitely not so much ☐ Not at all ☐

5) Worrying thoughts go through my mind:

A great deal of the time ☐ A lot of the time ☐

From time to time but not too often ☐ Only occasionally ☐

6) I feel cheerful:

Not at all ☐ Not often ☐

Sometimes ☐ Most of the time ☐

7) I can sit at ease and feel relaxed:

Definitely ☐ Usually ☐

Not often ☐ Not at all ☐

8) I feel as if I am slowed down:

Nearly all the time ☐ Very often ☐

Sometimes ☐ Not at all ☐

9) I get sort of frightened feeling like 'butterflies' in the stomach:

Not at all ☐ Occasionally ☐

Quite often ☐ Very often ☐

10) I have lost interest in my appearance:

Definitely ☐ I don't take so much care as I should ☐

I may not take quite as much care ☐ I take just as much care as ever ☐

11) I feel as if I have to be on the move:

Very much indeed ☐ Quite a lot ☐

Not very much ☐ Not at all ☐

12) I look forward with enjoyment to things:

As much as ever I did ☐ Rather les than I used to ☐

Definitely less than I used to ☐ Hardly at all ☐

13) I get sudden feelings of panic:

Very often indeed ☐ Quite often ☐

Not very often ☐ Not at all ☐

14) I can enjoy a good book or radio or TV programme:

Often ☐ Sometimes ☐

Not often ☐ Very seldom ☐

Please check that you have completed all questions. Thank-you for completing this questionnaire.

Activity Scale (OA-ESI)

Name: _____ Date: _____

Instructions: Please record if you did any of these physical activities in the past week and HOW MUCH TIME IN MINUTES you spent on each occasion?

	Time spent in MINUTES on each occasion							Office use		
	Mon	**Tues**	**Wed**	**Thurs**	**Fri**	**Sat**	**Sun**	**METS**	**xMins**	**Total**
WORK ACTIVITIES (Paid or Unpaid)										
Work in the home (sweaty)								**5.5**		
Work in the home (light)								**3.0**		
Outdoor Work (sweaty)								**6.0**		
Outdoor Work (light)								**3.0**		
Other										
TOTAL										
LEISURE ACTIVITES (Paid or Unpaid)										
Aerobic Fitness Class								**6.0**		
Aqua Class								**6.0**		
Badminton (singles)								**5.5**		
Badminton (doubles)								**4.0**		
Bicycling (sweaty)								**6.0**		
Bicycling (light)								**5.5**		
Bowling –Tenpin								**3.0**		
Bowling – Lawn								**3.0**		
Bowling – Carpet								**3.0**		
Calisthenics								**4.5**		
Canoeing or Kayaking								**3.0**		
Dancing -Square/Tap/Folk								**6.0**		
Dancing -Ballroom/Ballet								**5.0**		
Dancing - line								**4.0**		
Darts								**2.5**		

Golf								**3.5**		
Gymnastics or Rhythmics								**6.0**		
Hiking in hilly terrain								**8.0**		
Jogging (light)								**10.0**		
Jogging (sweaty)								**12.0**		
Rebounding (mini trampoline)								**10.0**		
Rope Skipping								**12.0**		
Rowing (machine or boat)								**8.0**		
Skating (Roller or ice)								**6.0**		
Stair climbing (continuous)								**8.0**		
Stretching								**3.0**		
Swimming (gentle)								**7.0**		
Swimming (non-stop)								**10.0**		
Table tennis								**4.0**		
Tai Chi/Yoga								**3.0**		
Tennis (singles)								**6.0**		
Tennis (doubles)								**4.0**		
Walking (Slow stroll)								**3.0**		
Walking (warmth inducing)								**4.0**		
Walking (power/speed)								**5.0**		
Other										
Other										
TOTAL										

GROUP A:
The Effects Of Two Modes Of Exercise On Obesity

Congratulations, you have successfully completed the selection criteria and you are now eligible to participate in this study.

You have been randomly assigned to GROUP A. This means that you will be required to complete ten exercise sessions each week, as well as abide by your SureSlim diet for the next 12 weeks.

DIET
SureSlim has provided you with an individualised diet. It is very important that you abide by this diet for the 12 weeks of this study. If for any reason you do not stick to the diet guidelines you will be required to contact the researcher to discuss if there are any implications.

EQUIPMENT
The researcher will issue you with a heart rate monitor, pedometer and exercise diary. Please ensure that you wear your pedometer when asked and that you wear your heart rate monitor during each exercise session. Please note that the pedometer is not water proof so will need to be removed during water activities (eg. showering). Please keep all equipment in a safe and secure location for the 12 weeks and return it to the researcher when finished.

EXERCISE
Exercise is to be completed on five days of the week. There is no restriction as to what days you exercise on, as long as you complete the exercise sessions on five of the seven days. You will be required to perform two exercise sessions per day, each lasting for a 15 minute duration, which will equate to 30 minutes of exercising per day. At least three hours will need to separate each exercise session. Exercise will consist predominately of walking. However, if your fitness does improve after several weeks, you may need to walk at a faster pace or even jog in order to attain your recommended heart rate during the higher intensity components of the session.

You will be required to walk at two different paces throughout the session and it is very important that you understand how to use the heart rate monitor and pedometer. If you are unsure please contact the researcher who will be happy to go through the instructions with you again.

Each exercise session of 15 minutes is to commence with two minutes of low intensity exercise, followed by one minute of higher intensity exercise. The two minutes to one minute ratio is to be repeated five times per session to make up the 15 minute session. The pace that you will be walking at has been individually tailored to your own fitness levels and is considered to be at a low to moderate level, which you should be able to manage.

Your low intensity level is to be set at a heart rate of _____ and your higher intensity level is to be set at a heart rate of _____.

The speed that you will be walking at will be dependent on your heart rate. If your heart rate falls below the heart rate specified above, speed up your walking pace and if your heart rate exceeds the heart rate specified above, slow down your walking pace. You will be walking for two minutes trying to maintain the low intensity heart rate. Once two minutes has past you will then walk faster for one minute at a higher intensity and you will try to maintain this heart rate for the minute. Once this minute has passed, you will then slow down your walking speed back to the lower intensity for another two minutes. You will repeat this process for the 15 minute session. The diagram below shows the intervals that you will be walking at.

SESSION 1: 15 minutes (10 minutes slow / 5 minutes fast)

0 - 2 mins	**2 - 3 mins**	**3 - 5 mins**	**5 - 6 mins**	**6 – 8 mins**
Low Intensity Slow	High Intensity Fast	Low Intensity Slow	High Intensity Fast	Low Intensity Slow
8 – 9 mins	**9 – 11 mins**	**11 – 12 mins**	**12 – 14 mins**	**14 – 15 mins**
High Intensity Fast	Low Intensity Slow	High Intensity Fast	Low Intensity Slow	High Intensity Fast

BREAK: At least three hours in between session 1 and 2

SESSION 2: 15 minutes (10 minutes slow / 5 minutes fast)

0 - 2 mins	**2 - 3 mins**	**3 - 5 mins**	**5 - 6 mins**	**6 – 8 mins**
Low Intensity Slow	High Intensity Fast	Low Intensity Slow	High Intensity Fast	Low Intensity Slow
8 – 9 mins	**9 – 11 mins**	**11 – 12 mins**	**12 – 14 mins**	**14 – 15 mins**
High Intensity Fast	Low Intensity Slow	High Intensity Fast	Low Intensity Slow	High Intensity Fast

TOTAL: 30 minutes per day (20 minutes slow / 10 minutes fast) on five days per week.

It is very important that you abide by these exercise requirements and constantly monitor your walking pace throughout the 15 minute session. Please keep your heart rate as close to the recommended heart rate as possible. Remember to change your pace after each two and one minute intervals.

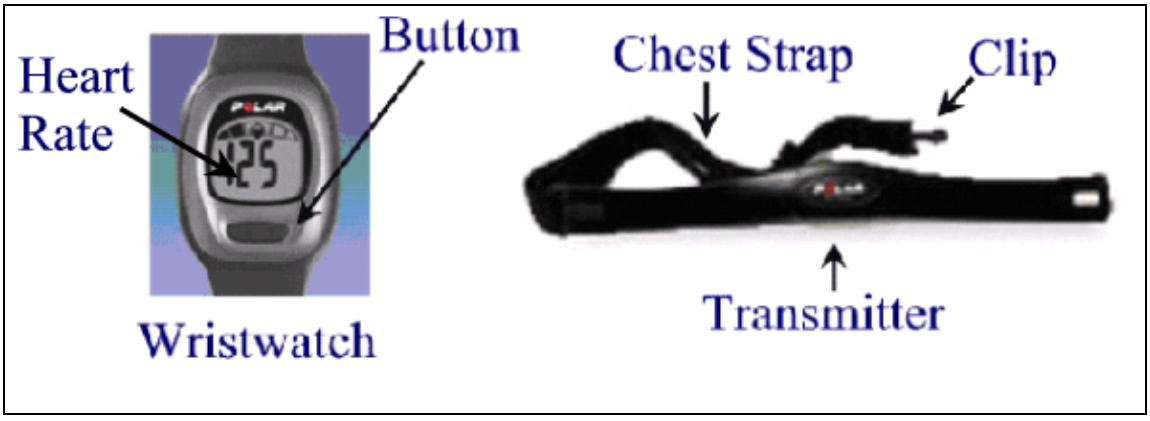
PEDOMETER INSTRUCTION

A pedometer is used to measure how many steps you have taken in a day. Please do not let the fact that you are wearing the pedometer influence your activity levels. The pedometer is to be worn only by you. It is a little device that should be clipped onto your waist. You are only required to wear your pedometer in week one of your exercise programme and then again in week 12. Please put the pedometer on as soon as you get out of bed in the morning. When you come to perform your exercise please record in the exercise diary the amount of steps taken thus far during the day. When you have finished your exercise session please record in the exercise diary the amount of steps taken after exercise. Then perform a simple calculation; after exercise minus before exercise to calculate the amount of steps taken during exercise. Please perform this process for each of the exercise session. At the end of the day when you are getting into bed record the total amount of steps taken for the whole day and reset the pedometer ready for the next day. On the two days that you are not performing your exercise sessions, please record the pedometer reading for the total amount of steps taken for the day.

HEART RATE MONITOR

A heart rate monitor is used to measure your exercise intensity during exercise. The heart rate monitor is only to be worn when completing exercise sessions. First, wet the back of the heart rate transmitter with water as this allows better detection of heart rate. Attach the transmitter to the chest strap on one side and place the monitor around your chest, then do the clip up on the other side of the transmitter. Make sure the middle of the transmitter is sitting just below nipple level in the middle of the chest and that it is sitting firmly against your skin. Attach the wristwatch to your arm and press the big black button on the front of the watch. A heart should begin flashing on the watch and after a few seconds a heart rate value should appear. If you are unable to get a heart rate value try moving the transmitter around and placing more water under the back of the transmitter (in between the skin and transmitter) and try again.

Please remember to record your heart rate range and average heart rate after each session, as well as your exercise time (which desirably should be 15 minutes).



The researcher will be in contact with you throughout this study to ensure no problems are being encountered. After you have completed your 12 weeks of exercising and dieting the researcher will contact you regarding organising a suitable time for you to revisit UWA and RPH for repeated testing.

PROBLEMS
If you experience difficulties, have any further problems or are unsure about any of the requirements, please contact the researcher.

Leanne Campbell (BSc)
Email: campb104@student.uwa.edu.au
Ph: 0404 119 910

GOOD LUCK!!

GROUP B:
The Effects Of Two Modes Of Exercise On Obesity

Congratulations, you have successfully completed the selection criteria and you are now eligible to participate in this study.

You have been randomly assigned to GROUP B. This means that you will be required to complete ten exercise sessions each week, as well as abide by your SureSlim diet for the next 12 weeks.

DIET
SureSlim has provided you with an individualised diet. It is very important that you abide by this diet for the 12 weeks of this study. If for any reason you do not stick to the diet guidelines you will be required to contact the researcher to discuss if there are any implications.

EQUIPMENT
The researcher will issue you with a heart rate monitor, pedometer and exercise diary. Please ensure that you wear your pedometer when asked and that you wear your heart rate monitor during each exercise session. Please note that the pedometer is not water proof so will need to be removed during water activities (eg. showering). Please keep all equipment in a safe and secure location for the 12 weeks and return it to the researcher when finished.

EXERCISE
Exercise is to be completed on five days of the week. There is no restriction as to what days you exercise on, as long as you complete the exercise sessions on five of the seven days. You will be required to perform two exercise sessions per day, each lasting for a 15 minute duration, which will equate to 30 minutes of exercising per day. At least three hours will need to separate each exercise session. Exercise will consist predominately of walking.

It is very important that you understand how to use the heart rate monitor and pedometer. If you are unsure please contact the researcher who will be happy to go through the instructions with you again.

Each exercise session of 15 minutes is to be completed at a constant intensity. The intensity has been individually tailored to your own fitness levels and is considered to be at a moderate level, which you will be able to manage. The intensity you are required to exercise at has been set at a heart rate of _____.

Session 1: 15 minutes at specified heart rate +
Break: At least three hours in between session 1 and 2 +
Session 2: 15 minutes at specified heart rate =
Total: 30 minutes per day on five days per week

The speed that you will be walking at will be dependent on your heart rate. If your heart rate falls below the heart rate specified above, speed up your walking pace and if your heart rate exceeds the heart rate specified above, slow down your walking pace. Please keep

your exercise intensity as close to the recommended heart rate as possible for the entire 15 minutes.

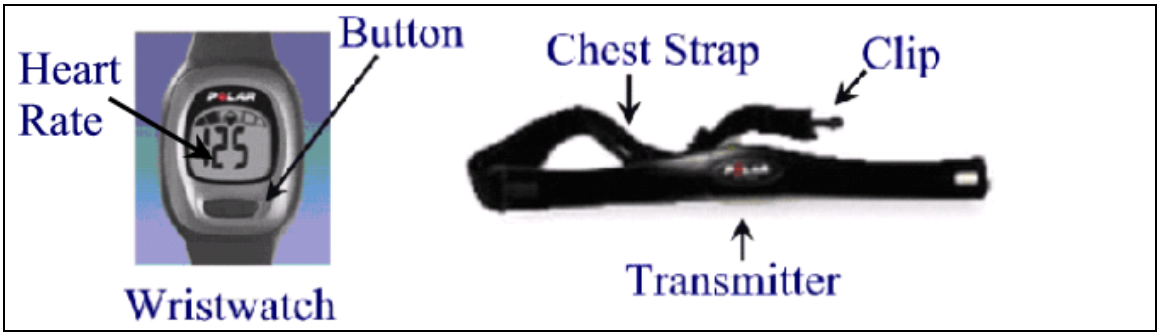
PEDOMETER INSTRUCTION

A pedometer is used to measure how many steps you have taken in a day. Please do not let the fact that you are wearing the pedometer influence your activity levels. The pedometer is to be worn only by you. It is a little device that should be clipped onto your waist. You are only required to wear your pedometer in week one of your exercise programme and then again in week 12. Please put the pedometer on as soon as you get out of bed in the morning. When you come to perform your exercise please record in the exercise diary the amount of steps taken thus far during the day. When you have finished your exercise session please record in the exercise diary the amount of steps taken after exercise. Then perform a simple calculation; after exercise minus before exercise to calculate the amount of steps taken during exercise. Please perform this process for each of the exercise session. At the end of the day when you are getting into bed record the total amount of steps taken for the whole day and reset the pedometer ready for the next day. On the two days that you are not performing your exercise sessions, please record the pedometer reading for the total amount of steps taken for the day.

HEART RATE MONITOR

A heart rate monitor is used to measure your exercise intensity during exercise. The heart rate monitor is only to be worn when completing exercise sessions. First, wet the back of the heart rate transmitter with water as this allows better detection of heart rate. Attach the transmitter to the chest strap on one side and place the monitor around your chest, then do the clip up on the other side of the transmitter. Make sure the middle of the transmitter is sitting just below nipple level in the middle of the chest and that it is sitting firmly against your skin. Attach the wristwatch to your arm and press the big black button on the front of the watch. A heart should begin flashing on the watch and after a few seconds a heart rate value should appear. If you are unable to get a heart rate value try moving the transmitter around and placing more water under the back of the transmitter (in between the skin and transmitter) and try again.

Please remember to record your heart rate range and average heart rate after each session, as well as your exercise time (which desirably should be 15 minutes).



The researcher will be in contact with you throughout this study to ensure no problems are being encountered. After you have completed your 12 weeks of exercising and dieting the researcher will contact you regarding organising a suitable time for you to revisit UWA and RPH for repeated testing.

PROBLEMS
If you experience difficulties, have any further problems or are unsure about any of the requirements, please contact the researcher.

Leanne Campbell (BSc)
Email: campb104@student.uwa.edu.au
Ph: 0404119910
GOOD LUCK!!

Instructions

EXERCISE DIARY REQUIREMENTS:

- You are to exercise twice a day for 15 minutes, with three hours between each session, on the five exercise days.
- You are able to choose which five days of the week you want to exercise on and the exercise days do not have to be the same each week.
- You are required to fill in the exercise diary every week.

Weeks 1 and 12 :

- During week 1 and 12, you are required to record for each exercise session
    1) exercise duration (Exercise time)
    2) heart rate range (HR range)
    3) average heart rate (Av. HR)
- You will be required to wear the pedometer during week 1 + 12 only.
- On the non-exercise days, you will be required to record:
    4) total amount of steps taken for the day (from getting up in the morning to going to bed)
- On the exercise days, you will also be required to record:
    5) amount of steps taken during each exercise session (steps after exercise - steps before exercise = steps during exercise)
    6) total amount of steps taken for the day (from getting up in the morning to going to bed)

Weeks 2 , 3, 4, 5, 6, 7, 8, 9, 10 and 11 :

- During weeks 2 to 11, you will be required to record for each exercise session:
    1) exercise duration (Exercise time)
    2) heart rate range (HR range)
    3) average heart rate (Av. HR)
- On these weeks, you are NOT required to wear the pedometer.

Name: ……EXAMPLE ONLY……. **Week** …..1.....

EXERCISE DAYS

Date:2/5/05 Total number of steps for the day-10008 Distance(km)-6.0 Calories(kcal)-386.9

Session 1: Exercise Time=15 mins 25 sec HR range=75-135 Av. HR= 110

Steps After Exercise 1250 - Steps Before Exercise 750 = Exercise 500

Session 2: Exercise Time= 15 mins 00 sec HR range=70-130 Av. HR= 100

Steps After Exercise 8700 - Steps Before Exercise 8210 = Exercise490

Date: 3/5/05 Total number of steps for the day-10062 .Distance(km)- 6.0 Calories(kcal)-389.1

Session 1: Exercise Time= 15 mins 25 sec HR range=77-141 Av. HR= 105

Steps After Exercise 1050 - Steps Before Exercise 550 = Exercise 500

Session 2: Exercise Time= 15 mins 06 sec HR range= 70-130 Av. HR= 100

Steps After Exercise 5500 - Steps Before Exercise 4995 = Exercise 505

Date: 5/5/05 Total number of steps for the day-12000 Distance(km)- 7.2 Calories(kcal)-464.0

Session 1: Exercise Time= 15 mins 05 sec HR range= 75-151 Av. HR= 108

Steps After Exercise 4500 - Steps Before Exercise 3990 = Exercise 510

Session 2: Exercise Time= 15 mins 10 sec HR range= 70-135 Av. HR= 106

Steps After Exercise 8000 - Steps Before Exercise 7485 = Exercise 515

Date: 7/5/05 Total number of steps for the day-10110 Distance(km)-6.1 Calories(kcal)-390.9

Session 1: Exercise Time= 15 mins 50 sec HR range= 80-145 Av. HR= 120

Steps After Exercise 5000 - Steps Before Exercise 4400 = Exercise 600

Session 2: Exercise Time= 14 mins 40 sec HR range= 70-130 Av. HR= 100

Steps After Exercise 7800 - Steps Before Exercise 7320 = Exercise 480

Date: 8/5/05 Total number of steps for the day-10005 Distance(km)-6.0 Calories(kcal)-386.9

Session 1: Exercise Time= 15 mins 00 sec HR range= 78-142 Av. HR= 110

Steps After Exercise 2052 - Steps Before Exercise 1552 = Exercise 500

Session 2: Exercise Time= 15 mins 05 sec HR range= 76-135 Av. HR= 95

Steps After Exercise 5600 - Steps Before Exercise 4995 = Exercise 605

NON EXERCISE DAYS

Date: 4/5/05 Total number of steps for the day-10000.Distance(km)-6.0 Calories(kcal)-386.9

Date: 6/5/05 Total number of steps for the day-8050 Distance(km)-4.8 Calories(kcal)-311.3

Instructions

FOOD DIARY REQUIREMENTS:

- Please refer to your SureSlim meal planner for dietary guidelines.

- You are required to keep a food diary for only weeks 1, 6 and 12 of this study.

- You are required to fill in the exact foods and quantities you eat for the whole week. If a meal consists of a class of food, for example 100 grams of vegetables, please specify what vegetables your meal consists of and the quantities of each vegetable that made up the 100 grams.

- Please fill in the diary during each meal.

- Please refer to the example week food diary to see how to fill in the diary.

- Please note, that the example food diary is only an example of how
to fill in the diary and is not based on the foods or the quantities that you are allowed.

SAMPLE FOOD DIARY

MONDAY
Breakfast – 2 boiled eggs, 55g mushroom, 40g spinach, 30g tomato, 2 tablespoons flaxseed meal, 1 mountain bread
Lunch – 75g Edam cheese, 30g capsicum, 30g rocket, 45g snow pea sprouts, 50g bamboo shoots, 1 tablespoon sesame seeds, 1 tablespoon sunflower seeds, 1 tablespoon olive oil, balsamic vinegar, 1 apple (136g). Also 20g cucumber, 25g celery (unlimited vegetables).
Dinner – 90g tofu, 55g broccoli, 40g zucchini, 75g bok choy, 2 tablespoons pepitas, 1 pear

TUESDAY
Breakfast – 200g plain low-fat yoghurt, 180g rock melon, 2 Tblsp flaxseed meal, 1 Tbsp sunflower
Lunch – 1 mountain bread, 150g chicken breast, 50g tomato, 10g spring onion, 20g alfalfa sprouts, 20g mung bean sprouts, 25g rocket, 25g green capsicum, 2 tsp tahini, 1 red apple (119g)
Dinner – 160g salmon, 50g green beans, 50g eggplant, 65g cauliflower, 2 Tbsp pepitas, 1 Tbsp olive oil

WEDNESDAY –
Breakfast - 30g oats (uncooked), 85ml milk, 100g strawberries, 2 Tbsp flaxseed meal
Lunch – 4 cruskits, 150g canned tuna, 60g tomato, 10g spring onions, 10g radish, 75g asparagus, 2 tsp tahini, 1 green apple (145g). Also 10g parsley, 30g lettuce, 20g cucumber.
Dinner – 160g lean beef mince, 80g squash, 85g leek, 2 Tbsp pepitas, 1 Tbsp olive oil

THURSDAY
Breakfast – 2 poached eggs, 60g tomato, 40g spinach, 25g asparagus, 1 Tbsp sesame seeds
Lunch – 1 mountain bread, 75g cheese, 30g broccoli, 30g onion, 30g mushroom, 55g snow pea sprouts, 1 Tbsp sunflower seeds, 10g parsley, 10g watercress, 160g kiwi fruit.
Dinner – 160 lean chicken thigh fillets, 30g bamboo shoots, 20g red capsicum, 30g green capsicum, 30g fennel, 55g snow peas, 2 Tbsp pepitas, 2 Tbsp flaxseed meal, 1 Tbsp olive oil

FRIDAY
Breakfast – 200g plain low-fat yoghurt, 100g blueberries, 2 Tbsp flaxseed meal, 1 Tbsp sunflower
Lunch – 4 cruskits, 75g low-fat cottage cheese, 40g tomato, 30g snow pea sprouts, 30g mung bean sprouts, 55g rocket, 20g lettuce, 20g cucumber, 1 Tbsp sesame seeds, 2 Tbsp pepitas, 1 apple
Dinner – 160g veal, 50g eggplant, 40g brussel sprouts, 75g broccoli, 1 Tbsp olive oil

SATURDAY
Breakfast – 2 boiled eggs, 70g asparagus, 55g tomato, 1 Tbsp sesame seeds, 1 orange (155g)
Lunch – 75g red kidney beans, 50g rocket, 20g red capsicum, 30g bean sprouts, 25g spring onions, 1 Tbsp sunflower seeds, 2 Tbsp pepitas, 20g cucumber, 20g watercress, 1 apple (143g)
Dinner – 160g turkey breast, 50g squash, 50g cabbage, 40g bok choy, 25g endive, 2 Tbsp flaxseed meal, 1 mountain bread, 1 Tbsp olive oil

The above food diary is only an example. You are free to choose whichever foods you like from your food selection list. The above grammages are an example only. You should follow the grammages on your program. Remember, unlimited vegetables can be eaten *in addition* to the vegetable grammages on your program eg if your program says you can have 125g vegetables for lunch, you must make up 125g vegetables from your vegetable section eg 50g snow peas, 50g beans, 25g tomato. On top of this you can have as much celery, cucumber, lettuce, parsley and watercress as you like.

Appendix K: Weekly Phone Questions

Standardized Questions each week

I am just ringing to see how your exercise and diet is going. I have a few questions to ask you if you are not busy. It will only take a few minutes.

1. What week are you up too?

……

2. Did you stick to your diet this week?

……

3. How did you find this weeks diet?

……

4. How did you find this weeks exercise sessions?

……

5. How many sessions did you complete this week?

……

6. How were your motivation levels this week?

……

7. Did you experience any problems?

……

8. How are you feeling in general?

……

9. Do you feel like you are losing weight?

……

10. Do you feel like you are becoming fitter?

11. Do you have any other comments?

……

Demographics

PRE

	Interval			
	Age	**Height**	**Weight**	**BMI**
Total	525	1973.4	1050.92	389.9
Average	43.75	164.45	87.57667	32.49167
SD	10.402141	7.809027	10.69407	3.753962
SEM	3.0028396	2.254272	3.087112	1.083676

PRE

	Steady-State			
	Age	**Height**	**Weight**	**BMI**
Total	621	2315.3	1303.64	475.14
Average	44.35714	165.3786	93.11714	33.93857
SD	10.36716	9.110533	17.70983	4.986585
SEM	2.77074	2.434892	4.733152	1.332721

POST

	Interval		Steady-State	
	Weight	**BMI**	**Weight**	**BMI**
Total	949.88	352.29	1196.06	434.35
Average	79.15667	29.3575	85.43286	31.025
SD	9.177652	3.671735	18.04334	4.567771
SEM	2.64936	1.059939	4.822286	1.220788

General Blood Test

PRE

	Interval						
	Hb	**PCV**	**MCV**	**RCC**	**RDW**	**MCH**	**MCHC**
Total	1654	5.14	1068	57.7	160	343	386
Average	137.8333	0.428333	89	4.808333	13.33333	28.58333	32.16667
SD	14.35798	0.030994	3.643175	0.387201	0.592887	1.505042	1.193416
SEM	4.144791	0.008947	1.051694	0.111775	0.171152	0.434468	0.34451

PRE

	Steady-State						
	Hb	**PCV**	**MCV**	**RCC**	**RDW**	**MCH**	**MCHC**
Total	1696	5.25	1058	59.8	158.7	341	388
Average	141.3333	0.4375	88.16667	4.983333	13.225	28.41667	32.33333
SD	12.62273	0.036958	2.552479	0.460895	0.499318	0.996205	0.887625
SEM	3.643869	0.010669	0.736837	0.133049	0.144141	0.28758	0.256235

POST

	Interval						
	Hb	**PCV**	**MCV**	**RCC**	**RDW**	**MCH**	**MCHC**
Total	1608	4.94	1064	55.9	163.8	347	389.3
Average	134	0.411667	88.66667	4.658333	13.65	28.91667	32.44167
SD	11.60721	0.028231	4.052683	0.357919	0.51434	1.729862	1.101617
SEM	3.350712	0.008149	1.169909	0.103322	0.148477	0.499368	0.31801

POST

	Steady-State						
	Hb	**PCV**	**MCV**	**RCC**	**RDW**	**MCH**	**MCHC**
Total	1679	5.19	1066	58.6	164.3	345	388.5
Average	139.9167	0.4325	88.83333	4.883333	13.69167	28.75	32.375
SD	13.50729	0.038406	2.918073	0.500606	0.555073	0.753778	0.618098
SEM	3.89922	0.011087	0.842375	0.144512	0.160236	0.217597	0.17843

PRE

	Interval							
	Total WCC	**Neutro**	**Lymph**	**Mono**	**Esoino**	**Baso**	**Platelets**	**ESR**
Total	72.1	41	21.3	5	2.5	1.2	3005	116
Average	6.00833	3.416667	1.775	0.416666	0.208333	0.1	250.4167	9.66666
SD	1.53413	1.049531	0.805802	0.152752	0.206522	1.45E-17	52.17185	7.40188
SEM	0.44286	0.302973	0.232615	0.044095	0.059618	4.18E-18	15.06071	2.13674

PRE

	Steady-State							
	Total WCC	**Neutro**	**Lymph**	**Mono**	**Esoino**	**Baso**	**Platelets**	**ESR**
Total	73.6	40.6	25.6	5.5	2.5	1.2	3361	110
Average	6.13333	3.383333	2.133333	0.458333	0.208333	0.1	280.08333	9.1666666
SD	1.21156	1.032942	0.4163	0.26097	0.144337	0	41.282746	10.51261
SEM	0.34974	0.298184	0.120185	0.075335	0.041666	0	11.917302	3.0347316

POST

	Interval							
	Total WCC	**Neutro**	**Lymph**	**Mono**	**Esoino**	**Baso**	**Platelets**	**ESR**
Total	68.8	41.3	20.7	5.2	1.7	1.2	2996	65
Average	5.733333	3.441667	1.725	0.433333	0.14166	0.1	249.6667	5.416667
SD	1.274457	0.939495	0.68903	0.137068	0.07929	1.45E-17	55.47863	4.601548
SEM	0.367904	0.271209	0.19890	0.039568	0.02289	4.18E-18	16.0153	1.328352

POST

	Steady-State							
	Total WCC	**Neutro**	**Lymph**	**Mono**	**Esoino**	**Baso**	**Platelets**	**ESR**
Total	63.3	33.8	23.3	4.3	1.8	1.2	3235	84
Average	5.275	2.816667	1.94166	0.358333	0.15	0.1	269.5833	7
SD	1.109566	0.779083	0.55343	0.144338	0.1167	1.449E-17	37.28382	7.00649
SEM	0.320304	0.224902	0.15976	0.041667	0.0337	4.184E-18	10.76291	2.0226

Liver Function

PRE

	Interval			Steady-State		
	AST	**GGT**	**ALT**	**AST**	**GGT**	**ALT**
Total	280	394	343	255	320	318
Average	23.33333	32.83333	28.58333	21.25	26.66667	26.5
SD	8.260897	17.66781	13.36521	4.594958	16.7513	15.06652
SEM	2.384716	5.100257	3.858203	1.32645	4.835684	4.349329

POST

	Interval			Steady-State		
	AST	**GGT**	**ALT**	**AST**	**GGT**	**ALT**
Total	309	264	264	220	213	221
Average	25.75	22	22	18.33333	17.75	18.41667
SD	19.5035	15.2554	12.98951	3.498918	9.808392	9.491224
SEM	5.630174	4.403855	3.749747	1.010051	2.831439	2.73988

Renal Function

PRE

Interval				
	Urea	**Creatine**	**Sodium**	**Potassium**
Total	60.6	744	1678	47.8
Average	5.05	62	139.8333	3.983333
SD	1.103301	7.954416	1.466804	0.332575
SEM	0.318496	2.296242	0.42343	0.096006

PRE

Steady-State				
	Urea	**Creatine**	**Sodium**	**Potassium**
Total	57.8	790	1667	47.9
Average	4.816667	65.83333	138.9167	3.991667
SD	0.904367	11.59807	2.108784	0.407784
SEM	0.261068	3.348073	0.608753	0.117717

POST

Interval				
	Urea	**Creatine**	**Sodium**	**Potassium**
Total	62	811	1687	50.7
Average	5.166667	67.58333	140.5833	4.225
SD	1.339833	11.11476	1.443376	0.362128
SEM	0.386776	3.208555	0.416667	0.104537

POST

Steady-State				
	Urea	**Creatine**	**Sodium**	**Potassium**
Total	59.6	796	1687	49.1
Average	4.966667	66.33333	140.5833	4.091667
SD	1.265869	12.31653	2.151462	0.299874
SEM	0.365425	3.555477	0.621074	0.086566

General

PRE

Interval			Steady-State	
	Glucose	**Uric Acid**	**Glucose**	**Uric Acid**
Total	58.7	4.07	61.7	4.16
Average	4.891667	0.339167	5.141667	0.346667
SD	0.773961	0.073541	0.618588	0.072405
SEM	0.223423	0.02123	0.178571	0.020901

POST

Interval			Steady-State	
	Glucose	**Uric Acid**	**Glucose**	**Uric Acid**
Total	55.6	4.17	58.7	3.6
Average	4.633333	0.3475	4.891667	0.3
SD	0.669237	0.121963	0.533357	0.088728
SEM	0.193192	0.035208	0.153967	0.025614

Lipids

PRE

	Interval					
	Cholesterol	**Triglyceride**	**HDL**	**LDL**	**VLDL**	**Coronary Risk**
Total	71.1	18.4	16.65	49.6	10.7	54
Average	6.4636364	1.6727273	1.513636	4.13333	0.8916667	4.5
SD	2.1814091	0.9089454	0.293028	1.89705	0.5976596	1.441590031
SEM	0.6577196	0.2740574	0.088351	0.54763	0.1725295	0.416151196

PRE

	Steady-State					
	Cholesterol	**Triglyceride**	**HDL**	**LDL**	**VLDL**	**Coronary Risk**
Total	60.8	15.7	17.4	35.5	5	44.3
Average	5.0666667	1.3083333	1.45	2.95833	0.625	3.6916667
SD	1.15706	0.6501165	0.344805	1.08498	0.5700877	1.1712141
SEM	0.3340145	0.1876725	0.099536	0.31320	0.2015564	0.3381004

POST

	Interval					
	Cholesterol	**Triglyceride**	**HDL**	**LDL**	**VLDL**	**Coronary Risk**
Total	67.3	13.3	18.22	42	3.8	43.9
Average	5.6083333	1.1083333	1.518333	3.5	0.5428571	3.658333333
SD	1.9190236	0.3918681	0.534532	1.84932	0.1397276	1.690862251
SEM	0.5539744	0.1131226	0.154306	0.53385	0.0403359	0.488109888

POST

	Steady-State					
	Cholesterol	**Triglyceride**	**HDL**	**LDL**	**VLDL**	**Coronary Risk**
Total	55.1	13.9	17.6	31.2	4.6	39
Average	4.5916667	1.1583333	1.466667	2.6	0.575	3.25
SD	0.9755729	1.0299676	0.365795	1.01534	0.587367	0.972812231
SEM	0.2816236	0.297326	0.105596	0.2931	0.1695582	0.280826702

Thyroid Function

PRE

	Interval	Steady-State
	TSH	**TSH**
Total	20.77	20.76
Average	1.730833	1.73
SD	0.651034	0.664065
SEM	0.187937	0.177479

POST

	Interval	Steady-State
	TSH	**TSH**
Total	18.46	20.77
Average	1.538333	1.730833
SD	0.635336	1.017756
SEM	0.183406	0.293801

Additional Tests

PRE

	Interval				
	IGF-1	**c-peptide**	**HA1c**	**C-React Protein**	**Fasting Insulin**
Total	165	6.76	65.9	56.36	66.9
Average	15	0.5633333	5.4917	4.696667	5.575
SD	3.5213634	0.2005145	0.6288	2.272061	2.215287792
SEM	1.061731	0.0578835	0.1815	0.655887	0.639498501

PRE

	Steady-State				
	IGF-1	**c-peptide**	**HA1c**	**C-React Protein**	**Fasting Insulin**
Total	131	6.66	53.8	105.89	67.7
Average	11.909091	0.666	5.38	9.6263636	6.1545455
SD	2.8090762	0.2138639	0.3675746	9.3772877	2.3363919
SEM	0.8469683	0.0676297	0.1162373	2.8273586	0.7044487

POST

	Interval				
	IGF-1	**c-peptide**	**HA1c**	**C-React Protein**	**Fasting Insulin**
Total	162	5.89	64	48.28	43.1
Average	14.727273	0.5355	5.3333	4.023333	3.918181818
SD	3.6356818	0.2309	0.4997	1.996858	1.39557743
SEM	1.1497035	0.0696	0.1443	0.576443	0.420782427

POST

	Steady-State				
	IGF-1	**c-peptide**	**HA1c**	**C-React Protein**	**Fasting Insulin**
Total	187	6.65	52.7	75.43	65.1
Average	17	0.6045455	5.27	6.8572727	5.9181818
SD	7.0285134	0.3065082	0.2869379	5.9521208	2.4669083
SEM	2.1191765	0.0924157	0.0907377	1.7946319	0.7438008

Aerobic Fitness

PRE

	Interval	Steady-State
	VO_2max	VO_2max
Total	300.29	332.05
Average	27.29909	25.54231
SD	5.463242	3.761197
SEM	1.647229	1.043168

POST

	Interval	Steady-State
	VO_2max	VO_2max
Total	346.4	379.85
Average	31.49091	29.21923
SD	6.776534	3.831696
SEM	2.043202	1.062721

Exercise Time To Exhaustion

PRE

	Interval	Steady-State
	Exercise Time	Exercise Time
Total	164.34	194.78
Average	14.94	14.98307692
SD	4.222970518	3.535136453
SEM	1.273273519	0.980470442

POST

	Interval	Steady-State
	Exercise Time	Exercise Time
Total	215.83	254.36
Average	19.62090909	19.56615
SD	4.246145204	3.318749
SEM	1.28026095	0.920455

Percentage Of Maximal Heart Rate

PRE

	Interval	Steady-State
	% Heart Rate	% Heart Rate
Total	1097	1271
Average	99.72727273	97.76923077
SD	5.832510765	8.880257562
SEM	1.68370083	2.373348664

POST

	Interval	Steady-State
	% Heart Rate	% Heart Rate
Total	988	1261
Average	98.8	97
SD	5.59364719	9.064583094
SEM	1.768866555	2.51406301

Resting Heart Rate

PRE

	Interval	Steady-State
	HR	HR
Total	844	962
Average	76.72727	74
SD	11.07331	13.45362
SEM	3.338728	3.731364

POST

	Interval	Steady-State
	HR	HR
Total	765	996
Average	76.5	76.61538
SD	8.984555	11.50752
SEM	2.841166	3.191613

Resting Blood Pressure

PRE

	Interval		Steady-State	
	Systolic	Diastolic	Systolic	Diastolic
Total	1360	899	1466	1003
Average	123.6364	81.72727	112.7692	77.15385
SD	18.76845	12.60231	13.34262	7.61409
SEM	5.658899	3.799739	3.700578	2.111768

POST

	Interval		Steady-State	
	Systolic	**Diastolic**	**Systolic**	**Diastolic**
Total	1302	839	1492	1030
Average	118.3636	76.27273	114.7692	79.23077
SD	14.64427	8.87796	15.56788	6.405126
SEM	4.415413	2.676806	4.317754	1.776462

Rate Of Perceived Exertion

PRE

	Interval	Steady-State
	RPE	**RPE**
Total	196.5	227.5
Average	17.86364	17.5
SD	2.346177	1.892969
SEM	0.677283	0.505917

POST

	Interval	Steady-State
	RPE	**RPE**
Total	195.5	233
Average	17.77273	17.92307692
SD	1.91525	1.693691159
SEM	0.57747	0.469745409

Resting Metabolic Rate

PRE

	Interval	Steady-State
	BMR	**BMR**
Total	4266.941	4613.403
Average	355.5785	329.5288
SD	61.20411	99.34686
SEM	4.221769	6.34446

POST

	Interval	Steady-State
	BMR	**BMR**
Total	4111.677	4767.761
Average	342.6398	340.5544
SD	57.23442	67.62405
SEM	3.947946	4.318587

Percentage of CHO and Lipids

PRE

	Interval		Steady-State	
	%CHO	**%Lipids**	**%CHO**	**%Lipids**
Total	369.8	830.2	248.5	1151.5
Average	30.81667	69.18333	17.75	82.25
SD	27.81	27.81	21.82485	21.82485
SEM	8.028055	8.028055	5.832937	5.832937

POST

	Interval		Steady-State	
	%CHO	**%Lipids**	**%CHO**	**%Lipids**
Total	532.9	667.1	338.8	1061.2
Average	44.40833	55.59167	24.2	75.8
SD	18.77941	18.77941	23.78383	23.78383
SEM	5.421149	5.421149	6.356497	6.356497

VCO_2 and VO_2

PRE

	Interval		Steady-State	
	VCO_2	VO_2	VCO_2	VO_2
Total	2.05	2.57	2.11	2.82
Average	0.170833	0.214167	0.150714	0.201429
SD	0.03704	0.037285	0.050909	0.060365
SEM	0.010693	0.010763	0.013606	0.016133

POST

	Interval		Steady-State	
	VCO_2	VO_2	VCO_2	VO_2
Total	2.08	2.49	2.26	2.9
Average	0.173333	0.2075	0.161429	0.207143
SD	0.031718	0.034411	0.037999	0.039111
SEM	0.009156	0.009933	0.010156	0.010453

RQ

PRE

	Interval	Steady-State
	RQ	**RQ**
Total	9.45	10.45
Average	0.7875	0.746429
SD	0.090667	0.073444
SEM	0.026173	0.019629

POST

	Interval	Steady-State
	RQ	**RQ**
Total	9.99	10.75
Average	0.8325	0.767857
SD	0.054293	0.076478
SEM	0.015673	0.02044

Body Composition

PRE

Interval				Steady-State		
	Fat	**Lean**	**% Body Fat**	**Fat**	**Lean**	**% Body Fat**
Total	452168	561373	534.6	583242	658979	662.7
Average	37680.667	46781.08	44.55	41660.14	47069.93	47.33571
SD	7729.5344	7986.217	7.135124	7915.468	11567.89	4.5731
SEM	2231.3244	2305.422	2.059733	2115.498	3091.647	1.222212

POST

Interval				Steady-State		
	Fat	**Lean**	**% Body Fat**	**Fat**	**Lean**	**% Body Fat**
Total	350168	561066	459.5	481360	656664	593.3
Average	29180.667	46755.5	38.29167	34382.86	46904.57	42.37857
SD	8082.555	8249.916	8.781019	8133.826	11452.77	5.063167
SEM	2333.2327	2381.546	2.534862	2173.856	3060.881	1.353188

Fat Distribution

PRE

	Interval		Steady-State	
	Android	**Gynoid**	**Android**	**Gynoid**
Total	621	598.1	758.1	724.4
Average	51.75	49.84167	54.15	51.74286
SD	6.6560294	8.164497	4.0097477	5.772976
SEM	1.9214302	2.356887	1.0716502	1.542893

POST

	Interval		Steady-State	
	Android	**Gynoid**	**Android**	**Gynoid**
Total	530.9	534.7	665.6	667.6
Average	44.241667	44.55833	47.542857	47.68571
SD	9.0205279	9.347188	5.3629375	6.558126
SEM	2.6040021	2.698301	1.4333053	1.752733

Fat Mass Ratio

PRE

Interval				Steady-State		
	Trunk/Total	**Legs/Total**	**Arm+Leg/Total**	**Trunk/Total**	**Legs/Total**	**Arm+Leg/Total**
Total	6.49	3.96	9.76	7.56	4.84	11.51
Average	0.5408333	0.33	0.813333333	0.54	0.345714	0.822142857
SD	0.0387201	0.043064	0.132276112	0.044893	0.042736	0.149109076
SEM	0.0111775	0.012432	0.038184824	0.0119982	0.011422	0.039851077

POST

Interval				Steady-State		
	Trunk/Total	**Legs/Total**	**Arm+Leg/Total**	**Trunk/Total**	**Legs/Total**	**Arm+Leg/Total**
Total	6.22	4.22	10.59	7.37	4.89	12.09
Average	0.5183333	0.351667	0.8825	0.5264286	0.349286	0.863571429
SD	0.037132	0.037132	0.134375661	0.0497079	0.045987	0.172163033
SEM	0.0107191	0.010719	0.038790912	0.013285	0.012291	0.046012506

Girth Measurements

PRE

	Interval			Steady-State		
	Hip	**Waist**	**Hip/Waist Ratio**	**Hip**	**Waist**	**Hip/Waist Ratio**
Total	1380.1	1169.7	10.1899	1661.9	1422.3	11.9762
Average	115.0083	97.475	0.849158	118.7071	101.5929	0.855443
SD	8.053397	7.028012	0.056555	8.720574	12.37382	0.074503
SEM	2.324815	2.028812	0.016326	2.330671	3.307043	0.019912

POST

	Interval			Steady-State		
	Hip	**Waist**	**Hip/Waist Ratio**	**Hip**	**Waist**	**Hip/Waist Ratio**
Total	1297.3	1077.3	9.9908	1561.8	1340.6	11.9864
Average	108.1083	89.775	0.832567	111.5571	95.75714	0.856171
SD	8.409244	6.010918	0.048215	8.532626	13.49283	0.0734
SEM	2.42754	1.735203	0.013918	2.28044	3.606111	0.019617

HADS

PRE

	Interval		Steady-State	
	Anxiety	**Depression**	**Anxiety**	**Depression**
Total	78	54	114	78
Average	6.5	4.5	8.142857	5.571429
SD	2.969542	3.450955	4.801557	4.182643
SEM	0.857233	0.996205	1.28327	1.117858

POST

	Interval		Steady-State	
	Anxiety	**Depression**	**Anxiety**	**Depression**
Total	70	27	78	22
Average	5.833333	2.25	5.571429	1.571429
SD	2.622744	2.301185	3.916715	1.34246
SEM	0.757121	0.664295	1.011287	0.34662

SF-36

PRE

	Interval							
	PF	**RP**	**BP**	**GH**	**V**	**SF**	**RE**	**MH**
Total	845	975	808	822	682	972.5	875	956
Average	70.4166	81.25	67.3333	68.5	56.8333	81.0416	72.9166	79.6666
SD	27.3411	24.1326	24.8315	22.897	26.8728	17.5310	31.2394	10.1563
SEM	7.89270	6.96650	7.16825	6.60979	7.75753	5.06078	9.01804	2.93188

PRE

	Steady-State							
	PF	**RP**	**BP**	**GH**	**V**	**SF**	**RE**	**MH**
Total	940	925	924	878	615	950	866.3	912
Average	67.1428	66.0714	66	62.7142	43.9285	67.8571	61.8785	65.1428
SD	20.7284	30.3934	22.6885	15.1983	20.0171	26.7261	34.3359	15.9559
SEM	5.53992	8.123	6.06376	4.06192	5.34981	7.14285	9.17668	4.26441

POST

	Interval							
	PF	**RP**	**BP**	**GH**	**V**	**SF**	**RE**	**MH**
Total	1090	1150	911	969	855	1037.5	1020.1	988
Average	90.8333	95.8333	75.9166	80.75	71.25	86.4583	85.0083	82.3333
SD	11.0439	9.73123	16.4839	16.1139	18.4791	18.8130	26.2034	8.77323
SEM	3.18812	2.80916	4.75849	4.65169	5.33445	5.43085	7.56427	2.53261

POST

	Steady-State							
	PF	**RP**	**BP**	**GH**	**V**	**SF**	**RE**	**MH**
Total	1270	1325	1177	1112	995	1237.5	1097	1080
Average	90.7142	94.6428	84.0714	79.4285	71.0714	88.3928	78.3571	77.1428
SD	6.46206	20.0445	14.3605	13.5573	18.3112	14.2642	33.5206	16.4122
SEM	1.72705	5.35714	3.83801	3.62335	4.8938	3.81227	8.95876	4.38636

OA-ESI

PRE			***POST***	
	Interval	**Steady-State**	**Interval**	**Steady-State**
	Overall	**Overall**	**Overall**	**Overall**
Total	29261	28804	12255	28835
Average	2660.091	2618.545	1225.5	2621.364
SD	3827.181	1994.561	884.4221	2519.063
SEM	1153.938	601.3828	266.6633	759.5262

Vascular Function

PRE

	Interval		**Steady-State**	
	FMD	**GTN**	**FMD**	**GTN**
Total	65.61	119.3893	95.86517	158.92
Average	13.12	23.88	11.98	22.70
SD	8.757851	4.98304	3.550223	8.055859
SEM	3.91663	2.228483	1.255193	3.044828

POST

	Interval		**Steady-State**	
	FMD	**GTN**	**FMD**	**GTN**
Total	64.90	152.1072	81.94	146.02
Average	12.98	30.42	10.24	20.86
SD	10.07093	12.59983	3.979956	4.754514
SEM	4.503859	5.634814	1.407127	1.797037

Accelerometer

PRE

	Calories	**Steps**	**Light**	**Moderate**	**Hard**	**Very Hard**
Total	1920.47	62825	6970	211	14	3
Average	384.094	12565	1394	42.2	2.8	0.6
SD	212.3614	1366.922	24.69818	24.92388	2.949576	1.341641
SEM	94.97091	611.306	11.04536	11.1463	1.319091	0.6

POST

	Calories	**Steps**	**Light**	**Moderate**	**Hard**	**Very Hard**
Total	1463.56	50151	6985	204	7	2
Average	292.712	10030.2	1397	40.8	1.4	0.4
SD	216.9305	3424.06	34.61936	33.81124	1.341641	0.894427
SEM	97.01425	1531.286	15.48225	15.12085	0.6	0.4

Pedometer

PRE

	Interval			Steady-State		
	Total Steps	**Exercise Steps**	**Incidental steps**	**Total Steps**	**Exercise Steps**	**Incidental steps**
Total	657614	175686	482028	669683	190152	479531
Average	82201.75	21960.75	60253.5	66968.3	19015.2	47953.1
SD	30978.10012	5820.569627	30050.74865	16534.163	3773.0071	14994.691
SEM	10952.41233	2057.882127	10624.54407	5228.5615	1193.1296	4741.7377

POST

	Interval			Steady-State		
	Total Steps	**Exercise Steps**	**Incidental steps**	**Total Steps**	**Exercise Steps**	**Incidental steps**
Total	716075	191212	524863	769210	204087	565042
Average	89509.38	23901.5	65607.88	76921	20408.7	56504.2
SD	27944.51	3729.414	27216.75	31375.3964	2991.459326	30516.33459
SEM	9879.876	1318.547	9622.574	9921.771512	945.9824998	9650.112313

Adherence

PRE

	Interval	Steady-State
	%	**%**
Total	1052	1207.7
Average	87.66667	92.9
SD	15.45506	9.513674369
SEM	4.461491	2.63861852

Food Intake

PRE

	Interval					
	Weight	**Energy**	**Protein**	**Fat**	**Cholesterol**	**CHO**
Total	10567.46	10241.3	747.49	444.7	2774.65	724.79
Average	1056.746	1024.13	74.749	44.47	277.465	72.479
SD	149.6801	170.0208	14.44189	11.31704	86.33453	12.8909
SEM	47.333	12.84715	4.566928	3.578763	27.30138	4.076461

PRE

	Steady-State					
	Weight	**Energy**	**Protein**	**Fat**	**Cholesterol**	**CHO**
Total	11994	11617.22	775.77	528.1	3331.04	827.07
Average	1090.364	1056.111	70.52455	48.00909	302.8218	75.18818
SD	199.6961	206.2279	25.91219	13.11753	130.0425	17.93371
SEM	60.21064	14.85784	7.81282	3.955083	39.20928	5.407216

POST

	Interval					
	Weight	**Energy**	**Protein**	**Fat**	**Cholesterol**	**CHO**
Total	12335.61	12800.29	841.67	513.7	2676.3	1012.2
Average	1233.561	1280.029	84.167	51.37	267.63	101.22
SD	547.7562	607.1061	22.08118	27.42595	96.39137	59.23129
SEM	173.2157	45.87427	6.982681	8.672848	30.48163	17.85891

POST

	Steady-State					
	Weight	**Energy**	**Protein**	**Fat**	**Cholesterol**	**CHO**
Total	11390.63	10832.02	706.25	417.47	3000.5	909.46
Average	1035.512	984.7294	64.20455	37.95182	272.7727	82.67818
SD	194.5502	172.1121	23.56446	11.52271	99.05951	27.36933
SEM	58.6591	12.39994	7.104953	3.474228	29.86756	8.252163

Intermittent Interval Exercise vs Intermittent Steady-State Exercise Participants at Baseline

Variable	t	df	Sig. (2-tailed)
Adherence	-1.029	23	0.314
DEMOGRAPHICS			
Age	-0.149	24	0.883
Body Weight	-0.945	24	0.354
Height	-0.276	24	0.785
BMI	-0.824	24	0.418
BLOODS			
Hb	-0.634	22	0.532
PVC	-0.658	22	0.517
MCV	0.649	22	0.523
RCC	-1.007	22	0.325
RDW	0.484	22	0.633
MCH	0.320	22	0.752
MCHC	-0.388	22	0.702
Total WCC	-0.222	22	0.827
Neutrophils	0.078	22	0.938
Lymphocytes	-1.369	22	0.185
Monocytes	-0.477	22	0.638
Esinophils	0.000	22	1.000
Platelets	-1.545	22	0.137
ESR	0.135	22	0.894
AST	0.763	22	0.453
GGT	0.877	22	0.390
ALT	0.358	22	0.724
Urea	0.567	22	0.577
Creatine	-0.944	22	0.355
Sodium	1.236	22	0.229
Potassium	-0.055	22	0.957
Glucose	-0.874	22	0.392
Uric Acid	-0.252	22	0.804
Total Cholesterol	1.943	21	0.066
Triglyceride	1.113	21	0.278
HDL	0.475	21	0.640
LDL	1.863	22	0.076
VLDL	1.283	13	0.222
Coronary Risk	1.508	22	0.146
Thyroid	0.003	22	0.998
C-peptide	-0.890	19	0.384
HA1c	0.494	20	0.626

IGF	2.276	20	0.034 **
CRP	-1.769	21	0.091
Fasting Insulin	-0.428	20	0.673
BODY COMPOSITION			
Fat Mass	-1.292	24	0.209
Lean Mass	-0.073	24	0.943
% Body Fat	-1.203	24	0.241
Android Fat Distribution	-1.133	24	0.269
Gynoid Fat Distribution	-0.693	24	0.495
Trunk/Total Ratio	0.050	24	0.960
Leg/Total Ratio	-0.931	24	0.361
Arm + Leg/Total Ratio	-0.158	24	0.876
GRADED EXERCISE TEST			
Peak $\dot{V}O_2$	0.930	22	0.363
Exercise Time to Exhaustion	-0.027	22	0.979
Resting Heart Rate	0.661	21	0.516
% Maximal Heart Rate	0.780	21	0.444
Systolic BP	1.654	22	0.112
Diastolic BP	1.096	22	0.285
Final RPE	0.420	22	0.678
RMR			
BMR	0.788	24	0.438
% CHO and Lipids	1.342	24	0.192
Oxygen Consumption	0.634	24	0.532
Carbon Dioxide Consumption	1.134	24	0.268
RQ	1.276	24	0.214
GIRTH MEASUREMENTS			
Waist Circumference	-1.019	24	0.318
Hip Circumference	-1.116	24	0.275
Waist to Hip Ratio	-0.239	24	0.813
QUESTIONNAIRES			
PF	0.347	24	0.732
RP	1.393	24	0.176
BP	0.143	24	0.887
GH	0.769	24	0.449
V	1.401	24	0.174
SF	1.506	24	0.146
RE	0.851	24	0.403
MH	2.713	24	0.012 **
Anxiety	-1.027	24	0.315
Depression	-0.705	24	0.488
Work Activity Level	0.201	20	0.843
Leisure Activity Level	-1.405	21	0.175
Overall Activity Level	0.032	21	0.975
VASCULAR FUNCTION			
%FMD	0.277	4.835	0.793
%GTN	0.287	10	0.780
EXERCISE DIARY			

Total Steps	0.981	19	0.339
Exercise Steps	1.300	16	0.212
Incidental Steps	1.135	16	0.273
FOOD DIARY			
Weight	-0.433	19	0.670
Energy Intake	-0.385	19	0.704
Proteins	0.455	19	0.654
Carbohydrates	-0.394	19	0.698
Fats	-0.659	19	0.518
Cholesterol	-0.521	19	0.609

Intermittent Interval Exercise vs Intermittent Steady-State Exercise

Two (group) by two (time) mixed design ANOVA, with repeated measures on the time factor.

Full Blood Count

Hb

Descriptive Statistics

	group	Mean	Std. Deviation	N
hbpr	interval	137.8333	14.35798	12
	continuous	141.3333	12.62273	12
	Total	139.5833	13.34139	24
hbpo	interval	134.0000	11.60721	12
	continuous	139.9167	13.50729	12
	Total	136.9583	12.68165	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	82.688	1	82.688	2.012	.170	.084	2.012	.274
time * group	17.521	1	17.521	.426	.521	.019	.426	.096
Error(time)	904.292	22	41.104					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	917703.521	1	917703.521	3056.71	.000	.993	3056.715	1.000
group	266.021	1	266.021	.886	.357	.039	.886	.147
Error	6604.958	22	300.225					

PVC

Descriptive Statistics

	group	Mean	Std. Deviation	N
pcvpr	interval	.4283	.03099	12
	continuous	.4375	.03696	12
	Total	.4329	.03368	24
pcvpo	interval	.4117	.02823	12
	continuous	.4325	.03841	12
	Total	.4221	.03464	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.001	1	.001	5.266	.032	.193	5.266	.593
time * group	.000	1	.000	1.527	.230	.065	1.527	.219
Error(time)	.006	22	.000					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	8.772	1	8.772	4317.463	.000	.995	4317.463	1.000
group	.003	1	.003	1.329	.261	.057	1.329	.197
Error	.045	22	.002					

MCV

Descriptive Statistics

	group	Mean	Std. Deviation	N
mcvpr	interval	89.0000	3.64318	12
	continuous	88.1667	2.55248	12
	Total	88.5833	3.10563	24
mcvpo	interval	88.6667	4.05268	12
	continuous	88.8333	2.91807	12
	Total	88.7500	3.45468	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.333	1	.333	.190	.667	.009	.190	.070
time * group	3.000	1	3.000	1.707	.205	.072	1.707	.239
Error(time)	38.667	22	1.758					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	377365.333	1	377365.333	18313.318	.000	.999	18313.318	1.000
group	1.333	1	1.333	.065	.802	.003	.065	.057
Error	453.333	22	20.606					

RCC

Descriptive Statistics

	group	Mean	Std. Deviation	N
rccpr	interval	4.8083	.38720	12
	continuous	4.9833	.46090	12
	Total	4.8958	.42578	24
rccpo	interval	4.6583	.35792	12
	continuous	4.8833	.50061	12
	Total	4.7708	.44083	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.187	1	.187	4.146	.054	.159	4.146	.495
time * group	.008	1	.008	.166	.688	.007	.166	.068
Error(time)	.995	22	.045					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1121.333	1	1121.333	3447.042	.000	.994	3447.042	1.000
group	.480	1	.480	1.476	.237	.063	1.476	.213
Error	7.157	22	.325					

RDW

Descriptive Statistics

	group	Mean	Std. Deviation	N
rdwpr	interval	13.3333	.59289	12
	continuous	13.2250	.49932	12
	Total	13.2792	.53890	24
rdwpo	interval	13.6500	.51434	12
	continuous	13.6917	.55507	12
	Total	13.6708	.52376	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	1.841	1	1.841	18.066	.000	.451	18.066	.982
time * group	.068	1	.068	.662	.424	.029	.662	.122
Error(time)	2.242	22	.102					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	8715.630	1	8715.630	17975.987	.000	.999	17975.987	1.000
group	.013	1	.013	.028	.870	.001	.028	.053
Error	10.667	22	.485					

MCH

Descriptive Statistics

	group	Mean	Std. Deviation	N
mchpr	interval	28.5833	1.50504	12
	continuous	28.4167	.99620	12
	Total	28.5000	1.25109	24
mchpo	interval	28.9167	1.72986	12
	continuous	28.7500	.75378	12
	Total	28.8333	1.30773	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	1.333	1	1.333	6.286	.020	.222	6.286	.669
time * group	.000	1	.000	.000	1.000	.000	.000	.050
Error(time)	4.667	22	.212					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	39445.333	1	39445.333	12338.351	.000	.998	12338.351	1.000
group	.333	1	.333	.104	.750	.005	.104	.061
Error	70.333	22	3.197					

MCHC

Descriptive Statistics

	group	Mean	Std. Deviation	N
mchcpr	interval	32.1667	1.19342	12
	continuous	32.3333	.88763	12
	Total	32.2500	1.03209	24
mchcpo	interval	32.4417	1.10162	12
	continuous	32.3750	.61810	12
	Total	32.4083	.87423	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.301	1	.301	1.344	.259	.058	1.344	.198
time * group	.163	1	.163	.729	.402	.032	.729	.129
Error(time)	4.926	22	.224					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	50168.401	1	50168.401	29862.817	.000	.999	29862.817	1.000
group	.030	1	.030	.018	.895	.001	.018	.052
Error	36.959	22	1.680					

WCC

Descriptive Statistics

	group	Mean	Std. Deviation	N
totwccpr	interval	6.0083	1.53413	12
	continuous	6.1333	1.21156	12
	Total	6.0708	1.35341	24
totwccpo	interval	5.7333	1.27446	12
	continuous	5.2750	1.10957	12
	Total	5.5042	1.19181	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	3.853	1	3.853	4.705	.041	.176	4.705	.545
time * group	1.021	1	1.021	1.247	.276	.054	1.247	.187
Error(time)	18.016	22	.819					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1607.768	1	1607.768	638.128	.000	.967	638.128	1.000
group	.333	1	.333	.132	.720	.006	.132	.064
Error	55.429	22	2.520					

Neutrophils

Descriptive Statistics

	group	Mean	Std. Deviation	N
neutropr	interval	3.4167	1.04953	12
	continuous	3.3833	1.03294	12
	Total	3.4000	1.01852	24
neutropo	interval	3.4417	.93950	12
	continuous	2.8167	.77908	12
	Total	3.1292	.90240	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.880	1	.880	1.642	.213	.069	1.642	.232
time * group	1.050	1	1.050	1.959	.176	.082	1.959	.268
Error(time)	11.795	22	.536					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	511.560	1	511.560	395.658	.000	.947	395.658	1.000
group	1.300	1	1.300	1.006	.327	.044	1.006	.160
Error	28.445	22	1.293					

Lymphocytes

Descriptive Statistics

	group	Mean	Std. Deviation	N
lymphpr	interval	1.7750	.80580	12
	continuous	2.1333	.41633	12
	Total	1.9542	.65341	24
lymphpo	interval	1.7250	.68904	12
	continuous	1.9417	.55343	12
	Total	1.8333	.62113	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.175	1	.175	1.117	.302	.048	1.117	.173
time * group	.060	1	.060	.384	.542	.017	.384	.091

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	172.142	1	172.142	266.863	.000	.924	266.863	1.000
group	.992	1	.992	1.538	.228	.065	1.538	.220
Error	14.191	22	.645					

Monocytes

Descriptive Statistics

	group	Mean	Std. Deviation	N
monopr	interval	.4167	.15275	12
	continuous	.4583	.26097	12
	Total	.4375	.21020	24
monopo	interval	.4333	.13707	12
	continuous	.3583	.14434	12
	Total	.3958	.14289	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.021	1	.021	1.355	.257	.058	1.355	.200
time * group	.041	1	.041	2.655	.117	.108	2.655	.344
Error(time)	.338	22	.015					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	8.333	1	8.333	166.163	.000	.883	166.163	1.000
group	.003	1	.003	.066	.799	.003	.066	.057
Error	1.103	22	.050					

Esionophils

Descriptive Statistics

	group	Mean	Std. Deviation	N
esinopr	interval	.2083	.20652	12
	continuous	.2083	.14434	12
	Total	.2083	.17425	24
esinopo	interval	.1417	.07930	12
	continuous	.1500	.11677	12
	Total	.1458	.09771	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.047	1	.047	3.849	.063	.149	3.849	.467
time * group	.000	1	.000	.017	.897	.001	.017	.052
Error(time)	.268	22	.012					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1.505	1	1.505	50.978	.000	.699	50.978	1.000
group	.000	1	.000	.007	.934	.000	.007	.051
Error	.650	22	.030					

Basophils

Descriptive Statistics

	group	Mean	Std. Deviation	N
basopr	interval	.1000	.00000	12
	continuous	.1000	.00000	12
	Total	.1000	.00000	24
basopo	interval	.1000	.00000	12
	continuous	.1000	.00000	12
	Total	.1000	.00000	24

Platelets

Descriptive Statistics

	group	Mean	Std. Deviation	N
platepr	interval	250.4167	52.17185	12
	continuous	280.0833	41.28275	12
	Total	265.2500	48.44024	24
platepo	interval	249.6667	55.47863	12
	continuous	269.5833	37.28382	12
	Total	259.6250	47.33214	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	379.687	1	379.687	1.407	.248	.060	1.407	.206
time * group	285.188	1	285.188	1.057	.315	.046	1.057	.166
Error(time)	5935.625	22	269.801					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	3305925.188	1	3305925.188	791.409	.000	.973	791.409	1.000
group	7375.521	1	7375.521	1.766	.198	.074	1.766	.246
Error	91899.792	22	4177.263					

ESR

Descriptive Statistics

	group	Mean	Std. Deviation	N
esrpr	interval	9.6667	7.40188	12
	continuous	9.1667	10.51262	12
	Total	9.4167	8.89512	24
esrpo	interval	5.4167	4.60155	12
	continuous	7.0000	7.00649	12
	Total	6.2083	5.85312	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	123.521	1	123.521	11.468	.003	.343	11.468	.899
time * group	13.021	1	13.021	1.209	.283	.052	1.209	.183
Error(time)	236.958	22	10.771					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	2929.688	1	2929.688	27.377	.000	.554	27.377	.999
group	3.521	1	3.521	.033	.858	.001	.033	.053
Error	2354.292	22	107.013					

Liver Function

AST

Descriptive Statistics

	group	Mean	Std. Deviation	N
astpr	interval	23.3333	8.26090	12
	continuous	21.2500	4.59496	12
	Total	22.2917	6.62327	24
astpo	interval	25.7500	19.50350	12
	continuous	18.3333	3.49892	12
	Total	22.0417	14.21719	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.750	1	.750	.006	.937	.000	.006	.051
time * group	85.333	1	85.333	.732	.401	.032	.732	.130
Error(time)	2563.917	22	116.542					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	23585.333	1	23585.333	189.515	.000	.896	189.515	1.000
group	270.750	1	270.750	2.176	.154	.090	2.176	.292
Error	2737.917	22	124.451					

GGT

Descriptive Statistics

	group	Mean	Std. Deviation	N
ggtpr	interval	32.8333	17.66781	12
	continuous	26.6667	16.75130	12
	Total	29.7500	17.12930	24
ggtpo	interval	22.0000	15.25540	12
	continuous	17.7500	9.80839	12
	Total	19.8750	12.72899	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	1170.188	1	1170.188	10.788	.003	.329	10.788	.881
time * group	11.021	1	11.021	.102	.753	.005	.102	.061
Error(time)	2386.292	22	108.468					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	29551.688	1	29551.688	83.864	.000	.792	83.864	1.000
group	325.521	1	325.521	.924	.347	.040	.924	.151
Error	7752.292	22	352.377					

ALT

Descriptive Statistics

	group	Mean	Std. Deviation	N
altpr	interval	28.5833	13.36521	12
	continuous	26.5000	15.06652	12
	Total	27.5417	13.96884	24
altpo	interval	22.0000	12.98951	12
	continuous	18.4167	9.49122	12
	Total	20.2083	11.27513	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	645.333	1	645.333	6.713	.017	.234	6.713	.697
time * group	6.750	1	6.750	.070	.793	.003	.070	.057
Error(time)	2114.917	22	96.133					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	27360.750	1	27360.750	115.893	.000	.840	115.893	1.000
group	96.333	1	96.333	.408	.530	.018	.408	.094
Error	5193.917	22	236.087					

Renal Function

Urea

Descriptive Statistics

	group	Mean	Std. Deviation	N
ureapr	interval	5.0500	1.10330	12
	continuous	4.8167	.90437	12
	Total	4.9333	.99375	24
ureapo	interval	5.1667	1.33983	12
	continuous	4.9667	1.26587	12
	Total	5.0667	1.27881	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.213	1	.213	.394	.537	.018	.394	.092
time * group	.003	1	.003	.006	.938	.000	.006	.051
Error(time)	11.923	22	.542					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1200.000	1	1200.000	551.878	.000	.962	551.878	1.000
group	.563	1	.563	.259	.616	.012	.259	.078
Error	47.837	22	2.174					

Creatinine

Descriptive Statistics

	group	Mean	Std. Deviation	N
creatipr	interval	62.0000	7.95442	12
	continuous	65.8333	11.59807	12
	Total	63.9167	9.92107	24
creatipo	interval	67.5833	11.11476	12
	continuous	66.3333	12.31653	12
	Total	66.9583	11.49094	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	111.021	1	111.021	3.287	.083	.130	3.287	.411
time * group	77.521	1	77.521	2.295	.144	.094	2.295	.305
Error(time)	742.958	22	33.771					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	205539.188	1	205539.188	1013.804	.000	.979	1013.804	1.000
group	20.021	1	20.021	.099	.756	.004	.099	.060
Error	4460.292	22	202.741					

Sodium

Descriptive Statistics

	group	Mean	Std. Deviation	N
creatipr	interval	62.0000	7.95442	12
	continuous	65.8333	11.59807	12
	Total	63.9167	9.92107	24
creatipo	interval	67.5833	11.11476	12
	continuous	66.3333	12.31653	12
	Total	66.9583	11.49094	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	111.021	1	111.021	3.287	.083	.130	3.287	.411
time * group	77.521	1	77.521	2.295	.144	.094	2.295	.305
Error(time)	742.958	22	33.771					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	205539.188	1	205539.188	1013.804	.000	.979	1013.804	1.000
group	20.021	1	20.021	.099	.756	.004	.099	.060
Error	4460.292	22	202.741					

Potassium

Descriptive Statistics

	group	Mean	Std. Deviation	N
potasspr	interval	3.9833	.33257	12
	continuous	3.9917	.40778	12
	Total	3.9875	.36393	24
potasspo	interval	4.2250	.36213	12
	continuous	4.0917	.29987	12
	Total	4.1583	.33221	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.350	1	.350	3.417	.078	.134	3.417	.424
time * group	.060	1	.060	.588	.452	.026	.588	.114
Error(time)	2.255	22	.102					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	796.255	1	796.255	5435.330	.000	.996	5435.330	1.000
group	.047	1	.047	.320	.577	.014	.320	.084
Error	3.223	22	.146					

General Biochemistry

Glucose

Descriptive Statistics

	group	Mean	Std. Deviation	N
glucospr	interval	4.8917	.77396	12
	continuous	5.1417	.61859	12
	Total	5.0167	.69699	24
glucospo	interval	4.6333	.66924	12
	continuous	4.8917	.53336	12
	Total	4.7625	.60635	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.775	1	.775	6.878	.016	.238	6.878	.708
time * group	.000	1	.000	.002	.966	.000	.002	.050
Error(time)	2.480	22	.113					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1147.585	1	1147.585	1541.833	.000	.986	1541.833	1.000
group	.775	1	.775	1.042	.319	.045	1.042	.164
Error	16.375	22	.744					

Uric Acid

Descriptive Statistics

	group	Mean	Std. Deviation	N
uricpr	interval	.3392	.07354	12
	continuous	.3467	.07240	12
	Total	.3429	.07147	24
uricpo	interval	.3475	.12196	12
	continuous	.3000	.08873	12
	Total	.3238	.10709	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.004	1	.004	2.448	.132	.100	2.448	.322
time * group	.009	1	.009	5.040	.035	.186	5.040	.574
Error(time)	.040	22	.002					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	5.333	1	5.333	357.978	.000	.942	357.978	1.000
group	.005	1	.005	.322	.576	.014	.322	.084
Error	.328	22	.015					

Lipids

Total Cholesterol

Descriptive Statistics

	group	Mean	Std. Deviation	N
cholespr	interval	6.4636	2.18141	11
	continuous	5.0667	1.15706	12
	Total	5.7348	1.82797	23
cholespo	interval	5.6727	1.99905	11
	continuous	4.5917	.97557	12
	Total	5.1087	1.61158	23

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	4.599	1	4.599	17.765	.000	.458	17.765	.980
time * group	.286	1	.286	1.106	.305	.050	1.106	.171
Error(time)	5.436	21	.259					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1363.069	1	1363.069	266.752	.000	.927	266.752	1.000
group	17.621	1	17.621	3.448	.077	.141	3.448	.426
Error	107.307	21	5.110					

Triglycerides

Descriptive Statistics

	group	Mean	Std. Deviation	N
triglypr	interval	1.6727	.90895	11
	continuous	1.3083	.65012	12
	Total	1.4826	.78835	23
triglypo	interval	1.0909	.40609	11
	continuous	1.1583	1.02997	12
	Total	1.1261	.77882	23

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	1.537	1	1.537	5.581	.028	.210	5.581	.615
time * group	.535	1	.535	1.943	.178	.085	1.943	.265
Error(time)	5.783	21	.275					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	78.500	1	78.500	80.627	.000	.793	80.627	1.000
group	.253	1	.253	.260	.615	.012	.260	.078
Error	20.446	21	.974					

HDL

Descriptive Statistics

	group	Mean	Std. Deviation	N
hdlpr	interval	1.5136	.29303	11
	continuous	1.4500	.34481	12
	Total	1.4804	.31549	23
hdlpo	interval	1.5291	.55926	11
	continuous	1.4667	.36580	12
	Total	1.4965	.45835	23

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.003	1	.003	.054	.819	.003	.054	.056
time * group	4.22E-006	1	4.22E-006	.000	.993	.000	.000	.050
Error(time)	1.159	21	.055					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	101.911	1	101.911	381.665	.000	.948	381.665	1.000
group	.046	1	.046	.171	.684	.008	.171	.068
Error	5.607	21	.267					

LDL

Descriptive Statistics

	group	Mean	Std. Deviation	N
ldlpr	interval	4.1333	1.89705	12
	continuous	2.9583	1.08499	12
	Total	3.5458	1.62614	24
ldlpo	interval	3.5000	1.84932	12
	continuous	2.6000	1.01534	12
	Total	3.0500	1.52971	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	2.950	1	2.950	12.368	.002	.360	12.368	.919
time * group	.227	1	.227	.951	.340	.041	.951	.154
Error(time)	5.248	22	.239					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	522.060	1	522.060	119.331	.000	.844	119.331	1.000
group	12.917	1	12.917	2.952	.100	.118	2.952	.376
Error	96.248	22	4.375					

VLDL

Descriptive Statistics

	group	Mean	Std. Deviation	N
vldlpr	interval	.9571	.40356	7
	continuous	.6250	.57009	8
	Total	.7800	.51158	15
vldlpo	interval	.5429	.13973	7
	continuous	.5750	.58737	8
	Total	.5600	.42561	15

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.402	1	.402	12.045	.004	.481	12.045	.893
time * group	.248	1	.248	7.415	.017	.363	7.415	.712
Error(time)	.434	13	.033					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	13.608	1	13.608	33.066	.000	.718	33.066	1.000
group	.168	1	.168	.408	.534	.030	.408	.091
Error	5.350	13	.412					

Coronary Risk

Descriptive Statistics

	group	Mean	Std. Deviation	N
coronpr	interval	4.5000	1.44159	12
	continuous	3.6917	1.17121	12
	Total	4.0958	1.34923	24
coronpo	interval	3.6583	1.69086	12
	continuous	3.2500	.97281	12
	Total	3.4542	1.36509	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	4.941	1	4.941	16.323	.001	.426	16.323	.971
time * group	.480	1	.480	1.586	.221	.067	1.586	.226
Error(time)	6.659	22	.303					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	684.030	1	684.030	205.726	.000	.903	205.726	1.000
group	4.441	1	4.441	1.336	.260	.057	1.336	.198
Error	73.149	22	3.325					

Thyroid Function

TSH

Descriptive Statistics

	group	Mean	Std. Deviation	N
tshpr	interval	1.7308	.65103	12
	continuous	1.7300	.66406	12
	Total	1.7304	.64313	24
tshpo	interval	1.5383	.63534	12
	continuous	1.7308	1.01776	12
	Total	1.6346	.83553	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.110	1	.110	.678	.419	.030	.678	.124
time * group	.112	1	.112	.690	.415	.030	.690	.125
Error(time)	3.576	22	.163					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	135.879	1	135.879	137.306	.000	.862	137.306	1.000
group	.110	1	.110	.111	.742	.005	.111	.062
Error	21.771	22	.990					

Additional Tests

C-Peptide

Descriptive Statistics

	group	Mean	Std. Deviation	N
cpeptpr	interval	.5873	.19147	11
	continuous	.6660	.21386	10
	Total	.6248	.20134	21
cpeptpo	interval	.5355	.23088	11
	continuous	.6290	.31157	10
	Total	.5800	.26950	21

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.021	1	.021	.514	.482	.026	.514	.105
time * group	.001	1	.001	.014	.906	.001	.014	.051
Error(time)	.764	19	.040					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	15.309	1	15.309	204.695	.000	.915	204.695	1.000
group	.078	1	.078	1.039	.321	.052	1.039	.162
Error	1.421	19	.075					

HA1-c

Descriptive Statistics

	group	Mean	Std. Deviation	N
ha1cpr	interval	5.4917	.62879	12
	continuous	5.3800	.36757	10
	Total	5.4409	.51793	22
ha1cpo	interval	5.3333	.49970	12
	continuous	5.2700	.28694	10
	Total	5.3045	.40880	22

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.196	1	.196	4.011	.059	.167	4.011	.479
time * group	.006	1	.006	.130	.722	.006	.130	.064
Error(time)	.979	20	.049					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1257.752	1	1257.752	3115.657	.000	.994	3115.657	1.000
group	.084	1	.084	.207	.654	.010	.207	.072
Error	8.074	20	.404					

IGF

Descriptive Statistics

	group	Mean	Std. Deviation	N
igfpr	interval	15.0000	3.52136	11
	continuous	11.9091	2.80908	11
	Total	13.4545	3.48776	22
igfpo	interval	14.7273	3.63568	11
	continuous	17.0000	7.02851	11
	Total	15.8636	5.58310	22

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	63.841	1	63.841	6.036	.023	.232	6.036	.647
time * group	79.114	1	79.114	7.480	.013	.272	7.480	.739
Error(time)	211.545	20	10.577					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	9455.114	1	9455.114	306.216	.000	.939	306.216	1.000
group	1.841	1	1.841	.060	.810	.003	.060	.056
Error	617.545	20	30.877					

CRP

Descriptive Statistics

	group	Mean	Std. Deviation	N
creactpr	interval	4.6967	2.27206	12
	continuous	9.6264	9.37729	11
	Total	7.0543	6.99218	23
creactpo	interval	4.0233	1.99686	12
	continuous	6.8573	5.95212	11
	Total	5.3787	4.49359	23

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	34.005	1	34.005	3.267	.085	.135	3.267	.407
time * group	12.604	1	12.604	1.211	.284	.055	1.211	.183
Error(time)	218.578	21	10.408					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1822.815	1	1822.815	34.310	.000	.620	34.310	1.000
group	172.960	1	172.960	3.256	.086	.134	3.256	.406
Error	1115.681	21	53.128					

Fasting Insulin

Descriptive Statistics

	group	Mean	Std. Deviation	N
finsulpr	interval	5.7364	2.24823	11
	continuous	6.1545	2.33639	11
	Total	5.9455	2.24769	22
finsulpo	interval	3.9182	1.39558	11
	continuous	5.9182	2.46691	11
	Total	4.9182	2.20748	22

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	11.608	1	11.608	4.257	.052	.175	4.257	.502
time * group	6.881	1	6.881	2.523	.128	.112	2.523	.328
Error(time)	54.541	20	2.727					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1298.205	1	1298.205	198.313	.000	.908	198.313	1.000
group	16.081	1	16.081	2.457	.133	.109	2.457	.320
Error	130.925	20	6.546					

Body Composition

BMI

Descriptive Statistics

	group	Mean	Std. Deviation	N
bmipr	interval	32.4917	3.75396	12
	continuous	33.9386	4.98658	14
	Total	33.2708	4.43531	26
bmipo	interval	29.3493	3.67703	12
	continuous	31.0250	4.56777	14
	Total	30.2516	4.18622	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	118.488	1	118.488	71.142	.000	.748	71.142	1.000
time * group	.169	1	.169	.102	.753	.004	.102	.061
Error(time)	39.973	24	1.666					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	51948.760	1	51948.760	1452.663	.000	.984	1452.663	1.000
group	31.503	1	31.503	.881	.357	.035	.881	.147
Error	858.265	24	35.761					

Body Weight

Descriptive Statistics

	group	Mean	Std. Deviation	N
weightpr	interval	87.5767	10.69407	12
	continuous	93.1171	17.70983	14
	Total	90.5600	14.87769	26
weightpo	interval	79.1567	9.17765	12
	continuous	85.4329	18.04334	14
	Total	82.5362	14.71510	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	837.894	1	837.894	74.951	.000	.757	74.951	1.000
time * group	1.749	1	1.749	.156	.696	.006	.156	.067
Error(time)	268.300	24	11.179					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	385174.182	1	385174.182	904.004	.000	.974	904.004	1.000
group	451.124	1	451.124	1.059	.314	.042	1.059	.167
Error	10225.822	24	426.076					

Fat

Descriptive Statistics

	group	Mean	Std. Deviation	N
fatpr	interval	37680.6667	7729.53440	12
	continuous	41660.1429	7915.46776	14
	Total	39823.4615	7934.83289	26
fatpo	interval	29180.6667	8082.55502	12
	continuous	34382.8571	8133.82563	14
	Total	31981.8462	8375.05925	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	804211943.8	1	804211943.80	114.8	.000	.827	114.883	1.000
time * group	4830097.6	1	4830097.648	.690	.414	.028	.690	.125
Error(time)	168007044.4	24	7000293.518					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	65977633568	1	65977633568	549.36	.000	.958	549.360	1.000
group	272363547.4	1	272363547.4	2.26	.145	.086	2.268	.304
Error	2882379070.3	24	120099127.9					

Lean

Descriptive Statistics

	group	Mean	Std. Deviation	N
leanpr	interval	46781.0833	7986.21693	12
	continuous	47069.9286	11567.88506	14
	Total	46936.6154	9882.75853	26
leanpo	interval	46755.5000	8249.91577	12
	continuous	46904.5714	11452.76887	14
	Total	46835.7692	9907.51774	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	117788.242	1	117788.242	.064	.803	.003	.064	.057
time * group	63118.627	1	63118.627	.034	.855	.001	.034	.054
Error(time)	44493867.065	24	1853911.128					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	113595159050	1	113595159050	562.060	.000	.959	562.060	1.000
group	619567.869	1	619567.869	.003	.956	.000	.003	.050
Error	4850519049	24	202104960.38					

% Body Fat

Descriptive Statistics

	group	Mean	Std. Deviation	N
bodfatpr	interval	44.5500	7.13512	12
	continuous	47.3357	4.57310	14
	Total	46.0500	5.93978	26
bodfatpo	interval	38.2917	8.78102	12
	continuous	42.3786	5.06317	14
	Total	40.4923	7.18153	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	406.388	1	406.388	98.417	.000	.804	98.417	1.000
time * group	5.470	1	5.470	1.325	.261	.052	1.325	.197
Error(time)	99.102	24	4.129					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	96197.952	1	96197.952	1206.110	.000	.980	1206.110	1.000
group	152.599	1	152.599	1.913	.179	.074	1.913	.264
Error	1914.213	24	79.759					

Android

Descriptive Statistics

	group	Mean	Std. Deviation	N
androipr	interval	51.7500	6.65603	12
	continuous	54.1500	4.00975	14
	Total	53.0423	5.41688	26
androipo	interval	72.9667	98.03314	12
	continuous	47.5429	5.36294	14
	Total	59.2769	66.41262	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	689.570	1	689.570	.310	.583	.013	.310	.083
time * group	2501.146	1	2501.146	1.126	.299	.045	1.126	.175
Error(time)	53312.123	24	2221.338					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	165613.342	1	165613.342	74.331	.000	.756	74.331	1.000
group	1712.617	1	1712.617	.769	.389	.031	.769	.134
Error	53473.583	24	2228.066					

Gynoid

Descriptive Statistics

	group	Mean	Std. Deviation	N
gynoidpr	interval	49.8417	8.16450	12
	continuous	51.7429	5.77298	14
	Total	50.8654	6.89887	26
gynoidpo	interval	44.5583	9.34719	12
	continuous	47.6857	6.55813	14
	Total	46.2423	7.95835	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	281.867	1	281.867	98.965	.000	.805	98.965	1.000
time * group	4.858	1	4.858	1.706	.204	.066	1.706	.241
Error(time)	68.355	24	2.848					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	121378.433	1	121378.433	1112.571	.000	.979	1112.571	1.000
group	81.695	1	81.695	.749	.395	.030	.749	.132
Error	2618.334	24	109.097					

Trunk to Total Ratio

Descriptive Statistics

	group	Mean	Std. Deviation	N
trunkpr	interval	.5408	.03872	12
	continuous	.5400	.04489	14
	Total	.5404	.04133	26
trunkpo	interval	.5183	.03713	12
	continuous	.5264	.04971	14
	Total	.5227	.04369	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.004	1	.004	26.738	.000	.527	26.738	.999
time * group	.000	1	.000	1.638	.213	.064	1.638	.233
Error(time)	.004	24	.000					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	14.597	1	14.597	4063.854	.000	.994	4063.854	1.000
group	.000	1	.000	.047	.829	.002	.047	.055
Error	.086	24	.004					

Leg to Total Ratio

Descriptive Statistics

	group	Mean	Std. Deviation	N
legpr	interval	.3300	.04306	12
	continuous	.3457	.04274	14
	Total	.3385	.04277	26
legpo	interval	.3517	.03713	12
	continuous	.3493	.04599	14
	Total	.3504	.04133	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.002	1	.002	5.230	.031	.179	5.230	.593
time * group	.001	1	.001	2.688	.114	.101	2.688	.350
Error(time)	.009	24	.000					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	6.123	1	6.123	1899.624	.000	.988	1899.624	1.000
group	.001	1	.001	.178	.677	.007	.178	.069
Error	.077	24	.003					

Arm + Leg to Total Ratio

Descriptive Statistics

	group	Mean	Std. Deviation	N
armlegpr	interval	.8133	.13228	12
	continuous	.8221	.14911	14
	Total	.8181	.13885	26
armlegpo	interval	.8825	.13438	12
	continuous	.8636	.17216	14
	Total	.8723	.15314	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.040	1	.040	20.968	.000	.466	20.968	.992
time * group	.002	1	.002	1.319	.262	.052	1.319	.197
Error(time)	.045	24	.002					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	36.943	1	36.943	869.072	.000	.973	869.072	1.000
group	.000	1	.000	.008	.930	.000	.008	.051
Error	1.020	24	.043					

Aerobic Fitness

VO_{2peak}

Descriptive Statistics

	group	Mean	Std. Deviation	N
vo2maxpr	interval	27.2991	5.46324	11
	continuous	25.5423	3.76120	13
	Total	26.3475	4.59971	24
vo2maxpo	interval	31.4909	6.77653	11
	continuous	29.2192	3.83170	13
	Total	30.2604	5.38171	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	184.461	1	184.461	44.330	.000	.668	44.330	1.000
time * group	.790	1	.790	.190	.667	.009	.190	.070
Error(time)	91.544	22	4.161					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	38413.232	1	38413.232	835.002	.000	.974	835.002	1.000
group	48.347	1	48.347	1.051	.316	.046	1.051	.165
Error	1012.082	22	46.004					

Exercise Time

Descriptive Statistics

	group	Mean	Std. Deviation	N
timepr	interval	14.9400	4.22297	11
	continuous	14.9831	3.53514	13
	Total	14.9633	3.77815	24
timepo	interval	19.6209	4.24615	11
	continuous	19.5662	3.31875	13
	Total	19.5913	3.68596	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	255.676	1	255.676	112.429	.000	.836	112.429	1.000
time * group	.029	1	.029	.013	.912	.001	.013	.051
Error(time)	50.030	22	2.274					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	14229.130	1	14229.130	529.916	.000	.960	529.916	1.000
group	.000	1	.000	.000	.997	.000	.000	.050
Error	590.737	22	26.852					

Resting Heart Rate

Descriptive Statistics

	group	Mean	Std. Deviation	N
resthrpr	interval	77.5000	11.35537	10
	continuous	74.0000	13.45362	13
	Total	75.5217	12.43481	23
resthrpo	interval	76.5000	8.98455	10
	continuous	76.6154	11.50752	13
	Total	76.5652	10.25948	23

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	7.375	1	7.375	.103	.752	.005	.103	.061
time * group	36.940	1	36.940	.515	.481	.024	.515	.105
Error(time)	1506.538	21	71.740					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	262234.114	1	262234.114	1329.679	.000	.984	1329.679	1.000
group	32.375	1	32.375	.164	.689	.008	.164	.067
Error	4141.538	21	197.216					

% Heart Rate Max

Descriptive Statistics

	group	Mean	Std. Deviation	N
hrperpr	interval	100.3000	5.81282	10
	continuous	97.7692	8.88026	13
	Total	98.8696	7.64737	23
hrperpo	interval	98.8000	5.59365	10
	continuous	97.0000	9.06458	13
	Total	97.7826	7.64530	23

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	14.553	1	14.553	.919	.349	.042	.919	.150
time * group	1.509	1	1.509	.095	.761	.005	.095	.060
Error(time)	332.404	21	15.829					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	438419.266	1	438419.266	4212.476	.000	.995	4212.476	1.000
group	53.005	1	53.005	.509	.483	.024	.509	.105
Error	2185.604	21	104.076					

Systolic Blood Pressure

Descriptive Statistics

	group	Mean	Std. Deviation	N
bpsystpr	interval	123.6364	18.76845	11
	continuous	112.7692	13.34262	13
	Total	117.7500	16.63221	24
bpsystpo	interval	118.3636	14.64427	11
	continuous	114.7692	15.56788	13
	Total	116.4167	14.93440	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	31.909	1	31.909	.215	.648	.010	.215	.073
time * group	157.576	1	157.576	1.061	.314	.046	1.061	.167
Error(time)	3267.091	22	148.504					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	656806.051	1	656806.051	1940.964	.000	.989	1940.964	1.000
group	623.051	1	623.051	1.841	.189	.077	1.841	.255
Error	7444.615	22	338.392					

Diastolic Blood Pressure

Descriptive Statistics

	group	Mean	Std. Deviation	N
bpdiaspr	interval	81.7273	12.60231	11
	continuous	77.1538	7.61409	13
	Total	79.2500	10.23315	24
bpdiapo	interval	76.2727	8.87796	11
	continuous	79.2308	6.40513	13
	Total	77.8750	7.61185	24

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	33.987	1	33.987	1.039	.319	.045	1.039	.164
time * group	168.987	1	168.987	5.165	.033	.190	5.165	.584
Error(time)	719.825	22	32.719					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	294453.941	1	294453.941	2277.342	.000	.990	2277.342	1.000
group	7.774	1	7.774	.060	.809	.003	.060	.056
Error	2844.538	22	129.297					

RPE

Descriptive Statistics

	group	Mean	Std. Deviation	N
rpepre	interval	17.7000	2.40601	10
	continuous	17.5000	1.89297	13
	Total	17.5870	2.08159	23
rpepost	interval	17.8500	2.00069	10
	continuous	17.9231	1.69369	13
	Total	17.8913	1.78985	23

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.928	1	.928	1.447	.242	.064	1.447	.209
time * group	.211	1	.211	.328	.573	.015	.328	.085
Error(time)	13.474	21	.642					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	14235.502	1	14235.502	1965.789	.000	.989	1965.789	1.000
group	.046	1	.046	.006	.938	.000	.006	.051
Error	152.074	21	7.242					

Resting Metabolic Rate

BMR

Descriptive Statistics

	group	Mean	Std. Deviation	N
bmrpr	interval	1488.0958	256.13918	12
	continuous	1379.0779	415.76660	14
	Total	1429.3938	349.03749	26
bmrpo	interval	1433.9475	239.52604	12
	continuous	1425.2200	283.00665	14
	Total	1429.2481	258.67339	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	207.089	1	207.089	.003	.954	.000	.003	.050
time * group	32495.657	1	32495.657	.544	.468	.022	.544	.109
Error(time)	1434498.943	24	59770.789					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	105940100.31	1	105940100.3	792.893	.000	.971	792.893	1.000
group	44791.375	1	44791.375	.335	.568	.014	.335	.086
Error	3206691.269	24	133612.136					

RQ

Descriptive Statistics

	group	Mean	Std. Deviation	N
rqpre	interval	.7875	.09067	12
	continuous	.7464	.07344	14
	Total	.7654	.08281	26
rqpost	interval	.8325	.05429	12
	continuous	.7679	.07648	14
	Total	.7977	.07361	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.014	1	.014	3.904	.060	.140	3.904	.475
time * group	.002	1	.002	.492	.490	.020	.492	.103
Error(time)	.088	24	.004					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	31.738	1	31.738	4199.770	.000	.994	4199.770	1.000
group	.036	1	.036	4.778	.039	.166	4.778	.555
Error	.181	24	.008					

VO_2

Descriptive Statistics

	group	Mean	Std. Deviation	N
vo2pr	interval	.2142	.03728	12
	continuous	.2014	.06037	14
	Total	.2073	.05048	26
vo2po	interval	.2075	.03441	12
	continuous	.2071	.03911	14
	Total	.2073	.03628	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	2.93E-006	1	2.93E-006	.002	.961	.000	.002	.050
time * group	.000	1	.000	.413	.527	.017	.413	.095
Error(time)	.029	24	.001					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	2.227	1	2.227	800.474	.000	.971	800.474	1.000
group	.001	1	.001	.199	.659	.008	.199	.071
Error	.067	24	.003					

VCO_2

Descriptive Statistics

	group	Mean	Std. Deviation	N
vco2pre	interval	.1708	.03704	12
	continuous	.1507	.05091	14
	Total	.1600	.04534	26
vco2pos	interval	.1733	.03172	12
	continuous	.1614	.03800	14
	Total	.1669	.03507	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.001	1	.001	.536	.471	.022	.536	.108
time * group	.000	1	.000	.207	.653	.009	.207	.072
Error(time)	.025	24	.001					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	1.392	1	1.392	625.877	.000	.963	625.877	1.000
group	.003	1	.003	1.490	.234	.058	1.490	.216
Error	.053	24	.002					

CHO and Lipids

Descriptive Statistics

	group	Mean	Std. Deviation	N
chopr	interval	30.8167	27.81000	12
	continuous	17.7500	21.82485	14
	Total	23.7808	25.14184	26
chopo	interval	44.4083	18.77941	12
	continuous	24.2000	23.78383	14
	Total	33.5269	23.55571	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	1297.698	1	1297.698	3.668	.067	.133	3.668	.452
time * group	164.780	1	164.780	.466	.501	.019	.466	.100
Error(time)	8490.582	24	353.774					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	44358.399	1	44358.399	61.037	.000	.718	61.037	1.000
group	3577.190	1	3577.190	4.922	.036	.170	4.922	.567
Error	17442.039	24	726.752					

Girth

Waist Circumference

Descriptive Statistics

	group	Mean	Std. Deviation	N
waistpr	interval	97.4750	7.02801	12
	continuous	101.5929	12.37382	14
	Total	99.6923	10.28268	26
waistpo	interval	89.7750	6.01092	12
	continuous	95.7571	13.49283	14
	Total	92.9962	10.94607	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	591.927	1	591.927	47.027	.000	.662	47.027	1.000
time * group	11.229	1	11.229	.892	.354	.036	.892	.148
Error(time)	302.086	24	12.587					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	477886.209	1	477886.209	2295.754	.000	.990	2295.754	1.000
group	329.571	1	329.571	1.583	.220	.062	1.583	.227
Error	4995.863	24	208.161					

Hip Circumference

Descriptive Statistics

	group	Mean	Std. Deviation	N
hippr	interval	115.0083	8.05340	12
	continuous	118.7071	8.72057	14
	Total	117.0000	8.46277	26
hippo	interval	108.1083	8.40924	12
	continuous	111.5571	8.53263	14
	Total	109.9654	8.48811	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	637.762	1	637.762	86.103	.000	.782	86.103	1.000
time * group	.202	1	.202	.027	.870	.001	.027	.053
Error(time)	177.768	24	7.407					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	664098.469	1	664098.469	4906.173	.000	.995	4906.173	1.000
group	165.055	1	165.055	1.219	.280	.048	1.219	.185
Error	3248.634	24	135.360					

Waist to Hip Ratio

Descriptive Statistics

	group	Mean	Std. Deviation	N
wtohpr	interval	.849158	.0565550	12
	continuous	.855443	.0745029	14
	Total	.852542	.0656040	26
wtohpo	interval	.832567	.0482145	12
	continuous	.856171	.0733998	14
	Total	.845277	.0629950	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	.001	1	.001	1.281	.269	.051	1.281	.192
time * group	.001	1	.001	1.527	.228	.060	1.527	.221
Error(time)	.015	24	.001					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	37.202	1	37.202	4756.224	.000	.995	4756.224	1.000
group	.003	1	.003	.369	.549	.015	.369	.090
Error	.188	24	.008					

Questionnaires

SF-36: Physical Function

Descriptive Statistics

	group	Mean	Std. Deviation	N
pfpr	interval	70.4167	27.34114	12
	continuous	67.1429	20.72849	14
	Total	68.6538	23.56089	26
pfpo	interval	90.8333	11.04399	12
	continuous	90.7143	6.46206	14
	Total	90.7692	8.68243	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	6251.385	1	6251.385	30.327	.000	.558	30.327	1.000
time * group	32.154	1	32.154	.156	.696	.006	.156	.067
Error(time)	4947.173	24	206.132					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	328987.191	1	328987.191	734.758	.000	.968	734.758	1.000
group	37.191	1	37.191	.083	.776	.003	.083	.059
Error	10745.982	24	447.749					

SF-36: Role Physical

Descriptive Statistics

	group	Mean	Std. Deviation	N
rppr	interval	81.2500	24.13268	12
	continuous	66.0714	30.39348	14
	Total	73.0769	28.21620	26
rppo	interval	95.8333	9.73124	12
	continuous	94.6429	20.04459	14
	Total	95.1923	15.84177	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	6016.770	1	6016.770	9.127	.006	.276	9.127	.826
time * group	632.154	1	632.154	.959	.337	.038	.959	.156
Error(time)	15822.173	24	659.257					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	368654.132	1	368654.132	998.850	.000	.977	998.850	1.000
group	865.671	1	865.671	2.345	.139	.089	2.345	.313
Error	8857.887	24	369.079					

SF-36: Bodily Pain

Descriptive Statistics

	group	Mean	Std. Deviation	N
bppr	interval	67.3333	24.83155	12
	continuous	66.0000	22.68853	14
	Total	66.6154	23.22598	26
bppo	interval	75.9167	16.48392	12
	continuous	84.0714	14.36055	14
	Total	80.3077	15.61991	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	2295.385	1	2295.385	9.006	.006	.273	9.006	.821
time * group	290.847	1	290.847	1.141	.296	.045	1.141	.177
Error(time)	6116.923	24	254.872					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	277967.180	1	277967.180	512.083	.000	.955	512.083	1.000
group	150.334	1	150.334	.277	.604	.011	.277	.080
Error	13027.589	24	542.816					

SF-36: General Health

Descriptive Statistics

	group	Mean	Std. Deviation	N
ghpr	interval	68.5000	22.89700	12
	continuous	62.7143	15.19832	14
	Total	65.3846	18.95907	26
ghpo	interval	80.7500	16.11394	12
	continuous	79.4286	13.55737	14
	Total	80.0385	14.50098	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	2710.389	1	2710.389	23.693	.000	.497	23.693	.997
time * group	64.389	1	64.389	.563	.460	.023	.563	.111
Error(time)	2745.554	24	114.398					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	274323.960	1	274323.960	584.187	.000	.961	584.187	1.000
group	163.191	1	163.191	.348	.561	.014	.348	.087
Error	11269.982	24	469.583					

SF-36: Vitality

Descriptive Statistics

	group	Mean	Std. Deviation	N
vpr	interval	56.8333	26.87288	12
	continuous	43.9286	20.01716	14
	Total	49.8846	23.85678	26
vpo	interval	71.2500	18.47910	12
	continuous	71.0714	18.31126	14
	Total	71.1538	18.01709	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	5580.165	1	5580.165	21.341	.000	.471	21.341	.993
time * group	523.242	1	523.242	2.001	.170	.077	2.001	.274
Error(time)	6275.315	24	261.471					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	190904.561	1	190904.561	305.601	.000	.927	305.601	1.000
group	553.022	1	553.022	.885	.356	.036	.885	.148
Error	14992.458	24	624.686					

SF-36: Social Function

Descriptive Statistics

	group	Mean	Std. Deviation	N
sfpr	interval	81.0417	17.53109	12
	continuous	67.8571	26.72612	14
	Total	73.9423	23.48588	26
sfpo	interval	86.4583	18.81303	12
	continuous	88.3929	14.26424	14
	Total	87.5000	16.20185	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	2176.007	1	2176.007	9.336	.005	.280	9.336	.834
time * group	738.507	1	738.507	3.169	.088	.117	3.169	.401
Error(time)	5593.824	24	233.076					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	338630.048	1	338630.048	597.102	.000	.961	597.102	1.000
group	408.894	1	408.894	.721	.404	.029	.721	.129
Error	13610.938	24	567.122					

SF-36: Role Emotional

Descriptive Statistics

	group	Mean	Std. Deviation	N
repr	interval	72.9167	31.23942	12
	continuous	61.8786	34.33599	14
	Total	66.9731	32.77113	26
repo	interval	85.0083	26.20342	12
	continuous	78.3571	33.52062	14
	Total	81.4269	29.96389	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	2637.143	1	2637.143	3.156	.088	.116	3.156	.400
time * group	62.176	1	62.176	.074	.787	.003	.074	.058
Error(time)	20054.296	24	835.596					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	287214.776	1	287214.776	244.723	.000	.911	244.723	1.000
group	1010.943	1	1010.943	.861	.363	.035	.861	.145
Error	28167.127	24	1173.630					

SF-36: Mental Health

Descriptive Statistics

	group	Mean	Std. Deviation	N
mhpr	interval	79.6667	10.15635	12
	continuous	65.1429	15.95598	14
	Total	71.8462	15.24124	26
mhpo	interval	82.3333	8.77324	12
	continuous	77.1429	16.41227	14
	Total	79.5385	13.44985	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	694.974	1	694.974	10.088	.004	.296	10.088	.861
time * group	281.436	1	281.436	4.085	.055	.145	4.085	.492
Error(time)	1653.333	24	68.889					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	299136.264	1	299136.264	1005.58	.000	.977	1005.581	1.000
group	1255.648	1	1255.648	4.221	.051	.150	4.221	.505
Error	7139.429	24	297.476					

HADS: Anxiety

Descriptive Statistics

	group	Mean	Std. Deviation	N
anxietpr	interval	6.5000	2.96954	12
	continuous	8.1429	4.80156	14
	Total	7.3846	4.07015	26
anxietpo	interval	5.8333	2.62274	12
	continuous	5.5714	3.91672	14
	Total	5.6923	3.31987	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	33.875	1	33.875	6.716	.016	.219	6.716	.701
time * group	11.722	1	11.722	2.324	.140	.088	2.324	.310
Error(time)	121.048	24	5.044					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	2192.007	1	2192.007	95.519	.000	.799	95.519	1.000
group	6.161	1	6.161	.268	.609	.011	.268	.079
Error	550.762	24	22.948					

HADS: Depression

Descriptive Statistics

	group	Mean	Std. Deviation	N
deprespr	interval	4.5000	3.45096	12
	continuous	5.5714	4.18264	14
	Total	5.0769	3.82542	26
deprespo	interval	2.2500	2.30119	12
	continuous	1.5714	1.34246	14
	Total	1.8846	1.84015	26

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	126.202	1	126.202	21.771	.000	.476	21.771	.994
time * group	9.894	1	9.894	1.707	.204	.066	1.707	.241
Error(time)	139.125	24	5.797					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	623.576	1	623.576	49.723	.000	.674	49.723	1.000
group	.499	1	.499	.040	.844	.002	.040	.054
Error	300.982	24	12.541					

OA-ESI: Work Activity

Descriptive Statistics

	group	Mean	Std. Deviation	N
workpr	interval	2346.0000	3854.94280	11
	continuous	2039.8182	1876.46502	11
	Total	2192.9091	2962.72606	22
workpo	interval	590.4545	673.57425	11
	continuous	1782.2727	1945.41688	11
	Total	1186.3636	1546.05272	22

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	11144471.27	1	11144471.27	3.100	.094	.134	3.100	.388
time * group	6171011.00	1	6171011.00	1.716	.205	.079	1.716	.239
Error(time)	71907435.72	20	3595371.78					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	125614325.81	1	125614325.81	16.283	.001	.449	16.283	.970
group	2156967.36	1	2156967.36	.280	.603	.014	.280	.080
Error	154293104.81	20	7714655.24					

OA-ESI: Leisure Activity

Descriptive Statistics

	group	Mean	Std. Deviation	N
leisurpr	interval	292.2727	416.84148	11
	continuous	578.7273	724.90952	11
	Total	435.5000	595.37165	22
leisurpo	interval	640.3636	577.77284	11
	continuous	839.0909	1535.04531	11
	Total	739.7273	1136.39079	22

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	1018096.568	1	1018096.568	1.424	.247	.066	1.424	.206
time * group	21164.205	1	21164.205	.030	.865	.001	.030	.053
Error(time)	14299627.72	20	714981.386					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	15192750.56	1	15192750.568	15.507	.001	.437	15.507	.963
group	647353.84	1	647353.841	.661	.426	.032	.661	.121
Error	19594734.09	20	979736.705					

OA-ESI: Overall Activity Level

Descriptive Statistics

	group	Mean	Std. Deviation	N
totalactpre	interval	2660.0909	3827.18096	11
	continuous	2618.5455	1994.56097	11
	Total	2639.3182	2978.21750	22
totalactpos	interval	1209.0000	840.81924	11
	continuous	2621.3636	2519.06341	11
	Total	1915.1818	1969.98689	22

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	5768108.20	1	5768108.205	1.404	.250	.066	1.404	.204
time * group	5813092.02	1	5813092.023	1.415	.248	.066	1.415	.205
Error(time)	82184612.27	20	4109230.614					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	228178172.75	1	228178172.7	26.138	.000	.567	26.138	.998
group	5167641.841	1	5167641.841	.592	.451	.029	.592	.113
Error	174597837.90	20	8729891.895					

Vascular Function

%FMD

Descriptive Statistics

	group	Mean	Std. Deviation	N
fmdpre	interval	13.1232	8.75858	5
	continuous	11.9825	3.55023	8
	Total	12.4212	5.76689	13
fmdpost	interval	12.9820	10.07030	5
	continuous	10.2400	3.98106	8
	Total	11.2946	6.70646	13

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	5.459	1	5.459	.118	.738	.011	.118	.061
time * group	3.945	1	3.945	.085	.776	.008	.085	.058
Error(time)	510.051	11	46.368					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	3593.179	1	3593.179	98.415	.000	.899	98.415	1.000
group	23.193	1	23.193	.635	.442	.055	.635	.113
Error	401.615	11	36.510					

%GTN

Descriptive Statistics

	group	Mean	Std. Deviation	N
gtnpre	1.00	23.8780	4.98300	5
	2.00	22.7029	8.05586	7
	Total	23.1925	6.69280	12
gtnpost	1.00	30.4214	12.59983	5
	2.00	20.8600	4.75527	7
	Total	24.8439	9.71102	12

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	32.223	1	32.223	.557	.473	.053	.557	.104
time * group	102.565	1	102.565	1.773	.213	.151	1.773	.226
Error(time)	578.370	10	57.837					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	13966.500	1	13966.500	205.079	.000	.954	205.079	1.000
group	168.108	1	168.108	2.468	.147	.198	2.468	.296
Error	681.030	10	68.103					

Diary

Adherence

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
adherenc	interval	12	87.6667	15.45506	4.46149
	continuous	13	92.9000	9.51367	2.63862

Pedometer: Total Steps

Descriptive Statistics

	group	Mean	Std. Deviation	N
totalpre	interval	76920.4000	30602.73080	10
	continuous	66656.5227	15719.73141	11
	Total	71544.0833	23928.70901	21
totalpos	interval	81037.0000	30795.56459	10
	continuous	73969.9818	31333.16998	11
	Total	77335.2286	30507.85264	21

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	342168752.15	1	342168752.1	1.608	.220	.078	1.608	.226
time * group	26766425.83	1	26766425.8	.126	.727	.007	.126	.063
Error(time)	4043650271.9	19	212823698.5					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	233494244902	1	233494244902	175.98	.000	.903	175.983	1.000
group	786656978	1	786656978	.593	.451	.030	.593	.113
Error	25209170074	19	1326798424					

Pedometer: Exercise Steps

Descriptive Statistics

	group	Mean	Std. Deviation	N
exerpre	interval	21960.7500	5820.56963	8
	continuous	19015.2000	3773.00711	10
	Total	20324.3333	4873.90794	18
exerpos	interval	23901.5000	3729.41363	8
	continuous	20408.7000	2991.45933	10
	Total	21961.0556	3695.14639	18

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	24704940.13	1	24704940.13	3.914	.065	.197	3.914	.460
time * group	665516.806	1	665516.80	.105	.750	.007	.105	.061
Error(time)	101000628.0	16	6312539.25					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	16163838626.27	1	16163838626	584.889	.000	.973	584.889	1.000
group	92116334.93	1	92116334.939	3.333	.087	.172	3.333	.404
Error	442171973.20	16	27635748.325					

Pedometer: Incidental Steps

Descriptive Statistics

	group	Mean	Std. Deviation	N
incidpre	interval	60253.5000	30050.74865	8
	continuous	47953.1000	14994.69132	10
	Total	53419.9444	23031.10825	18
incidpos	interval	65607.8750	27216.74812	8
	continuous	56504.2000	30516.33459	10
	Total	60550.2778	28630.32279	18

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	429693855.50	1	429693855.5	2.311	.148	.126	2.311	.298
time * group	22709001.61	1	22709001.61	.122	.731	.008	.122	.062
Error(time)	2974981842.3	16	185936365.1					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	117881537897.2	1	117881537897	99.602	.000	.862	99.602	1.000
group	1018076503.56	1	1018076503.5	.860	.367	.051	.860	.141
Error	18936397264.98	16	1183524829.0					

Accelerometer

Energy Expenditure

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	caloriespre	384.0940	5	212.36142	94.97091
	caloriespos	292.7120	5	216.93047	97.01425

Steps

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	stepspre	12565.0000	5	1366.92172	611.30598
	stepspost	10030.2000	5	3424.05997	1531.28617

Activity Levels

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	lightpre	1394.0000	5	24.69818	11.04536
	lightpost	1397.0000	5	34.61936	15.48225
Pair 2	modpre	42.2000	5	24.92388	11.14630
	modpost	40.8000	5	33.81124	15.12085
Pair 3	hardpre	2.8000	5	2.94958	1.31909
	hardpost	1.4000	5	1.34164	.60000
Pair 4	vhardpre	.6000	5	1.34164	.60000
	vhardpost	.4000	5	.89443	.40000

Food Diary

Weight

Descriptive Statistics

	group	Mean	Std. Deviation	N
weightpr	interval	1056.7460	149.68010	10
	continuous	1090.3636	199.69610	11
	Total	1074.3552	174.11811	21
weightpo	interval	1233.5610	547.75622	10
	continuous	1035.5118	194.55022	11
	Total	1129.8210	405.23364	21

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	38958.380	1	38958.380	.593	.451	.030	.593	.113
time * group	140563.015	1	140563.015	2.139	.160	.101	2.139	.284
Error(time)	1248288.224	19	65699.380					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	51078414.80	1	51078414.807	399.220	.000	.955	399.220	1.000
group	70813.111	1	70813.111	.553	.466	.028	.553	.109
Error	2430964.075	19	127945.478					

Energy Intake

Descriptive Statistics

	group	Mean	Std. Deviation	N
energypr	interval	4285.9840	711.53717	10
	continuous	4419.8255	863.06393	11
	Total	4356.0914	777.79151	21
energypo	interval	5356.9210	2540.73894	10
	continuous	4121.0927	720.28932	11
	Total	4709.5824	1887.94002	21

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	1561736.625	1	1561736.625	1.482	.238	.072	1.482	.212
time * group	4913320.662	1	4913320.662	4.662	.044	.197	4.662	.536
Error(time)	20025714.98	19	1053984.999					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	865991828.71	1	865991828.71	297.721	.000	.940	297.721	1.000
group	3180505.815	1	3180505.815	1.093	.309	.054	1.093	.168
Error	55266001.064	19	2908736.898					

Proteins

Descriptive Statistics

	group	Mean	Std. Deviation	N
proteipr	interval	74.7490	14.44189	10
	continuous	70.5245	25.91219	11
	Total	72.5362	20.83868	21
proteipo	interval	84.1670	22.08118	10
	continuous	64.2045	23.56446	11
	Total	73.7105	24.52389	21

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	25.137	1	25.137	.320	.578	.017	.320	.084
time * group	648.698	1	648.698	8.247	.010	.303	8.247	.778
Error(time)	1494.585	19	78.662					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	225833.770	1	225833.770	251.840	.000	.930	251.840	1.000
group	1532.160	1	1532.160	1.709	.207	.083	1.709	.237
Error	17037.993	19	896.736					

Carbohydrates

Descriptive Statistics

	group	Mean	Std. Deviation	N
chopre	interval	72.4790	12.89090	10
	continuous	75.1882	17.93371	11
	Total	73.8981	15.41136	21
chopo	interval	101.2200	59.23129	10
	continuous	82.6782	27.36933	11
	Total	91.5076	45.20330	21

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	3437.985	1	3437.985	4.983	.038	.208	4.983	.563
time * group	1182.775	1	1182.775	1.714	.206	.083	1.714	.238
Error(time)	13108.483	19	689.920					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	287926.546	1	287926.546	178.375	.000	.904	178.375	1.000
group	656.523	1	656.523	.407	.531	.021	.407	.093
Error	30669.186	19	1614.168					

Fat

Descriptive Statistics

	group	Mean	Std. Deviation	N
fatpr	interval	44.4700	11.31704	10
	continuous	48.0091	13.11753	11
	Total	46.3238	12.12226	21
fatpo	interval	51.3700	27.42595	10
	continuous	37.9518	11.52271	11
	Total	44.3414	21.26086	21

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	26.108	1	26.108	.182	.675	.009	.182	.069
time * group	753.105	1	753.105	5.236	.034	.216	5.236	.584
Error(time)	2732.570	19	143.819					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	86563.637	1	86563.637	199.645	.000	.913	199.645	1.000
group	255.610	1	255.610	.590	.452	.030	.590	.113
Error	8238.178	19	433.588					

Cholesterol

Descriptive Statistics

	group	Mean	Std. Deviation	N
cholpre	interval	277.4650	86.33453	10
	continuous	302.8218	130.04247	11
	Total	290.7471	109.44433	21
cholpo	interval	267.6300	96.39137	10
	continuous	272.7727	99.05951	11
	Total	270.3238	95.36458	21

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
time	4166.226	1	4166.226	1.134	.300	.056	1.134	.173
time * group	1070.168	1	1070.168	.291	.596	.015	.291	.081
Error(time)	69830.495	19	3675.289					

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	3289379.912	1	3289379.912	179.535	.000	.904	179.535	1.000
group	2436.296	1	2436.296	.133	.719	.007	.133	.064
Error	348112.337	19	18321.702					

Intermittent Interval Exercise vs Intermittent Steady-State Exercise

Post Hocs – Paired t-tests and Independent t-tests

General Biochemistry

Uric Acid

Paired Samples Test

group			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
interval	Pair 1	uricpr - uricp	-.00833	.06965	.02011	-.05259	.03592	-.414	11	.687
continuous	Pair 1	uricpr - uricp	.04667	.04849	.01400	.01586	.07748	3.334	11	.007

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
uricpo	Equal variances assumed	1.346	.259	1.091	22	.287	.04750	.04354	-.04279	.13779
	Equal variances not assumed			1.091	20.096	.288	.04750	.04354	-.04329	.13829

Lipids

VLDL

Paired Samples Test

group		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
interval	vldlpr - vldlpo	.41429	.34365	.12989	.09646	.73211	3.190	6	.019
continuous	vldlpr - vldlpo	.05000	.15119	.05345	-.07639	.17639	.935	7	.381

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
vldlpo	Equal variances assumed	2.275	.155	-.141	13	.890	-.03214	.22841	-.52560	.46132
	Equal variances not assumed			-.150	7.896	.885	-.03214	.21428	-.52740	.46311

Additional Tests

IGF

Paired Samples Test

group		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
interval	igfpr - igfpo	.27273	3.71728	1.12080	-2.22458	2.77003	.243	10	.813
continuous	igfpr - igfpo	-5.09091	5.33769	1.60937	-8.67682	-1.50500	-3.163	10	.010

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
igfpo	Equal variances assumed	.441	.514	-.953	20	.352	-2.27273	2.38591	-7.24965	2.70419
	Equal variances not assumed			-.953	14.994	.356	-2.27273	2.38591	-7.35835	2.81290

Aerobic Fitness

Diastolic Blood Pressure

Paired Samples Test

group		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
interval	bpdiaspr - bpdiapo	5.45455	8.57162	2.58444	-.30395	11.21304	2.111	10	.061
continuous	bpdiaspr - bpdiapo	-2.07692	7.66444	2.12573	-6.70850	2.55465	-.977	12	.348

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
bpdiapo	Equal variances assumed	2.589	.122	-.946	22	.354	-2.95804	3.12546	-9.43985	3.52377
	Equal variances not assumed			-.921	17.861	.369	-2.95804	3.21265	-9.71133	3.79524

Questionnaires

SF-36: Mental Health

Paired Samples Test

group		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
interval	mhpr - mhpo	-2.66667	9.69848	2.79971	-8.82879	3.49546	-.952	11	.361
continuous	mhpr - mhpo	-12.00000	13.22003	3.53320	-19.63302	-4.36698	-3.396	13	.005

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
mhpo	Equal variances assumed	3.956	.058	.980	24	.337	5.19048	5.29530	-5.73848	16.11943
	Equal variances not assumed			1.025	20.429	.317	5.19048	5.06501	-5.36074	15.74169

Diary
Adherence

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
adherenc	Equal variances assumed	3.422	.077	-1.029	23	.314	-5.23333	5.08674	15.75605	5.28939
	Equal variances not assumed			-1.010	18.020	.326	-5.23333	5.18336	16.12230	5.65563

Food Diary
Energy Intake

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
group		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
interval	energypr - energypo	-1070.94	1957.23051	618.93063	-2471.06	329.18136	-1.730	9	.118
continuous	energypr - energypo	298.73273	746.63704	225.11954	-202.865	800.33032	1.327	10	.214

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
energypo	Equal variances assumed	7.735	.012	1.367	20	.187	1063.3809	777.86156	-559.210	2685.972
	Equal variances not assumed			1.367	11.679	.197	1063.3809	777.86156	-636.618	2763.380

Proteins

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
group		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
interval	proteipr - proteipo	-9.41800	12.42049	3.92770	-18.30308	-.53292	-2.398	9	.040
continuous	proteipr - proteipo	6.32000	12.65209	3.81475	-2.17979	14.81979	1.657	10	.129

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
proteipo	Equal variances assumed	.306	.586	1.813	20	.085	17.71182	9.76926	-2.66651	38.09014
	Equal variances not assumed			1.813	19.933	.085	17.71182	9.76926	-2.67088	38.09452

Fat

Paired Samples Test

group		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
interval	fatpr - fatpo	-6.90000	20.43165	6.46106	-21.51592	7.71592	-1.068	9	.313
continuous	fatpr - fatpo	10.05727	13.06931	3.94054	1.27719	18.83735	2.552	10	.029

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
fatpo	Equal variances assumed	6.938	.016	1.327	20	.199	11.63091	8.76395	-6.65037	29.91219
	Equal variances not assumed			1.327	13.604	.206	11.63091	8.76395	-7.21739	30.47921

Cardiovascular Fitness Categories ($\dot{V}O_{2\ max}$ values in $ml/kg^{-1}/min^{-1}$)

Gender	Age	Poor	Fair	Average	Good	Excellent
Men	≤ 29	≤ 24.9	25-33.9	34-42.9	44-52.9	≥ 53
	30-39	≤ 22.9	23-30.9	31-41.9	42-49.9	≥ 50
	40-49	≤ 19.9	20-26.9	27-38.9	39-44.9	≥ 45
	50-59	≤ 17.9	18-24.9	25-37.9	38-42.9	≥ 43
	60-69	≤ 15.9	16-22.9	23-35.9	36-0.9	≥ 41
Women	≤ 29	≤ 23.9	24-30.9	31-38.9	39-48.9	≥ 49
	30-39	≤ 19.9	20-27.9	28-36.9	37-44.9	≥ 45
	40-49	≤ 16.9	17-24.9	25-34.9	35-41.9	≥ 42
	50-59	≤ 14.9	15-21.9	22-33.9	34-39.9	≥ 40
	60-69	≤12.9	13-20.9	21-32.9	33-36.9	≥ 37

Taken from: McArdle, W., Katch, F. & Katch, V. (2001). *Exercise Physiology: Energy, Nutrition and Human Performance.* (5th ed.). Philadelphia: Lippincott Williams & Wilkins.

SF-36 Profiles for BMI and Exercise Based on Australian Norms (mean score ± SEM).

	PF	RP	BP	GH	V	SF	RE	MH
BMI								
Acceptable	85.5±0.3	82.3±0.5	78.8±0.3	74.2±0.3	66.5±0.3	86.6±0.3	84.1±0.5	76.9±0.2
Overweight	80.8±0.5	77.1±0.8	74.3±0.6	69.8±0.5	62.8±0.5	83.6±0.5	81.3±0.8	75.2±0.4
Obese	73.8±0.9	73.7±1.4	71.1±0.9	64.5±0.8	59.1±0.8	81.3±0.9	80.0±1.3	74.3±0.7
Exercise								
Sedentary	77.1±0.4	75.1±0.6	73.4±0.5	67.0±0.4	60.8±0.4	81.6±0.4	79.9±0.6	73.8±0.3
Low	84.3±0.3	80.5±0.6	77.8±0.4	72.0±0.3	64.6±0.3	85.4±0.4	83.1±0.6	76.1±0.3
Moderate	86.6±0.4	84.4±0.7	79.9±0.5	75.2±0.4	68.3±0.4	88.0±0.4	85.5±0.6	80.6±0.6

Taken from: Australian Bureau of Statistics (2002). National Health Survey: Summary of Results, Australia (No. 4364.0). Canberra: Australian Bureau of Statistics.

HADS Scoring System

Anxiety or Depression Score	Category
0-7	Normal
8-10	Borderline Abnormal
11-21	Abnormal

Based on Snaith, R. & Zigmond, A. (1994). The hospital anxiety and depression scale with the irritability-depression-anxiety scale and the leeds situational anxiety scale: manual. England: Nfer-Nelson Publishing Company.