THE EFFECT OF A 10-WEEK TAE-BO INTERVENTION PROGRAM ON CARDIOMETABOLIC DISEASE RISK FACTORS IN OVERWEIGHT AND OBESE FEMALES AT THE UNIVERSITY OF ZULULAND

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ABSTRACT

Background and aims: The prevalence of obesity, sedentary life styles and associated cardiometabolic disease (CMD) risk are increasing among black African women and require urgent attention in the form of preventative strategies. To date, there is limited scientific evidence highlighting the efficacy of Tae-bo as an intervention for reducing CMD risk. Regular physical activity leads to significant changes in terms of the reduction of CMD risk. The present study was designed to investigate the effect of a 10-week Tae-bo intervention program on cardiometabolic disease risk factors in overweight and obese females.

Methods: Sixty previously sedentary participants who were overweight (BMI > 25–29.9 $kg.m^{-2}$) or obese (BMI ≥ 30–39.9 $kg.m^{-2}$) were recruited for the study. Participants performed a 10-week aerobic (Tae-bo) program 60 min/day for three days a week at moderate intensity (40–60% HRR) for the first five weeks and high intensity (60–70% HRR) for the last five weeks. The intensities were established by the use of Karvonen's formula. Anthropometric parameters, blood pressure, fasting glucose and lipoproteins (both using finger prick) were measured at baseline, after six weeks and 24 hours after completion of the 10-week program. Data was analysed using repeated measures analysis of variance and a Tukey Post hoc test.

Results: The prevalence of metabolic syndrome was 26.7% pre-intervention and decreased to 16.3% post intervention. There was a statistically significant ($p \leq 0.05$) improvement in all the parameters measured, mid and post intervention. Some effect sizes, following the intervention, include: weight (0.3), BMI (0.2), TC/HDL (-0.2).

Conclusion: A 10-week Tae-bo training program was effective in reducing cardiometabolic disease risk factors in overweight/obese female university students.

KEY WORDS: Aerobic, Tae-bo, overweight, obese, cardiometabolic disease risk.

DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously submitted it in its entirety or in part at any university for a degree.

Signature: Date:

DEDICATION

I dedicate this dissertation to my parents Thomas Mathunjwa and Thoko Dlamini.

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LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
BMI	Body mass index
BP	Blood pressure
CMD	Cardiometabolic disease
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
HDL-C	High density lipoprotein cholesterol
HR	Heart rate
HRR	Heart rate reserve
LDL-C	Low density lipoprotein cholesterol
Min	Minutes
mmHg	Millimeters of mercury
PAR-Q	Physical activity readiness questionnaire
RHR	Resting heart rate
RPE	Rating of perceived exertion
SBP	Systolic blood pressure
SD	Standard deviation
WC	Waist circumference
WHO	World Health Organization
WHR	Waist to hip ratio

LIST OF RESEARCH OUTPUTS

Publication

Mathunjwa M., Semple S. and Du Preez C. (2013). A 10-week aerobic exercise program reduces cardiometabolic disease risk in overweight/obese female African university students. Ethnicity and Disease, Volume 23, Spring, pp143-148. (Manuscript number: MS #12-144, see Chapter 3 and Appendix D)

International Conference Proceeding

Mathunjwa ML, Semple S and Du Preez C. (2012). The effect of a 10-week Tae-bo intervention program on physical fitness and health related risk factors in overweight/obese females. Biokinetics Association of South Africa Conference.SAJSM.24(3)98.

Local Conference Proceeding

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CHAPTER 1

INTRODUCTION

South Africa is facing an increase in non-communicable diseases as a result of overweight and obesity (Unwin et al., 2001). Being overweight (BMI ≥ 25.0 kg/m^2) or obese (BMI ≥ 30.0 kg/m^2) increases the risk of diseases such as type 2 diabetes, osteoarthritis, sleep apnea, cardiovascular diseases, and various cancers (James et al., 2004).

According to the World Health Organisation (2013), the global epidemic of overweight and obesity is estimated to be approximately 1.4 billion. The prevalence of overweight and obesity in developed countries like the United States is approximately 32.2% in women and 26.6% in men above 20 years of age (Ogden et al., 2006). Research in South Africa indicates that the prevalence of both overweight and obesity is 56% in females and 29% in males aged above 15 years (Puoane et al., 2002). It has also been shown that 56.3% of the South African population is overweight, of which 33.6% are obese, and 6.2% are morbidly obese (BMI ≥ 40 kg/m^2) (Ogden and Carrol, 2010). Reddy et al. (2012) in the 2^{nd} South African National Youth Risk Behaviour Survey of 2008 found that obesity in female adolescents increased by 2.5% since the first survey was conducted in 2002. Rossouw, Grant and Viljoen (2012) in their studies indicated that 13% of children are overweight and 3.3% are obese and many obese children are likely to grow up to be obese adults (Ogden et al., 2006).

Research findings have shown that Black South African women have the highest prevalence of overweight and obesity (58.5%), followed by women of mixed ancestry (52%), White women (49.2%) and then Indian women (48.9%) (Puoane et al., 2002). Women living in the urban areas have higher BMIs than those living in the rural regions and in both of these categories, while increases in BMI were found to be related to increases in age (Puoane et al., 2002). Abdominal obesity prevalence (using waist to hip ratio of 1.0 and 0.85 for men and women respectively) was found to be 42.2% in women and most prevalent in urban African and women of mixed ancestry (Puoane et al., 2002).

Overweight and obesity is fundamentally caused by energy imbalance between calories consumed and calories expended (World Health Organisation, 2005). Although adipose tissue is necessary and serves as the body's fuel reserve, too much adipose tissue is harmful (Klein, 2001). The intra-abdominal visceral deposition of adipose tissue, which characterises upper body, central obesity (assessed by waist circumference and/or waist: hip ratio) is a major contributor to the development of hypertension, elevated plasma insulin concentrations (insulin resistance), hyperglycaemia and hyperlipidaemia (Alberti et al., 2009). Metabolic syndrome (MetS) is often called cardiometabolic disease and consists of a clustering of risk factors such as elevated visceral obesity, glucose intolerance, elevated triglycerides, reduced high density lipoprotein cholesterol and hypertension (Scaglione et al., 2010).

The combination of obesity, physical inactivity and consumption of an atherogenic diet has been found to be a leading cause of insulin resistance (Grundy et al., 2005). Cardiometabolic risk (CMR) is associated with cardiovascular disease (CVD) and type 2 diabetes, obesity, insulin resistance, hyperglycemia, physical inactivity, smoking and hypertension (Scaglione et al., 2010). (See Figure 1.1). Lipoprotein abnormalities, including elevated triglycerides, low HDL cholesterol and increased LDL particles are common in individuals with CMD.

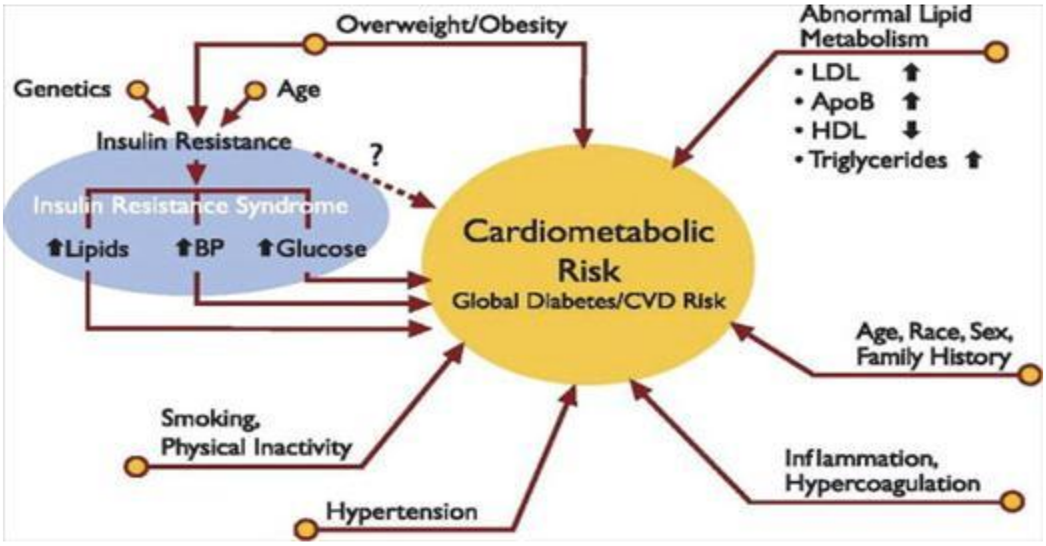

Figure 1.1 Cardiometabolic risk factors (John et al., 2008)

An individual is classified as being sedentary if he/she engages in less than 30 minutes of moderate intensity physical activity 5 days of the week (America College of Sport Medicine, 2010). A survey done in 2003 by the South African Department of Health and the South African Medical Research Council, showed that 62% of South African men and 48% of South African women aged 15 years and older follow a sedentary lifestyle (Reddy et al., 1998). It has also been shown that 33% of South African boys and 42% of South Africa girls are sedentary (Reddy et al., 1998). From the above it is clear that the majority of South African adults and children are not meeting the recommended daily physical activity guidelines.

Physical inactivity increases the risk of all-cause and cardiovascular mortality (United States Department of Health and Human Services, 2008) and may contribute towards non-communicable diseases such as coronary heart disease, type 2 diabetes and high blood pressure (Daniels et al., 2005) (Figure 1.1). In addition, it negatively effects serum lipoprotein profiles and increases the risk for asthma and arthritis (Dietz, 2004). A sedentary lifestyle effects insulin and glucose metabolism which influences the atherosclerotic processes

(Chandrashekhar and Anad, 1991). Globally, it is estimated that inactivity causes approximately 6% of coronary heart disease, 7% of type 2 diabetes, 10% of breast cancer, 10% of colon cancer and 9% of premature mortality (Lee et al., 2012). Health individuals who are not fit have a mortality risk that is 4.5 times that of the most fit (Myers, 2003) (Figure 1.3). It is clear that improving ones level of fitness reduces the risk for metabolic syndrome (Figure 1.2) and reduces the risk of mortality (Figure 1.3).

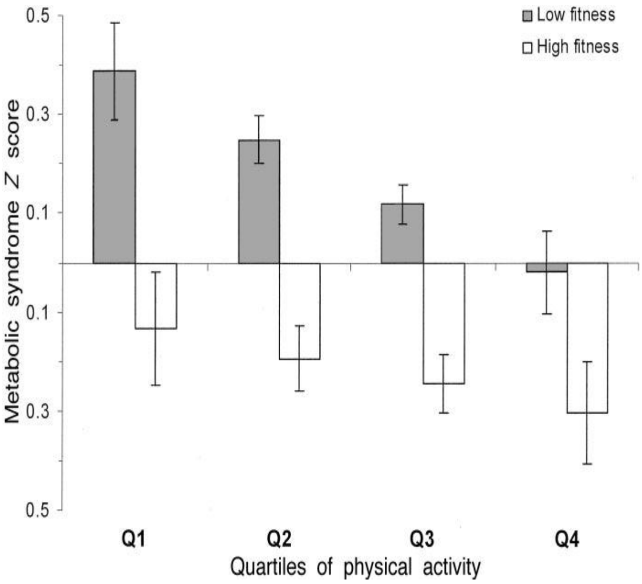

Figure 1.2 Association of physical activity with metabolic syndrome (Brageet al., 2004),

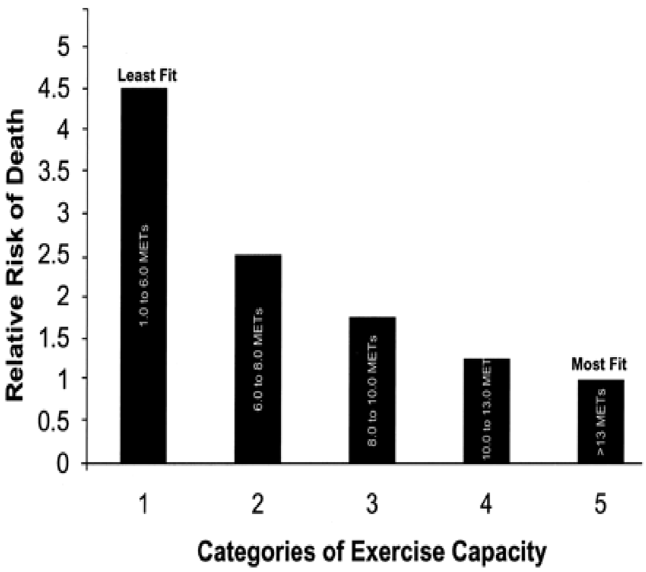

Figure 1.3 Association of exercise with risk of death (Rigatto and Parfrey, 2006)

Approximately 3% of men and 4% of South African women 30 years and older may die due to lack of physical activity (Joubert et al., 2007). The World Health Organisation (2004) recommends for health benefits, that all adults should do at least 30 minutes or more of moderate intensity aerobic physical activity daily and that sixty minutes of daily physical activity is required to prevent weight gain. This should either happen in a single session or 'accumulated' in multiple bouts, each lasting at least 10 minutes at a time (American College of Sport Medicine, 2010).

Physical activity is one of the approaches to prevent and manage individuals who are overweight or obese. Research has shown that the combination of regular exercise and dietary intervention is effective for weight loss and weight control, improved self-efficacy and better long-term weight loss maintenance in overweight and obese people (Donnelly et al., 2004). Strong evidence shows that physical activity reduces the risk of all-cause and cardiovascular mortality, stroke and metabolic syndrome (Lee et al., 2012).

There are several modes of exercise to improve cardiorespiratory fitness such as running, taekwondo, karate, boxing, hip-hop dancing, etc. To the best of the author's knowledge, there are only two studies investigating Tae-bo as an exercise intervention. One study investigated kinaesthetic perception and the potential ability to sustain or improve performance in athletes such as dribbling, shooting and footwork (Roby, 2010). Another study by Milenkovic and Veselinovic (2010) investigated the effects of experimental Tae-bo training on coordination development in young women. No study has addressed the efficacy of group Tae-bo training as an intervention to reduce cardiometabolic disease risk in previously sedentary, overweight Black African university females, between 20 and 30 years of age.

1.2 Problem Statement

Black African women have a higher prevalence of overweight and obesity which in turn increases their risk of disease (United States Department of Health and Human Services, 2010). Although anecdotal, it is fair to say that obese African University of Zululand students are by and large sedentary, and there is currently very little scientific information available looking at exercise interventions in this population.

1.3 Study Aim

To determine if a group based 10-week Tae-bo intervention of 30 sessions would be effective in reducing cardiometabolic disease risk in Black African females.

1.4 Research Hypothesis

There will be a significant reduction in cardiometabolic disease risk factors in overweight/obese Black African female students following a 10-week Tae-bo intervention program.

1.5 Structure of Dissertation

The dissertation is divided into sections. Chapter 1 contains the introduction, Chapter 2 a concise review of the relevant literature, Chapter 3 the scientific publication which fulfilled the requirements of the Journal of Ethnicity and Disease and Chapter 4, the conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The following chapter provides a comparison of short and long duration exercise intervention programs and the effect that they may have on reducing cardiometabolic disease risk. This chapter provides an overview of the impact that physical activity may have on selected risk factors. Different studies were used to compare the impact of aerobic training versus resistance training as well as diet on improving fitness and reducing the risk factors associated with non-communicable diseases (cardiovascular diseases, hypertension, dyslipidemia and diabetes). The articles selected are not extensive but include recent randomized-controlled trials and meta-analyses.

2.2 Anthropometry

Anthropometric parameters included in the studies cited below include height, weight, body mass index, waist circumference, body fat percentage, subcutaneous fat, visceral fat, skinfold thickness and body composition (Mezghanni et al. 2012; Arslan 2011). A large amount of research has been done on anthropometric parameters including body mass index (BMI), waist to hip ratio (WHR), waist circumference, lean body mass and body fat percentage (subcutaneous and visceral fat) (Mezghanni et al. 2012; Saremi et al. 2010; Kerksick et al. (2010). Anthropometric measurement is a relatively quick, easy and inexpensive method to calculate body composition.

Multiple studies have shown that anthropometric measurements change significantly with physical activity and diet interventions of varying mode, duration, frequency and intensity. Table 2.1 provides an overview of 29 studies where anthropometric measurements were monitored in response to exercise interventions. In the studies presented the sample sizes ranged from 10 to 216 at the commencement of the intervention in the empirical studies, and up to 8357 in the meta-analysis. The majority (27) of the studies presented in the table included females as participants**.** The literature reviewed was done on aerobics related workouts (step-aerobics, stair step counts, treadmill routines, dance, water aerobics, etc.) and few of them with a combination of aerobics and resistance training as well as aerobics and diet interventions. The duration of the interventions ranged from 4 weeks to 12 months with

6-8 weeks being the most common intervention period. A meta-analysis of literature found that exercise alone has little effect on body weight; therefore four studies on aerobic exercise that incorporated diet were reviewed to differentiate the level of weight loss in these studies (Cornelissen and Fagard, 2005).

Table 2.1 Anthropometric Measurements

Study	Participants			Intervention			Significant Outcome(s)
	Number	Age, mean (SD)/range in years	Sex	Duration	Type	Variable(s)	
Mezghanni et al. (2012)	31	25.2 (4.8)	F	12-wk, 5 sessions/wk	50-75% HRR aerobic training group	BMI, weight, total fat, WC, fat free mass	A significant ($p<0.01$) reduction of 3.3% in BMI, 9.5% in total fats, 8.1% in WC
Rashidlamir & Saadatnia (2012)	152	37.06 (5.1)	F & M	8-wk, 4 X 50 min sessions/wk	60-80% HR_{max} aerobic training	BMI, weight, body fat %	A significant ($p<0.05$) reduction in body fat %
Arslan (2011)	49	41.55 (6.72)	F	8-wk, 3 X 60 min sessions/wk	Step-aerobic dance exercise	BMI, weight, WC, HC,WHR, four-site skinfold thickness, body fat %	A significant decrease ($p<0.05$) in WHR, ($p<0.01$) in WC, HC in ($p<0.01$)
Azizi (2011)	24	29.8 (4.1)	F	8-wk, 3 X 30 min sessions/wk	65-85% HR_{max} aerobic training	BMI, weight	A significant ($p=0.001$) decrease in weight and BMI
Touvra et al. (2011)	10	55.5 (5)	F	8-wk, 4 sessions/wk	Combined aerobic and strength training	BMI, WC	A significant reduction in BMI and WC

Behboudi et al. (2011)	82	45-65	M	8-wk, 3 X 30-60 min sessions/wk	60-70% HR_{max} aerobic exercise and whole body vibration	BMI, body fat %	A significant (p=0.05) change in BMI and 0.3% body fat %
Kwon et al. (2011)	23	30-58	F	2-h/day and 30 min sessions/wk	Walking step with stair step counts.	BMI, weight.	A significant (p<0.05) reduction in BMI and weight
Amin-Shokravi et al. (2011)	40	45-55	F	12-wk, 3 X 30 min sessions/wk	70-80% HR_{max} treadmill running exercise	BMI, weight, WHR	A significant (p<0.05) decrease in BMI, weight and WHR
Manzoniet al. (2011)	212	32–57, 58–65 and 66–85	F & M	6 X 30-45 min sessions/wk	Cycloergometer and walking	BMI, weight	A significant reduction in BMI 1.6% and weight 3.6%
Saremi et al. (2010)	25	44.3 (4.1)	M	12-wk, 5 sessions/wk	Aerobic training	BMI, WC, body fat %, subcutaneous fat, visceral fat and body composition	A significant (p<0.05) decrease in WC, body fat %, subcutaneous fat, visceral fat and BMI
Chaudhary et al. (2010)	30	35-45	F	6-wk, 3 sessions/wk	60-70% HR_{max} aerobic with resistance training	BMI, weight, body fat %	A significant (p<0.001) decreased in BMI and body fat %

Kerksick et al. (2010)	216	38.7 (8.0)	F	14-wk, 3 sessions/wk	Exercise and carbohydrate, protein diet	WC, lean, body composition	A significant (p<0.01) decrease WC and weight
Habibzadeh (2010)	20	19-25	F	2-month, 3 sessions/wk	50-75% HR_{max} aerobic exercise	BMI, weight, fat mass, lean body mass, body fat %	A significant (p=0.000) decrease of 2.2% body fat, 2.3% BMI, 2% fat mass 1.1% and (1.1%) lean mass
Christiansen et al. (2010)	79	18–45	F & M	12-wk, 3 X 60-75 min sessions/wk	Aerobic exercise only (EXO) hypocaloric diet only (DIO) and hypocaloric diet & exercise (DEX)	Weight	A significant (p<0.05) decrease of 10% in body weight (p=0.06) (EXO), weight loss (DIO and DEX), 14-18%hypocaloric diet
Okuneye et al. (2010)	15	19-28	F	6-wk, 3 X 30min sessions/wk	Aerobic dance program	WHR	A significant (p<0.05) reduction in WHR
Lau et al. (2010)	18	12.45 (1.77)	F & M	6-wk, 3 X 60 min sessions/wk	Resistance training	BMI, weight, WC, HC, WHR, body composition	A significant (p<0.00) decrease in BMI and HC

van der Heijden et al. (2010)	*	15.3 (6.3)	F	12-wk, 2 X 30 min sessions/wk	Aerobic exercise	BMI, body fat %, body mass, fat mass, lean body mass	A significant increase in lean body mass 2–3% and body fat 1.4%
Yassine et al. (2009)	24	65.5 (5.0)	F & M	12-wk, 5 sessions/wk	Exercise and moderate caloric restriction with control group	BMI, weight, WC, WHR, fat mass, visceral fat, fat free-mass, and Subcutaneous fat	A significant ($p<0.05$) reduction in WC and WHR
Wilund et al. (2009)	65	50-70	F & M	6-month, 3 sessions/wk	Endurance exercise training.	BMI, Weight, body fat %, intra-abdominal fat mass, WC, LBM	A significant ($p<0.05$) reduction in weight, WC, fat mass, visceral fat, BMI and subcutaneous fat
Akdur et al. (2007)	60	34 (11)	F	10-wk, 3 X 60 min sessions/wk	60-70% HR_{max} diet and step-aerobic exercise, diet and walking and diet only	BMI, Fat mass, WC and HC, body fat %, intra-abdominal fat mass	A significant ($p<0.001$) decrease in weight of 1.3 %, body fat of 4 %, and 7 % of intra-abdominal fat mass
Deibert et al. (2007)	76	43.7 (6.4)	F	12-month, 60 min sessions/wk,	Aerobic or endurance type activities	Weight, WHR, fat mass and body mass	A significant ($p=0.00036$) decrease in weight and body fat %

Ozcelik & Kelestimur (2006)	17	39.94 (2.7)	F	4-wk, 3 X 45 min sessions/wk	Electromagnetic ally braked cycle ergometer	Weight,body fat%, body mass, WHR, LBM	A significant (p<0.001) reduction in weight loss, 21% fat mass, 17% WHR and 2.5% body mass
Stewart et al. (2005)	115	55-75	F & M	6-month	Combined aerobic and resistance training	Weight, BMI, and body fat %	A significant (p=0.0001) reduction in weight 4.3% and fat mass 8.1%
Kelley & Kelley (2005)	*	≥18	M & F	8-wk, 3 sessions/wk	Aerobic exercise	Weight, body fat %, WC	A significant reduction in body fat% 3.5% and increase in LBM 3.5%
Cornelissen & Fagard (2005)	8357	21-83	F & M	4-wk , 7 X 60 min sessions/wk	Aerobic endurance training	Weight, body fat % WC and subcutaneous fat	A significant decrease of 2% in weight , 1.4% in WC and body fat %
Irwin (2003)	173	50-75	F & M	12-month, 5 sessions/wk	Moderate-intensity exercise	Weight, body fat %, LBM, WC, visceral fat, subcutaneous fat	A significant (p<0.001) decrease of weight, 2.3% WC and 7% body fat %
Park et al. (2003)	30	40-45	F	24-wk, 3 X 60 min sessions/wk	Aerobic training group, combined training group	BMI, weight, abdominal fat, visceral fatand percent body fat %	A significant (p<0.05) reduction in 6.1% weight and 4.2% body fat %

Nieman et al. (2002)	102	25-75	F	12-wk, 5 X 45 min sessions/wk	60-65%, 70-80% MHR step exercise only, exercise and diet, or diet only	Weight, body composition, body fat%, abdominal fat and visceral fat	A significant decrease in Weight by 8.3%, body fat % by 9.2%, abdominal fat by 18% and visceral fat by 48%
Andersen et al. (1999)	40	21-60	F	16-wk, 60 min	Aerobic exercise with low fat diet	BMI, weight, body fat %	A significant ($p<0.001$) reduction in BMI, weight and body fat %

Wk-week(s)./-per, F-female. M-male, h-hour, min-minutes. WHR-waist hip ratio. BMI-body mass index. LBM-Lean body mass. * number of participants who are not mentioned. WC-waist circumference.

The most effective programs for weight loss as observed in the various studies were between 8-16 weeks, combined aerobic and resistance exercise, 3 times per week with caloric restriction (Arslan, 2011; Touvra et al 2011). A study by Park et al. (2003) established that the subcutaneous fat and visceral fat were decreased through a combination of resistance and aerobic training rather than only aerobic training. In a randomised controlled 12-week study of a group of 91 moderately obese women, a combination of diet and exercise training significantly lowered body mass index, percent body fat, total cholesterol and triacylglycerol (Nieman et al., 2002). The American College of Sport Medicine (2010) proposes that up to 60 min/day (>250min/week) may be required when relying on exercise alone for weight loss.

Although different studies have investigated low, moderate and high intensity exercise in the management of weight loss in obese individuals, it is evident that most of these studies emphasised using moderate intensity exercise for weight loss. Some studies suggest that a well-structured aerobic exercise intervention should perhaps range between >30-40% $VO2_{max}$or 50-70%HR_{max} (Behboudi et al., 2011; Mezghanni et al., 2012). Short term high intensity aerobic exercise (85% HR_{max}) may bring additional health benefits but may not necessarily induce weight loss (Azizi, 2011). Although other studies suggested training 3 times per week (Arslan,2011) has shown that an effective frequency for moderate-intensity aerobic activity is 5 times per week (Yassine et al.,2009;Mezghanni et al., 2012). Vigorous activity can be separated into shorter bouts of 10 minute intervals with the aim of accumulating 60 minutes in total (American College of Sport Medicine, 2010).

While aerobic exercise remains a common modality used to lower some anthropometric values, there has been no evidence from randomised controlled trials investigating weight loss by resistance training. A short term study by Lau et al.(2010), showed a significant (p<0.01) increase with a small effect size (0.2) in waist-hip circumference, fat-free mass and an increase loss of fat mass all of which was associated with a reduction in health associated risks. Saremi et al.(2010), observed reductions in abdominal obesity with a 12 week, 5days per week intervention and this is consistent with Arslan (2011) who reported that obese participants who performed an 8-week, 1 hour per day, 3 days per week step-aerobic dance exercise program showed a marked reduction in body composition (WHR, WC, weight, BMI, fat percentage and lean body mass). Similar results were found for a long term study of 24 weeks, 3 times per week,60 minutes/ day where significant (p<0.05) reductions in body weight and a reduction (4.2%) of total body fatwere reported (Park et al., 2003).

In summary, there is substantial evidence that regular aerobic exercises can effectively alter body composition in both men and women. Physical activity may increase total FFM, and reduce weight and percentage body fat. Whilst exercise is clearly effective in improving a person's body composition profile, the evidence is also clear that a combination of exercise and caloric restriction is more effective.

2.3 Lipoproteins

Lipoproteins consist of total cholesterol, triglycerides, low density lipoproteins ('bad' cholesterol) and high density lipoproteins (good cholesterol). There are numerous studies that have been conducted looking at the effects that exercise may have on lipoproteins (Mezghanni et al. 2012; Khademi et al. 2011). In table 2, the author has summarized 30 studies, the majority of which are based on aerobics related interventions (treadmill running, stationary bike, Korean dance, water aerobics, etc). Five of the articles included a comparison of aerobic versus resistance training. Two studies on aerobic training combined with dietary intervention were included as a combination of diet and exercise is advocated as the best non pharmacological method for reducing blood lipoproteins (Akdur et al., 2007;Yassine et al., 2009).

Most studies reported in the table below consist of female participants with interventions ranging from 1 month to 24 months (Khademi et al. 2011; Chaudhary et al. 2010). The literature search was done using recently published articles found in “Science Direct”, “Pubmed” and “Google Scholar” from 1999 until 2012. Multiple studies including meta-analyses of randomised-controlled trials and recently published articles were searched to provide a concise summary of the available evidence. Most studies recommended that aerobic exercise and lipoprotein reduction is the primary treatment goal for CVD risk reduction. Physical activity and weight management should be implemented in those individuals with the MetS, with the aim of treating elevated triglycerides and low HDL-C. Although aerobic exercise training has generally been shown to increase HDL-C and to decrease triglycerides, results are mixed particularly for that of LDL-C.

Table 2.2 Lipoproteins

Study	Participants			Intervention			Significant Outcome
	Number	Age, Mean (SD)/range in years	Sex	Duration	Intensity	Variable(s)	
Mezghanni et al. (2012)	31	25.2 (4.8)	F	12-wk, 5 sessions/wk	50%-75% HRR aerobic intensity training group	TG, HDL-C, LDL-C	A significant ($p<0.001$) reduction in LDL-C by 16.5%
Khademi et al. (2011)	20	15-65	M	8-wk, 3 X 45 min sessions/wk	60-79% HR_{max} aerobic exercise	LDL, LDL/TC, TC,TG and HDL	A significant ($p<0.05$) reduction of LDL/TC and TG
Seo et al. (2011)	20	40	F	12-wk, 3 sessions/wk	60-70% HR_{max} combined resistance and aerobic exercise training program	TG, HDL	A significant ($p<0.05$) decrease in TG and increase in HDL-C
Chaudhary et al. (2010)	30	35-45	F	6-wk, 3 sessions/wk	60-70% HR_{max} resistance and aerobic training	TC,TG, HDL, LHL	A significant ($p<0.001$) decrease of LDL-C and increase in HDL-C
Saremi et al. (2010)	25	44.3 (4.1)	M	12-wk, 5 sessions/wk	Aerobic training	TC,TG, LDLC	A significant ($p<0.05$) decrease in TG, TC & LDL-C

Amin-Shokravi et al. (2010)	40	45-55	F	12-wk, 3 X 30 min sessions/wk	70-80% HR_{max} treadmill running exercise	HDL-C, TC and lipoprotein	A significant ($p<0.001$) decrease in TC and increase HDL-C
Habibzadeh et al. (2010)	20	19-25	F	2-month, 3 sessions/wk	50-75% HR_{max} exercise	TC, TG	A significant ($p<0.05$) decrease in TC and TG
Miyashita et al. (2010)	10	46 (2)	M	30 min sessions/wk	60% HR_{max} moderate-intensity exercise	TG	A significant ($p<0.05$) decrease in TG by 9%
Akçakoyun (2010)	100	40-45	M	8-wk, 3 X 55 min sessions/wk	Exercise	TC, TG, LDL, HDL	A significant ($p<0.001$) decrease TG and increase in HDL-C of ($p<0.01$)
Adamo et al. (2010)	30	12-17	F & M	10-wk, 2 X 60 min sessions/wk	80-100% HR_{max} experimental group with stationary bike music vs video	TC,TG, LDL, HDL	A significant reduction in TC by 7%
Christos et al. (2009)	20	55 (5.2)	F	16-wk, 4 sessions/wk	Resistance and aerobics exercise training	TC,TG, LDL, HDL	A significant ($p<0.001$) reduction in TG by 18.9% & decrease in HDL-C by 17.2%
Yassine et al. (2009)	24	65.5 (5.0)	F & M	12-wk, 5 sessions/wk	Exercise group and EX + CR	TC, TG,LDL, HDL	A significant ($p<0.05$) decrease in TC, LDL-C & TG

Wilund et al. (2009)	65	50-70	F & M	6-month, 3 sessions/wk	Endurance exercise training	TC, TG, LDL-C, HDL-C	A significant ($p<0.05$) decrease in TC and LDL-C and increase in HDL-C
Mitchell et al. (2008)	10	18-25	F	3 X 60 min sessions/wk	Exercise group	TG	A significant ($p=0.006$) reduction in TG level
Kim et al. (2007)	64	65-90	F	10-wk, 4 sessions/wk	Korean dance exercise	TC, TG, LDL-C, HDL-C, HDL-C/HDL-C	A significant ($p<0.001$) decrease in LDL-C, LDL-C /HDL-C and increase HDL-C
Akdur et al. (2007)	60	34 (11)	F	10-wk, 2 X 60 min sessions/wk	Diet and step-aerobic exercise, or diet and walking, or diet only	TC, TG, HDL and LDL	A significant ($p<0.05$) decrease in TC and LDL-C
Kelley & Kelley (2007)	220	≥18 years	F & M	8-wk, 3 sessions/wk	Aerobic exercise	TC, TG,HDL-C, LDL-C and TC/HDL-C	A significant reduction of 5% in LDL-C, 6% in TC/HDL-C and 5% in TG
Varady et al. (2007)	84	40-70	F	8-wk, 3 sessions/wk	Combination of exercise and plant sterols	TC, LDL-C, HDL-C	A significant ($p<0.01$) decrease in TC by 7.7%, LDL-C, TG by 11.8% and increase in HDL-C by 7.5%

Deibert et al. (2007)	76	43.7 (6.4)	F	12-month, 2 X 60 min sessions/wk	Aerobic or endurance type activities	TC, TG, LDL-C, HDL-C	A significant ($p<0.01$) reduction in TC, in LDL-C, TC and increase in HDL-C
Kelley et al. (2006)	1,260	≥18 years	F & M	≥4-wk	Aerobic exercise	TC, TG, LDL-C, and HDL-C	A significant increase in HDL-C by 9% and a decrease of 11% in TG
Kelley & Kelley (2006)	984	≥18 years	F & M	≥8wk	Aerobic exercise	HDL3-C, HDL2-C, HDL-C	A significant increase in HDL2-C by 11%
Cornelissen & Fagard (2005)	8357	21-83	F &M	4-wk, 7 X 15-63 min sessions/wk	Aerobic endurance training	TG, LDL, HDL	A significant ($p<005$) increase in HDL–C and decrease in TG
Varady & Jones (2005)	40	21-60	F &M	16-wk, 3–7 X 30-60min sessions/wk	Diet and exercise	TC, TG, LDL-C and HDL-C	A significant decrease 7–18% in TC, 7–15% in LDL-C, and 4–18% in TG and increase in HDL-C levels by 2–8%
Bhalodkar et al. (2005)	388	49 (10.5)	F & M	3-5 X 128-152 min sessions/wk	Exercise group	LDL, HDL	A significant increase in HDL-C by11%

Kelley et al. (2004)	*	≥18	F	8-wk	Aerobic exercise	HDL-C, TC, LDL-C, and TG	A significant increase of 3% in HDL-C and decrease of 2% in TC, 3% in LDL-C, and 5% in TG
Park et al. (2003)	30	40-45	F	24-wk, 3 X 60 min sessions/wk	Aerobic training group with combined training group	TC, TG,LDL-C, HDL-C, Apolipoprotein A-I and ApolipoproteinB	A significant ($p<0.05$) decrease TC, LDL-C, TG and Apolipoprotein B and increase in HDL-C
Nieman et al. (2002)	102	25-75	F	12-wk, 45-60 min sessions/wk	60-65%, 70-80% MHR step exercise only, exercise and diet or diet only	TC, TG, LDL-C and HDL-C	A significant ($p<0.001$) decrease in TC, LDL-C, TG and increase in HDL-C
Andersen et al. (1999)	40	21-60	F	1 to 6-wk, 60 min sessions/wk	Aerobic exercise with low fat diet	TC, TG, LDL-C and HDL-C	A significant ($p<0.05$) reduction in TC by 10.1% and TG by 16.3%

Wk-week(s)./-per, d-day(s).h-hour. min-minutes, x-times.* number of participants who are not mentioned, HDL2-C, high density lipoprotein two cholesterol.TC-Total-cholesterol (mg/dl).LDL-C-Low density lipoprotein Cholesterol (mg/dl).HDL-C-High density lipoprotein-Cholesterol (mg/dl).TG-Triglyceride (mg/dl). Exercise combined with caloric restriction (EX + CR).

It has been suggested that aerobic exercises between 150 and 250 min/week, 30 min/day may improve cardio-respiratory fitness and reduce triglycerides ($p=0.05$), total cholesterol ($p=0.04$) and low density lipoproteins ($p=0.05$) (Saremi et al., 2010). According to Arslan (2011), an appropriate training program includes vigorous exercise training sessions 3 days per week while, Yassine et al. (2009) and Mezghanni et al (2012) suggest that a suitable frequency for moderate-intensity aerobic activity is 5 times per week. According to Mezghanni et al. (2012), moderate intensity exercise greater than (50%-75% HRR, 5days per week) is required to prevent weight gain and manage cholesterol levels. In that study a significant ($p=0.001$) reduction in low density lipoprotein (-16.5%) was seen in both exercise and diet groups. Equally, some studies suggest that the optimal intensity of a well-structured exercise aerobic program should range between >30-40 VO2max or 60-79HR_{max} to maximise health benefits (Chaudhary et al., 2010; Khademi et al., 2011). A meta-analyses of short term high intensity aerobic exercise (4 weeks) bouts may bring additional health benefits and a significantly increase HDL-C by 9% and decrease triglycerides by 11%.

A short term study by Cornelissen & Fagard (2005) found a significant ($p<0.05$) increase in high density lipoprotein with a significant decrease in triglycerides. Along term study lasting 16 weeks, with training sessions 3-7 times per week for 60 minutes resulted in a significant reduction in all the cholesterol values total cholesterol (7–18%), low density lipoprotein cholesterol (7–15%), and triglycerides (4–18%). Another study by Park et al. (2003), which lasted 24 weeks, with training sessions 3 times per week for 60 minutes, combined aerobic and resistance training resulted in a significant decrease in TC, LDL-C, TG and an increase in HDL-C. It has also been suggested that short term interventions also show some statistically significant change in LDL and total cholesterol (Akdur et al., 2007). Longer term interventions (16 weeks 60 minutes per day) have resulted in significant reductions in total cholesterol (10.1%) and triglycerides by (16.3%) (Andersen et al., 1999). It is recommended that therapeutic lifestyle changes (e.g., physical activity, weight management and dietary intervention) should be implemented in those individuals with the Metabolic Syndrome with the aim of treating elevated triglycerides, LDL-C, decreased HDL-C. Generally, aerobic exercise training increases HDL-C and decrease triglycerides and LDL-C(Cornier et al., 2008).

In summary, the beneficial effects of exercise training on lipids and lipoproteins are routinely observed and may have additional impact when combined with dietary modification and weight loss. Some studies suggest that a combination of resistance and aerobic training (moderate to high intensity) increases HDL-C, decreases TG, TC, LDL-C as well as improving cardiovascular function, in both male and female diabetics. Further research is required to investigate the combination of aerobic and resistance training of varying intensities, and the duration to treat patients with cardiometabolic.

2.4 Glucose

Impaired glucose tolerance form physical activity is potent regulator of blood glucose levels and chronically elevated blood glucose and associated impaired glucose tolerance is associated with a high prevalence of coronary heart disease (Tokmakidis et al., 2004). High glucose concentration causes cardiovascular disease, hyperglycemia and eye disease as well as accelerating atherosclerosis (Seo et al., 2011). Blood glucose decreases after physical training depending on various intensities or from different durations of training.

The effect of exercise on glucose has been investigated by many researchers on different types of exercise i.e swimming, running, cycling etc. Table 2.3 provides an overview of 25 studies investigating the effects of aerobic exercise, combined aerobics and resistance as well as exercise and diet on glucose levels. 19 of the studies employed aerobic interventionsof moderate intensity over a long period of time and clarifying mechanisms by which physical training enhances blood glucose; 6 looked at the efficacy of resistance training and 3are combined exercise and diet intervention.

Table 2.3 Glucose

Study	Participants			Intervention			Significant Outcome
	Number	Age, Mean (SD)/range in years	Sex	Duration	Intensity	Variable	
Valizadeh et al. (2012)	25	35-50	M	8-wk, 3 sessions/wk	50-60% HR_{max} aerobic exercise group	Glucose	A significant ($p<0.05$) reduction in glucose
Short et al. (2012)	18	13-27	F & M	45-min	Aerobic exercise	Glucose	A significant reduction of 6% in glucose level
Behboudi et al. (2011)	82	45-65	M	8-wk, 3 X 30-60 min sessions/wk	60-70% HR_{max} aerobic exercise and whole body vibration	Fasting glucose	A significant ($p<0.05$) decrease in fasting glucose
Seo et al. (2011)	20	40	F	12-wk, 3 sessions/wk	60-70% combined resistance and aerobic exercise training	Glucose	A significant decrease in Glucose level
Sushma et al. (2011)	35-65	84	F & M	1-3months	aerobic exercise (walking)	Glucose	A significant decrease in Glucose level
Touvra et al. (2011)	10	55.5 (5)	F	8-wk, 4 sessions/wk	Combined aerobic and strength training	Glucose	A significant decrease (11.8%) in glucose
Hazley et al. (2010)	12	53 (9) 55 (9)	F	8-wk	Resistance training	Glucose	A significant ($p<0.05$) decrease in glucose

Saremi et al. (2010)	25	44.3 (4.1)	M	12-wk 5 sessions/wk	Obese group Aerobic training	Fasting glucose	A significant (p=0.01) decrease in fasting glucose
Christiansen et al. (2010)	79	18-45	F & M	12-wk, 3 X 60–75 min sessions/wk	Aerobic exercise only, hypocaloric diet only, or hypocaloric diet and exercise	Glucose	A significant (p<0.05) decrease in fasting glucose EXO by 10%, DIO + DEX by 14-18%
Lau et al. (2010)	18	12.45 (1.77)	F & M	6-wk, 3 X 60 min sessions/wk	Resistance training	Glucose	A significant (p<0.001) decrease in glucose
Solomon et al. (2010)	22	66 (1.0)	F & M	12-wk, 5 X 60 min session/wk	85% HR_{max} exercise training intervention	Glucose	A significant (p<0.05) reduction in glucose level
Christos et al. (2009)	20	55 (5.2)	F	16-wk, 4 sessions/wk	Resistance and aerobics exercise	Glucose	A significant (p<0.001) decrease in fasting glucose by 5.4%
Bweir et al. (2009)	23	45-65	F	10-wk	Resistance exercise training	Glucose	A significant (p<0.001) reduction in glucose
Yassine et al. (2009)	24	65.5 (5.0)	F & M	12-wk, 5 sessions/wk	Exercise group or exercise + moderate caloric restriction	Glucose	A significant (p<0.001) decrease in glucose in both groups
Tresierras & Balady (2009)	56	45 (6.1)	F & M	45 min sessions/wk	Resistance exercise training	Glucose	A significant (p<0.001) decrease in glucose

Wilund et al. (2009)	65	50-70	F & M	6-month, 3 X 60 min sessions/wk	Endurance exercise training	Glucose	A significant ($p<0.05$) decrease in glucoseby 10%
Mitchell et al. (2008)	10	18-25	F	3 sessions/wk	Exercise group	Glucose	A significant ($p=0.016$) decrease in glucose levels
Deibert et al. (2007)	76	43.7 (6.4)	F	12-month, 2 X 60 min sessions/wk	Aerobic and endurance activities	Glucose	A significant ($p<0.01$) decrease in fasting glucose levels by ~ 10 %
Kreider (2007)	40	25.2 (4.8)	F & M	1 yr	Resistance training	Glucose	A significant ($p<0.01$) reduction in glucose
Snowling & Hopkins (2006)	1003	55±7	F & M	5-104 wks	Combined aerobic and resistance training	Glucose	A significant ($p<0.01$) reduction in glucose
Cornelissen & Fagard (2005)	8357	21-83	F & M	4-wk, 7 X 15-63 min sessions/wk	Aerobic endurance training vs control groups	Glucose	A significant ($p<0.001$) decrease in glucose
Boule et al. (2005)	596	40-65	F & M	20-wk, 30 min/day	55-75% VO_{2max} endurance training	Glucose	A significant ($p<0.02$) decrease in glucose by 3%
Nieman et al. (2002)	102	25-75	F	12-wk, 5 X 45-60 min sessions/wk	60-65%, 70-80% MHR step exercise only, diet and exercise or diet only	Glucose	A significant ($p<0.001$) decrease in glucose

W-week(s), /(per), d-(day)(s), h-(hour), min-(minutes). EXO-(exercise only).DIO + DEX- (diet and exercise), DIO-(diet only).

Several studies have supported the notion that losing between 5-10% of total body weight may help delay the onset of diabetes in pre-diabetic patients (Behboudi et al. 2011; Sushma et al. 2011). Valizadeh et al. (2012) reported that a relatively short term intervention (aerobic exercise at 50 – 60%HR_{max}) of 8 weeks was effective in decreasing blood concentration. It has also been reported that after 12 weeks training, 5 days per week at 60-85% of MHR, a significant decrease in fasting glucose can be expected (Saremi et al. 2010). Behboudi et al. (2011) reported a significant decrease in fasting glucose after 8 weeks of aerobic exercise training 3 times a week compared with individuals using all body vibration techniques and the control group ($p=0.02$). Lau et al. (2010) reported that 1 hour sessions of resistance training performed three times a week on alternate days, for 6 weeks significantly reduced fasting glucose ($p<0.001$) in obese adolescents. Christiansen et al. (2010) found that a 12 week, 3 times per week (60-75% HR_{max}) aerobic exercise program decreased fasting glucose in hypo-caloric diet and exercise(14-18% $p=0.05$) versus hypocaloric diet(diet only $p<0.05$)**.** This is in agreement with Yassine et al. (2009) who investigated a 12 week, 5 day per week exercise program (-6.8 ±2.7kg) compared with more effective program of individuals performing exercise in conjunction with a moderate caloric restricted diet (-500kcal, EX+CR) (-3.7 ±3.4kg). Meta-analyses involving 439 studies and 3936 participants showed a significant decrease in blood glucose after4 weeks of exercising 7 sessions per week between 15-63 minutes per session Cornelissen & Fagard, (2005).

A study by O'Leary et al. (2006) found that a 4.9% reduction in fasting blood glucose is associated with a 4.7% reduction in obesity, type 2 diabetes, and cardiovascular disease. A minimum of 60 minutes, but optimally 80-90 minutes of moderate intensity physical activity per day may be needed to limit weight gain and to prevent or treat cardiovascular diseases in overweight or obese individuals.

Research has suggested that a substantial part of the favourable changes that exercise elicits on glucose metabolism may be attributed to the effects of the most recent exercise session. Several studies have shown that exercise for longer than 50 min at ∼70–75% of maximum heart rate reserve (MHRR) for 7 consecutive days can improve insulin sensitivity and glucose tolerance by as much as 35% in obese and glucose-intolerant individuals (Lakka & Bouchard 2005; Behboudi et al., 2011).

It is clear that combined aerobic and resistance exercise improves glucose homeostasis by enhancing glucose transport and insulin action in working skeletal muscle (Cornier et al., 2008). The muscle contractions stimulate uptake of glucose through non-insulin-dependent mechanisms during exercise, but sensitivity to insulin-mediated glucose uptake is greatly improved immediately after exercise (Saremi et al. 2010). Although a session of aerobic training is not effective in improving glucose tolerance in an insulin-resistant individual with type 2 diabetes, glucose uptake during exercise is increased, and glucose and insulin response to a meal immediately after exercise is improved (Cornier et al., 2008). Interestingly, Cornier et al. (2008) mentioned that frequent exercise are accompanied by improvements in cardiorespiratory fitness (i.e., aerobic exercise training), nevertheless no change in body weight, do not appear to improve insulin-mediated glucose uptake beyond the effect of the last bout of exercise. In order to gain continued benefits of exercise on insulin action, an individual would need to follow the ACSM recommendation to exercise at least 30 minutes in most days of the week. There is evidence to suggest that aerobic exercise training may need to be accompanied by weight loss for a persistent effect on glucose tolerance and insulin action beyond the immediate post-exercise effects (Seremi et al. 2010).

Christiansen et al. (2010) reported that the combination of diet and exercise induce weight loss while diet elicits reduce blood glucose. These data suggest that a high-diet appears to exacerbate weight, when combined with exercise, may delay the onset of T2D in the risk of individuals, but only a low-diet treatment method prevents diabetic onset.

A total number of 8357 in a meta-analyses study of non- diabetic individuals found a significant decrease in glucose after aerobic endurance training (Cornelissen & Fagard, 2005). The effectiveness of aerobic training in reducing cardiovascular risk depends on many variables including age, sex, race, cardiovascular history, current risk levels, and the type of training regimen employed. There is also substantial evidence that aerobics, resistance, and combined exercise training can moderately and effectively alter glucose levels which are related risk factors for diabetes in both men and women (Sushma et al., 2011).

2.5 Blood Pressure

Elevated blood pressure (BP),or hypertension is one risk factor that contributes towards the development of cardiometabolic disease. In South Africa, it is estimated that 55% of the population are hypertensive and it has been documented that the prevalence thereof is higher in Black Africans (Steyn et al., 2001).In the literature reviewed, there is generally consensus that aerobic training elicits significant reductions in BP. It is well documented that in hypertensive individual’s exercise induces a reduction in systolic blood pressure of approximately 7.4mmHg and 5.8mmHg in diastolic pressure whilst this may seem like a small reduction it is clinically relevant (Delavar and Faraji, 2011). Table 2.4 provides an overview of20 studies investigating the effect of exercise interventions on blood pressure. These studies include different aerobic interventions such as water aerobics, treadmill running and few have been included on resistance training and dietary interventions to investigate the combined effect of the training modalities in reducing blood pressure. The duration of the interventions ranged from 4-52 weeks.

Table 2.4 Blood pressure

Study	Participants			Intervention			Significant Outcome
	Number	**Age, Mean (SD)/range in years**	**Sex**	**Duration**	**Intensity**	**Variable(s)**	
Khademi et al. (2011)	20	15-65	M	8-wk, 3 X 45 min sessions/wk	60-79% HR_{max} aerobic exercise	SBP (mmHg), DBP (mmHg)	A significant ($p<0.000$) reduction of SBP and DBP
Delavar & Faraji (2011)	10	37.6 (6.5)	F	3-7 X 2-h sessions/wk	60% HR_{max} resistance exercise with endurance exercise	SBP (mmHg), DBP (mmHg)	A significant ($p<0.05$) reduction of SBP and DBP
Seo et al. (2011)	*20*	40	F	3 sessions/wk	60-70% HR_{max} resistance	SBP (mmHg), DBP (mmHg)	A significant ($p<0.001$) reduction in post-DBP
Chaudhary et al. (2010)	30	35-45	F	6-wk, 3 sessions/wk	60-70% HR_{max} resistance with aerobic training	SBP (mmHg), DBP (mmHg)	A significant ($p<0.001$) reduction in post-DBP
Farahani et al. (2010)	40	48.3 (10.74)	M	10-wk, 3 X 55 min sessions/wk	Water Aerobic Exercise	SBP (mmHg), DBP (mmHg), mean BP	A significant ($p<0.001$) reduction in DBP and mean arterial pressure ($p=0.016$)

Saremi et al. (2010)	25	44.3 (4.1)	M	12-wk 5 sessions/wk	Aerobic training	SBP (mmHg), DBP (mmHg)	A significant ($p<0.05$) decrease in SBP
Amin-Shokravi et al. (2011)	40	45-55	F	12-wk, 3 sessions/wk	70-80% HR_{max} treadmill running exercise	SBP (mmHg), DBP (mmHg)	A significant ($p<0.001$) decrease in SBP and DBP
Piotrowska-Całka (2010)	19	30-62	F	24-wk, 2 X 45 min sessions/wk	Moderate intensity deep water aerobics	SBP (mmHg), DBP (mmHg)	A significant ($p<0.05$) reduction in SBP
Christos et al. (2009)	20	55.0 (5.2)	F	16-wk, 4 sessions/wk	Resistance and aerobics exercise training	BP	A significant ($p<0.01$) reduction in BP
Yassine et al. (2009)	24	65.5 (5.0)	F & M	12-wk, 5 X 50-60 min sessions/wk	60-85% HR_{max} 70% VO_{2max} EX with EX + CR	SBP (mmHg), DBP (mmHg)	A significant ($p<0.001$) reduction in SBP and DBP
Wilund et al. (2009)	65	50-70	F & M	6-month, 3 sessions/wk	Endurance exercise training	SBP (mmHg), DBP (mmHg)	A significant ($p<0.05$) decrease in SBP and DBP
Rodriguez et al. (2008)	30	19.6 (0.7) 76.0 (2.7)	M	6-month, 3 sessions/wk	70% of 1RM MS & TRI non-exercise	SBP (mmHg), DBP (mmHg), mean BP	A significant ($p<0.05$) reduction in mean BP
Pantelićet al. (2007)	59	22-25	F	3-month, 3 X 60 min sessions/wk	60-75% HR_{max} aerobic exercise	SBP (mmHg), DBP (mmHg)	A significant ($p<0.01$) decrease in SBP and in DBP

Deibert et al. (2007)	76	43.7 (6.4)	F	12-month, 2 X 60 min sessions/wk	Aerobic or endurance type activities	SBP (mmHg), DBP (mmHg)	A significant ($p<0.001$) decrease in SBP
Stewart et al. (2005)	115	55-75	F & M	6-month, 3 sessions/wk	Combined aerobic and resistance training	SBP (mmHg), DBP (mmHg)	A significant decrease in SBP and DBP
Cornelissen & Fagard (2005)	8357	21-83	F & M	4-wk, 7 X 63 min sessions/wk	Endurance training	SBP (mmHg), DBP (mmHg)	A significant ($p<0.001$) reduction in SBP and DBP
Fagard (2005)	2674	21-79	F & M	4-52-wk, 1-7 X 15-70 min sessions/wk	30-80% HR_{max} aerobics training, diet and exercise	SBP (mmHg), DBP (mmHg)	A significant ($p<0.01$) reduction of in SBP and DBP
Fagard (2001)	2674	21-79	F & M	4-52-wk, 3-5 X 30-60 min sessions/wk	45-85% HR_{max} aerobic/endurance exercise	SBP (mmHg), DBP (mmHg)	A significant ($p<0.001$) reduction in SBP and DBP
Andersen et al. (1999)	40	21-60	F	16-wk, 60 min sessions	Aerobic exercise with low fat diet	SBP (mmHg), DBP (mmHg)	A significant ($p<0.001$) reduction in SBP

Multiple set group (MS); and a tri-set group (TRI). Resistance before endurance exercise (RBE).exercise EX; caloric restriction CR, Minutes (Min); A tri-set group (TRI). Systolic blood pressure (SBP) and Diastolic blood pressure (DBP); $HR_{max;}$ maximam heart rate; Day per week (d/wk

Meta-analyses of randomized, controlled trial studies on the effect of aerobic exercise on blood pressure suggested that exercise reduces systolic and diastolic blood pressure by approximately 3.8 and 2.6 mm Hg, respectively. It provided strong evidence that although the effect of aerobic exercise on blood pressure was small, there may be added benefit when combined with dietary modification.

Studies have shown that aerobic exercise of 20-60 minutes, 3-5 days per week at 50-70% maximum heart rate (HR_{max}) can be used to reduce blood pressure (Amin-Shokravi et al., 2010; Khademi et al., 2011). Anaerobic exercise is the most effective exercise modality in the prevention and treatment of hypertension (Saremi et al., 2010). Saremi et al.(2010) have reported that moderate intensity exercise (60-70% HR_{max}) may result in greater decreases in resting blood pressure than exercise of a higher intensity. Research studies conducted using resistance training reveal inconsistent results (Saremi et al., 2010). For example, no significant ($p>0.05$) reduction in blood pressure was seen after 3 sets of 10 repetitions of resistance exercise performed at different intensities (40, 60, and 80% of 1RM) within a time period of 120 minutes post-exercise (Rodriguezet al., 2008). However, it was also stated that no significant differences were found between multiple sets and tri-set groups compared with the control group while mean blood pressure significantly reduced ($p<0.05$) after 6 months of exercising 3times per week. Although resistance training showed a significant ($p<0.001$) change in post diastolic blood pressure, it has been established that it is not the preferred mode of exercise in the prevention and treatment of hypertension although it can be incorporated into an exercise program that uses low resistance and high repetitions (Chaudhary et al. 2010).Fagard (2005) have performed a meta-analysis of 44 randomised controlled interventions in which 1738 health sedentary women aged 21-79 years undertook an exercise intervention lasting between 7 to 52 weeks, 15-70 minutes per session at intensities between 30-80% HR_{max}. The results indicate that sessions of five to seven times per week produced a greater reduction in blood pressure whereas three sessions per week have been considered to have a minimal effect for blood pressure reduction. It is debatable whether duration longer than 30 minutes produces a greater reduction in blood pressure. Evidence has revealed that high intensity exercise (85% HR_{max}) was as effective as low intensity (<60HR_{max}) in reducing elevated blood pressure (Yassine et al. 2009). Regular aerobic exercise at 40-70% of VO_2R, 3-7 days per week, 30 to 60 minutes showed a 5 to 7 mmHg reduction in blood pressure (Fagard, 2001).

Aerobic exercise of short and long duration, low- to moderate-intensity was found to lower BP. The duration of the blood pressure reduction persists up to 24 h after exercise (Deibert et al., 2007) and daily exercise is required. The effects of exercise have been found to be more consistent with DBP. Farahani et al., (2010) reported that a 10week water aerobics training program of 55 minutes, 3days per week on alternate days was as effective in lowering SBP.

A meta-analysis encompassing 2674 persons revealed that a decrease in systolic blood pressure of just 2mmHg will reduce death from stroke by 10% and death from ischemic heart disease by 7% among middle-aged persons (Fagard, 2005). These calculations are in accordance with older analyses (Fagard 2001; Andersen et al., 1999).

In conclusion adopting a healthy lifestyle including physical activity is critical in preventing high BP and is an indispensable part of the treatment of those with hypertension. Evidence from the above studies shows that aerobic endurance training elicits small but significant reductions in BP (Delavar and Faraji, 2011) and this in turn will reduce the risk of cardiometabolic disease.

CHAPTER 3

SCIENTIFIC PUBLICATION

Title of paper

A 10-week aerobic exercise program reduces cardiometabolic disease risk in overweight/obese female African university students.

Accepted for publication in the Journal of Ethnicity and Disease (see Appendix D)

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Abstract

Objectives: The prevalence of obesity and associated cardiometabolic disease (CMD) is increasing among black African women and requires urgent attention in the form of preventative strategies. To date, there is limited scientific evidence highlighting the efficacy of Tae-bo as an intervention for reducing weight and CMD risk factors.

Design: Prospective experimental.

Setting: South Africa, University of Zululand

Participants: Sixty previously sedentary participants [25 ± 5 y] who were overweight (BMI > 25 - 29.9 $kg.m^{-2}$) or obese (BMI ≥ 30 – 39.9 $kg.m^{-2}$).

Intervention: Participants performed a 10-week aerobic (Tae-bo) program 60 min/day for three days a week at moderate intensity for the first five weeks and high intensity for the last five weeks.

Main Outcome Measures: Anthropometric parameters (height, weight, waist and hip circumference and sum of skinfolds), blood pressure, fasting glucose, and lipoproteins were measured at baseline, after six weeks and 24 hours after completion of the 10-week program. Data was analysed using repeated measures ANOVA and a Tukey Post hoc test.

Results: The prevalence of metabolic syndrome was 26.7% pre-intervention and decreased to 16.3% post intervention. There was a statistically significant ($p \leq 0.05$) improvement in weight, BMI, waist and hip circumference, glucose, triglycerides, total cholesterol, LDL-C, HDL-C, resting heart rate and resting systolic and diastolic blood pressures following the intervention.

Conclusion: A 10-week 30 session Tae-bo exercise program was effective in reducing traditional risk factors associated with cardiometabolic disease in overweight/obese university students.

KEY WORDS: Aerobic, cardiometabolic disease, obesity

Introduction

It is well established that being overweight or obese increases the risk of developing cardiometabolic related diseases such as coronary artery disease, type 2 diabetes and hypertension.[1]

Research in South Africa indicates that 56.6% of the female population is overweight, 32.2% are obese and 4.8% are morbidly obese (BMI $\geq$ 40.0 kg.m^{-2}).[2] This is a significant health concern due to the increase in morbidity and mortality associated with being overweight. Data from the Behavioural Risk Factor Surveillance System revealed that the African population in South Africa, particularly women, shows an increased risk of being overweight and obese compared with other racial groups[3] and in some instances the prevalence of obesity is greater in females compared with males living in the same geographical location.[4]

A major factor contributing to the obesity epidemic is physical inactivity.[5] According to World Health Organisation[6] an unhealthy lifestyle may lead to obesity, high blood pressure and diabetes. Poor aerobic fitness levels are associated with cardiometabolic disease (CMD) risk factors such as large waist circumferences, hypertension and elevated insulin and blood glucose and lipid levels.[4,7] The trend of low physical activity amongst African South African women has recently been highlighted and research confirms that approximately 48% of the female follow a sedentary livestyle.[8]There is also evidence indicating that obese African females are more likely to suffer from hypertension, increased vascular resistance and metabolic syndrome compared to their Caucasian counterparts. [9,10]

Tae-bo stands for Total Awareness Excellence Body Obedience and combines the moves of taekwondo, karate, boxing and hip-hop dancing. This non-contact sport is characterised by fast punches and high kicks [11] and is essentially a form of aerobic training which aims to enhance cardiorespiratory fitness and improve balance, coordination and flexibility. To date, there have been limited studies that have investigated the efficacy of Tae-bo in improving cardiometabolic disease risk factors. The purpose of the present exploratory study was to determine the effects of an aerobic (Tae-bo) exercise program on reducing cardiometabolic disease risk factors in sedentary overweight and obese African female university students.

Methods and participants

Sixty-seven overweight and obese, apparently healthy African female University of Zululand students [25 ± 5 y] were recruited for participation in the study. All participants were sedentary for at least six months prior to beginning the intervention. Pre-participation screening in the form of a medical health history questionnaire was conducted on all participants. Of the original 67 that were recruited seven participants withdrew from the study due to personal reasons. All participants completed the physical activity readiness questionnaire (PAR-Q) and an informed consent. The participants were requested to adhere to their normal dietary practices for the duration of the study. Ethical clearance was obtained from the Institution's Faculty of Science and Agriculture Ethics Committee. Each participant was taught to use the Borg Rating of Perceived Exertion (RPE) scale[12]and this was recorded in individual log books following each exercise session.

The following American College of Sports Medicine (ACSM) and International Diabetes Federation (IDF) 'tools' were utilised to calculate the risk factor classification and prevalence of metabolic syndrome amongst the participants. The ACSM,[13] utilises specific criteria to place individuals into low, moderate or high risk categories for coronary artery disease. Participants were classified as low risk if they had ≤ 1 cardiovascular disease risk factor, moderate risk if they had ≥ 2 cardiovascular disease risk factors and as high risk if they had known cardiovascular, pulmonary, or metabolic diseases. The risk factors that are utilised for placing a person into these categories are; hypertension, hypercholesterolemia, family history, cigarette smoking, impaired fasting glucose, obesity and a sedentary lifestyle.

According to the IDF[14]for a person to be diagnosed with metabolic syndrome (MS), they must first have elevated abdominal obesity or a waist circumference >80 cm (women), plus any two of the following:

- Hypertriglyceridaemia (triglyceride ≥1.7mmol.L^{-1})
- Elevated blood pressure (systolic blood pressure ≥130mmHg and/or diastolic blood pressure ≥85 mmHg)
- Low HDL-C levels (≤1.29 mmol.L^{-1})
- Impaired fasting glucose (≥5.6 mmol.L^{-1})

Intervention program: The exercise intervention required participants to complete 30 supervised Tae-bo sessions. The sessions were conducted by experienced instructors three days a week for a period of 10 weeks. The duration of a session was sixty minutes. At each training session, warm-up exercises lasted for 10 minutes, followed by a 40 min workout, and 10 min cool-down consisting of light activities and stretching. Exercise intensity progressed from moderate intensity in the first five weeks (11 - 13 RPE) to high-intensity (14 – 16 RPE) during the last five weeks. Table 1 provides an outline of the program.

Table 1 Outline of aerobic (Tae-bo) intervention program

Week	**1 - 5**	**6–10**
Intensity	**Moderate**	**High**
Borg RPE Scale	**11-13**	**14-16**
1. Warm up (10min)	Walking, step touch, double step touch, leg curl, double leg curl, knee up, double knee up.	Jogging, step touch, double step touch, leg curl, double leg curl, knee up, double knee up.
2. Workout (40min)	Routine: punches (jab, hook, cross, upper cut) and kicks (front, round, side and back) 135 beats per minutes (bpm) = 135 moves per minutes. Free arm curl, lateral pull down, lateral raises in elbow flexion, crunches, lunges, squats, knee flexion, star jumps, side punches, basic run.	Routine: punches (jab, hook, cross, upper cut) and kicks (front, back, round, side and hammer). (150 bpm=150 moves per minutes).Free arm curl, lateral pull down, lateral raises in elbow flexion, crunches, lunges, squats, knee flexion, star jumps, side punches, basic run, walk forward and lift knee, jump up and down.
3. Cool down (10 min)	Static stretches (hold 15-20s X 2). Chest, triceps, upper back, hamstring, lower back and hip, inner thigh, quads, calf.	Static stretches (hold 15-20s X 2). Chest, triceps, upper back, hamstring, lower back and hip, inner thigh, quads, calf

Anthropometric and body composition measurements: Height (m) and weight (kg) were measured to calculate BMI as kg.m^{-2}. Measurements were taken wearing light clothes and bare feet standing on a Growth Management scale (Genifis, China). The body fat measurements were obtained using a Lange skinfold calliper (Rosscraft, Canada) from the following sites: triceps, sub scapula, supra iliac crest, abdominal, thigh, calf. The calliper was placed one cm away from the thumb and finger, perpendicular to skinfold, and halfway between crest and base of fold and left for one to two seconds before reading the dial. Measurements were taken twice and averaged. Waist circumference was taken at the narrowest (minimum) point while the hip circumference was measured at the widest (maximum) part of the buttocks using a tape measure on a horizontal plane.[15]

Blood pressure: Resting systolic and diastolic blood pressures were measured twice after sitting for 5 min in the laboratory. The brachial artery auscultation technique was used with anALPK$_2$ sphygmomanometer and stethoscope auscultation (Microlife, Switzerland). The measurement procedures followed the criteria of the American College of Sport Medicine.[13] Resting heart rate was taken using stethoscope auscultation while participants were seated. Systolic blood pressure was measured at the point of appearance of the Korotkoff sounds (phase I) and diastolic BP at the point of disappearance (phase V).

Blood sample analysis: All participants reported for blood sampling in the morning between 8am and 11am after an overnight fast (9-12 hours). Blood samples were drawn at baseline (pre-intervention), at week 6 and then at week 10 (post-intervention). Post intervention blood samples were obtained 24h after the last exercise session. Fasting total cholesterol (TC), high-density lipoprotein cholesterol(HDL-C), low-density lipoprotein cholesterol(LDL-C), triglycerides (TG) and glucose concentrations were analysed in (mmol.L^{-1}) using a Cardio Check$^{(R)}$(PA system Polymer Technology Systems, Indianapolis, USA) and CareSens II blood glucose monitoring system (Seoul, Korea).

Statistical analysis: Data are presented as means ± SD, 95% Confidence Intervals (CI) and effect sizes. Differences between the values at pre, mid and post-testing were analysed using repeated measures analysis of variance (ANOVA) and a Tukey post-hoc test. The level of statistical significance was set at $p \leq 0.05$.

Results

Pre, mid and post test results are provided in Table 2. The prevalence of metabolic syndrome using the IDF criteria was 26% at pre testing and 16% after the 10 - week Tae-bo intervention program. The cardiovascular disease risk classification results are presented in Table 2. Values for weight, BMI, waist circumference, glucose, triglyceride, total cholesterol, low-density lipoprotein cholesterol, and systolic and diastolic blood pressure from both baseline to mid and baseline to post showed significant ($p \leq 0.05$) improvements. The prevalence of participants in the moderate-risk category before the intervention was 68.3% and dropped to 42.3% after the intervention. Similarly, the prevalence of participants in the low risk was 31.7% pre-intervention and increased to 57.7% at post intervention (Table 3).

Table 2.Group differences at pre, mid and post intervention [(mean ± SD; (95% (CI),ES, % Δ]

Variables	Pre (n=60)	Mid (n=60)	Post (n=60)	ES	Δ% Mid	Δ% Post
Weight (kg)	81.86 ± 15.85 (77.44 - 86.27)	79.81 ± 15.16* (75.59 - 84.03)	77.00 ± 15.15* (72.78 - 81.22)	0.3	↓2.5*	↓5.9*
BMI ($kg.m^{-2}$)	32.26 ± 5.65 (30.8 - 33.72)	31.22 ± 5.55* (29.78 - 32.65)	30.11 ± 5.46* (28.70 - 31.52)	0.2	↓3.1*	↓6.7*
Waist (cm)	87.59 ± 9.95 (85.02 - 90.16)	83.63 ± 9.71* (81.13 - 86.14)	81.82 ± 10.02* (79.23 - 84.40)	0.6	↓4.5*	↓6.6*
Hip (cm)	118.60 ± 10.86 (115.8- 121.40)	116.20 ± 10.66* (113.40 - 119.00)	116.20 ± 10.66* (113.40 - 119.00)	0.4	↓2.0*	↓3.5*
SS (mm)	212.20 ± 33.30 (203.77 - 220.99)	200.08 ± 34.97* (191.53 - 208.63)	187.43 ± 34.64* (178.78 - 196.09)	0.7	↓5.7*	↓11.7*
RHR (bpm)	79.23 ± 3.76 (78.26 - 80.21)	76.25 ± 2.75* (75.54 - 76.96)	73.27 ± 2.63* (72.59 - 73.95)	1.8	↓3.8*	↓7.5*
Glucose ($mmol.L^{-1}$)	3.99 ± 0.59 (3.84 - 4.15)	3.83 ± 0.74* (3.64 - 4.02)	3.61 ± 0.46* (3.49 - 3.73)	0.7	↓4.0*	↓9.5*
LDL ($mmol.L^{-1}$)	2.12 ± 0.82 (1.89 - 2.32)	1.92 ± 0.79* (1.71 - 2.12)	1.68 ± 0.65* (1.51 - 1.85)	0.6	↓9.4*	↓20.8*
HDL ($mmol.L^{-1}$)	1.35 ± 0.75 (2.52 - 2.91)	1.53 ± 0.49* (2.73 - 2.99)	1.61 ± 0.46 * (2.69 - 2.93)	-1.0	↑13.3*	↑19.3*
TG ($mmol.L^{-1}$)	1.74 ± 0.92 (1.14 - 1.76)	1.46 ± 1.15* (1.16 - 1.76)	1.45 ± 1.23* (1.51 - 1.97)	0.4	↓16.1*	↓16.7*
TC ($mmol.L^{-1}$)	3.76 ± 1.02 (3.49 - 4.02)	3.5 ± 0.82* (3.31 - 3.73)	3.36 ± 0.85* (3.14 - 3.58)	0.4	↓6.9*	↓10.6*
TC/HDL ($mmol.L^{-1}$)	2.86 ± 0.49 (2.53 - 2.91)	2.81 ± 0.46* (2.73 - 2.99)	2.72 ± 0.75* (2.69 - 2.93)	-0.2	↓1.7*	↓4.9*
SBP (mmHg)	106.30 ± 8.48 (104.10 - 108.50)	104.20 ± 11.02* (101.40 - 107.00)	100.60 ± 8.05* (98.55 - 102.70)	0.7	↓1.9*	↓5.4*
DBP (mmHg)	66.73 ± 6.96 (64.93 - 68.53)	63.45 ± 9.38* (61.03 - 65.87)	62.45 ± 7.36* (60.55 - 64.35)	0.6	↓5.2*	↓6.7*

*BMI: body mass index, RHR: resting heat rate, bpm: beats per minutes, LDL-C, low-density lipoprotein cholesterol; HDL-C. high-density lipoprotein cholesterol; TG, triglyceride; TC, total cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure; SS, sum of skinfold; TC/HDL, Ratio of total cholesterol to high-density lipoprotein; * Significant (P<0.05) difference between pre and mid, pre and post; CI, confidence interval; SD, standard deviation; % Δ, percentage change compared to; ↓decrease; ↑increase; ES, effect size (pre-post).*

Table 3.Cardiovascular disease risk classification (%)

	Pre (n=60)	Mid (n=60)	Post (n=60)
Low risk	31.7%	45.4%	57.7%
Moderate risk	68.3%	54.6%	42.3%

Discussion

The objective of this study was to determine if 30 group supervised sessions of Tae-bo would be effective in reducing cardiometabolic disease risk factors in sedentary overweight/obese African female university students. It is well established that engaging in physical activity reduces an individual's risk for diabetes and cardiovascular disease [16,17] however, to the best of the authors knowledge it is unknown if a relatively short intervention consisting of 30 sessions of Tae-bo can favorably modify the cardiometabolic disease risk profile in female African students.

Anthropometry

Although anecdotal, the majority of students enrolled at the University of Zululand do not meet the minimum recommended physical activity guidelines and as such it would be fair to say that this is a strong contributing factor towards the high prevalence of overweight/obesity. The U.S. Department of Health and Human Services[17]hasshown that overweight/obese individuals are at greater risk for developing diabetes, hypertension and CVD. In addition, Sampaliset al[19]have shown that relatively small reductions in weight can impart significant health benefits. Another study of a 4 week aerobic training program recorded a 4.3% reduction in body weight.[20]The participants in the current study showed an almost 6% reduction in weight from pre to post intervention. The reduction in weight mirrored the observations for BMI, waist and hip measurements with all these variables showing significant reductions after the 10-week intervention program. Interestingly, significant changes were already observed mid-intervention i.e. following 15 sessions or after 5 weeks, and this trend was similar for the other dependent variables.

Blood Pressure and Resting Heart Rate

Elevated blood pressure or hypertension is estimated to affect approximately 55% of South Africans. [21] The deleterious effects of chronically elevated blood pressure are well documented,[22] and include increased risk of cardiovascular morbidity and mortality. Overweight/obese individuals are more at risk of developing hypertension. In the current study, blood pressure (systolic and diastolic) was within the recommended range at all-time points. Surprisingly, the resting blood pressure pre-intervention was lower than anticipated for this group of overweight students. Studies conducted on other African females have shown a propensity towards elevated blood pressure.[23,24] Beneficial changes were observed post intervention for both systolic and diastolic pressures with the mean systolic pressure dropping by 5% and the diastolic by almost 7%. From a clinical perspective these changes are meaningful as a recent study has shown that reductions of 9%, or 5.9 mmHg, can reduce the risk or incidence of coronary heart disease and all-cause mortality by 14% and 7% respectively.[25]Significant reductions in the participants RHR was observed following the 10 week intervention. This drop together with reductions in BP would tend to suggest that cardiovascular efficiency had improved amongst the participants.

Blood Parameters

Glucose

As per the IDF criteria, elevated fasting blood glucose levels ($\geq$5.6mmol.l^{-1}) is one of the risk factors for developing metabolic syndrome. As a screening tool, fasting blood glucose levels can also give an indication if an individual is glucose intolerant (pre-diabetic) or diabetic.

Both these conditions place individuals at greater risk of developing cardiovascular disease. A study has shown that8.1% reduction in fasting blood glucose significantly improved after 4 weeks ($p<0.01$) and also associated with risk factors of obesity, type 2 diabetes, and cardiovascular disease. [17]The participants in the current study exhibited a 9.5% reduction in blood glucose concentration following the intervention. This compares favorably with the results of a 12-week aerobics training which resulted in an improvement of insulin resistance by 4.7% .[26]

Lipoproteins

Elevations in TC, TG, LDL as well as the TC/HDL ratio are considered to be independent risk factors for the development of CVD and increased incidence of cardiac events. [27] The most pronounced change observed in the current study for the lipoproteins was that of the LDL which dropped by 20% (ES=0.6). Studies by Durrington et al[28] and Deibert et al[29] have reported similar findings with LDL-C decreasing by almost 35% and TG by almost 13%. This drop, together with reductions in TG, TC and increases in HDL are all significant in that it favorably alters the participant's lipoprotein profile and risk of disease. It was surprising to see such pronounced changes especially considering that the participants were not instructed to follow a specific diet or calorie restriction program. This of course does not rule out the possibility that the participants subconsciously altered the type and amount of food intake during the study. Similar to the changes in blood pressure, the alterations in the lipoproteins are of clinical significance. Zhan et al[30] have shown that a reduction of 3.77% TC or 5.25% LDL and 7.27% TG together with an increase in HDL are associated with a reduction in cardiac events. [26]

Overall the number of participants that modified their risk classification to such an extent that they would no longer meet the IDF criteria for metabolic syndrome was 10% (Fig. 1). This is a substantial drop and when one considers the worldwide prevalence of metabolic syndrome a similar reduction globally would see millions of people significantly reduce their risk for premature morbidity and mortality. Similarly, using the ACSM[13] criteria (Table 3) there was a 26% reduction in the number of participants who were classified as moderate risk after the intervention.

Conclusion

The prevalence of cardiometabolic disease is increasing amongst urban and rural South African females. In rural settings, similar to where this intervention took place, there is a lack of infrastructure and limited opportunities exist for people to engage in organised physical activity programs. The intervention employed in the current study was effective in reducing the cardiometabolic disease risk profile of overweight/obese African female university students.

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CHAPTER 4

CONCLUSION

4.1 Conclusion

Overweight and obesity is for the most part a consequence of increased caloric intake and a reduction in physical activity levels (World Health Organization, 2005). The prevalence of overweight or obese adults and children is increasing and this is accompanied with an increase in chronic disease (World Health Organisation 2013; World Health Organisation 2005). It is estimated that 48% of men and 63% of South African women are sedentary (Mungal-Singh, 2012). Physical inactivity remains a significant problem and increases the risk of cardiometabolic disease.

Regular exercise results in a reduction of the risk factors for obesity, type 2 diabetes, and cardiovascular disease (Lazarevic et al., 2008; O'Leary et al., 2006). In the present study, the 10-week Tae-bo intervention program improved the participants body composition (i.e. body weight, BMI, percentage body fat), fasting glucose, blood lipid profile (i.e. triglycerides, total cholesterol, low-density lipoprotein cholesterol), and resting blood pressure. The results observed in the current study are consistent with previous reports and reinforce the positive effect that physical activity may have on reducing an individual's risk of non-communicable diseases such as, type 2 diabetes, and cardiovascular disease (Chang et al.,2009; Davidson et al., 2009; Prasad & Das, 2009). In the present study, 10 weeks of Tae-bo training decreased glucose by 9.5%, which is in line with previous investigations (Davidson et al., 2009; Kamijo& Murakami, 2009).

To the best of the author's knowledge, this is the first study which investigated the impact that Tae-bo has on cardiometabolic disease risk factors.

Clearly the intervention was effective in this cohort of previously sedentary individuals with 31.7% of the participants placed in the low risk category at the beginning of the study and 57.7% at the end of the study. Similarly there was a 10% reduction in the prevalence of metabolic syndrome and changes were already observed halfway through the intervention (i.e. at 5 weeks).

4.2 Study limitation

I. Participants were not given dietary guidelines to follow during the study. It is thus tenable that some of the participants may have changed their dietary patterns and this may have had an effect on body composition.

II. The inclusion of a non-exercising control group could have shed light on the effect (if any) that being a research participant may have on the modification of risk factors. That is, the mere fact that participants knew that their blood lipids, glucose etc was being monitored may have caused them to change their normal eating and physical activity patterns.

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Appendix A: Informed Consent to participate in a Research Study

TITLE: **THE EFFECT OF A 10-WEEK TAE-BO INTERVENTION PROGRAM ON CARDIOMETABOLIC DISEASE RISK FACTORS IN OVERWEIGHT/OBESE FEMALES OF THE UNIVERSITY OF ZULULAND**

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PURPOSE AND BACKGROUND

Under the supervision of Prof S Semple and Dr C du Preez at the University of Zululand, Mr M Mathunjwa a graduate student in research from the Department of Biokinetics and Sport Science is conducting research on the effect of a 10-week Tae-bo intervention program oncardiometabolic disease risk factor in overweight/obese femalesstudent of the University of Zululand. The purpose of this study is to see if Tae-bo intervention will have an impact on the cardiometabolic risk factors in overweight/obese females.

This study will investigate the effect of Tae-bo interventions on cardiometabolic diseases such as: resting heart rate, resting blood pressure, glucose and cholesterol (TC, TG, LDL, HDL, TC/HDL).

You are being invited to take part in this research study because you are within the body weight range for this study, and you do not have any medical conditions that would prohibit you from participating in moderate to vigorous activity. Moderate activity is defined as activity similar to brisk walking where you can also have a conversation, with vigorous activity defined as activity is walking at a faster pace and you cannot have a conversation because you are breathing deeper and faster. Females invited into this study have to be between 20-30 years of age. This study is being performed on a total of 67 individuals at the University of Zululand. If you decide to take part in this research study, you will undergo the following procedures that are not part of your standard medical care: Screening Procedures: Procedures to determine if you are eligible to take part in a research study are called “screening procedures”. For this research study, the screening procedures include: You will complete a physical activity readiness questionnaire (PAR-Q), and this will take approximately 5 minutes to complete. You will also complete a detailed medical history, and this will take approximately 20 minutes to complete. These questionnaires will allow the investigators to determine if you have any significant medical condition that would indicate that exercise is unsafe for you. Participants cannot be pregnant, and you will be required to accurately report whether you are pregnant to the investigators prior to beginning of this study and during the study if your status should change.

Procedures and Protocol

Experimental Procedures: If you qualify to take part in this research study, you will undergo the following experimental procedures: You will first be asked to complete a series of questionnaires, and it is estimated that you will be able to complete these questionnaires in approximately 30minutes. These questionnaires will provide information about your health. Your body weight, body composition, blood pressure, physical fitness, muscular strength, physical function, level of physical activity, and food intake will be measured. These assessments will take place at the department of Biokinetics and Sport Science at the University of Zululand, and these assessments will be completed in approximately 90 minutes. A brief description of these assessments follows.

A. Body Weight and Height (2 minutes): Your body weight will be measured using a standard detector scale. Your height will be measured with a ruler that is attached to a flat wall. These will be measured at 0, 5, and 10 weeks during this study.

B. Body Composition (5 minutes): Your body composition is the amount of fat weight and lean weight (muscle and bone) that you have on your body. Your body composition will be measured using a skin fold calliper technique. This procedure requires 6 sides (triceps, Sub scapular, abdominal, thigh, calf). A small pinch with skin fold calliper and index and thumb signal that is not harmful to you and that you will not feel is uncomfortable because you will be aware. Measurements of your waist and hip areas will also be made using a measuring tape. These measures will be made at 0, 5, and 10 weeks during this study.

C. Blood Pressure (5 minutes): Your blood pressure will be measured using a standard blood pressure cuff and will follow standard measurement procedures. Blood pressure will be measured at 0, 5, and 10 weeks during this study.

D. Cardiorespiratory Fitness (3 minutes Harvard step test): Measurement of your cardiorespiratory fitness will provide information about how fit your heart and lungs are to perform exercise.

E. Muscular Strength (hand grip strength): Muscular strength refers to the maximum amount of weight you can lift and is specific to each muscle group. Your muscular strength will be estimated for upper body by performing a hand grip strength calliper. The exercise uses the hand muscles. Muscular strength will be measured at 0, 5, and 10 weeks during this study.

F. Skill-related fitness (20 minutes): Physical function refers to how well you can perform common tasks. Your physical function will be measured by having you perform a series of tasks that include the following: performing a T-test (running). Performing a stork test (test for balance on your legs) for up to 10 seconds.Performing power (horizontal jump). These tasks will be measured at 0, 5, and 10 weeks during this study.0, 3, and 6 months during this study.

G. Dietary Patterns (60 minutes): During the intervention, you will complete a 3 day food dairy about the amount and type of food that you eat for three times a week. You will also complete questionnaires about factors such as your mood, general health, and other things that may affect your exercise and eating behaviours. Participants who have a positive score on the mood measure that is being used in this study will be referred to their personal physician or other appropriate medical personnel for follow-up care. You will also be taught how to decrease the amount of food or fat that you eat, and will be encouraged to decrease fat intake to 20-30% of your total calories. These questionnaires will be completed for every 2 weeks during this study.

RISKS AND BENEFITS:
The possible risks of this research study may be due to the exercises that you will be performing and the assessments that will be performed.

RISKS

A. Risks of Exercise and test of Physical Fitness: There are moderate risks associated with participating in an exercise test, a physical function test, and a regular exercise program. During exercise, you may experience a serious cardiac (affecting your heart) event, an arrhythmia (your heart beats at a pace that is not normal), or chest pain. An example of a cardiac event would be a heart attack or another medical condition that causes damage to your heart or cardiovascular system. The possibility of experiencing a serious cardiac event has been estimated to be less than 1 per 20,000 in exercising adults, with the risk of death during a maximal exercise test being less than 0.5 per 10,000 tests. Therefore, the risk is of this happening to you is rare, because it occurs in less than 1% of people (less than 1 out of 100 people). In addition, during exercise, you may experience an increase in heart rate, an increase in blood pressure, shortness of breath, general fatigue, and in some cases muscle soreness. The risk of this happening to you is likely because these occur in more than 25% of people (more than 25 out of 100 people). When testing muscular strength you may experience muscle strain, with the risk of this happening to you infrequent because it occurs in 1-10% of people (1-10 out of 100 people). In the event that you experience a serious medical condition during your exercise testing session or during a supervised exercise session, the session will be stopped and appropriate emergency medical care will be provided. This may include providing CPR until Paramedics or other appropriate medical personnel arrive.
B. Risk Associated with Completion of Questionnaires: You may experience non-physical risks such as boredom, frustration, stress, and time constraints when completing the questionnaires. The risk of this happening to you is likely because this occurs in more than 25% of people (more than 25 out of 100 people).
C. Risk Associated with Participating in the Intervention: Attending group sessions has been shown to be effective for weight loss. However, attendance at these sessions you may find yourself sharing information about yourself and your weight loss efforts to the group members and unscientific argument may arise.

There are also possible benefits of this research study that may be due to the exercises that you will be performing.

However, there is no guarantee that any or all of these changes will occur as a result of you participating in this study.

BENEFITS

A. Benefits of Exercise: The benefits of participation in an exercise program have been shown to include improvements in physical fitness, weight loss, improvements in blood pressure, and improvements in blood cholesterol levels. However, there is no guarantee that any or all of these changes will occur as a result of you participating in this study.

If we should find out about a medical condition you were unaware of, with your written permission, this information will be shared with the doctor of your choice.

NEW INFORMATION: You will be promptly notified if any new information develops during the conduct of this research study, which may cause you to change your mind about continuing to participate.

COSTS AND PAYMENTS: Neither you, nor your insurance provider, will be charged for the costs of any of the procedures performed for the purpose of this research study. However, there is no guarantee that any or all of these changes will occur as a result of you participating in this study.

COMPENSATION FOR INJURY: University of Zululand researchers and their associates who provide services at the University of Zululand Medical recognize the importance of your voluntary participation in their research studies. These individuals and their staffs will make reasonable efforts to minimize, control, and treat any injuries that may arise as a result of this research. If you believe that you are injured as a result of the research procedures being performed, please contact immediately the researcher.

CONFIDENTIALITY: Any information about you obtained from this research will be kept as confidential (private) as possible. All records related to your involvement in this research study will be stored in a locked file cabinet. Your identity on these records will be indicated by a case number rather than by your name, and the information linking these case numbers with your identity will be kept separate from the research records. In addition, all research databases will have password controlled access, and this will be controlled by the researchers. Only the researchers listed on the first page of this form and their staff will have access to your research records. You will not be identified by name in any publication of research results unless you sign a separate form giving your permission (release).

This research study will involve the recording of current and/or future identifiable medical information from your hospital and/or other (e.g. physician office) records. The information that will be recorded will be limited to information concerning medical clearance from your physician to participate in this research study. This may include information related to coronary heart disease risk factors such as blood pressure, blood cholesterol, or other medical conditions that may increase the risk of heart disease and/or indicate that exercise participation may be unsafe for you. This information will be used to determine whether it is safe for you to participate in this research study.

In addition to the investigators listed on the first page of this authorization (consent) form and their research staff, the following individuals will or may have access to identifiable information related to your participation in this research study.

RIGHT TO PARTICIPATE OR WITHDRAW FROM PARTICIPATION:

Your participation in this research study, to include the use and disclosure of your de-identifiable information for the purposes described above, is completely voluntary. (Note, however, that if you do not provide your consent for the use and disclosure of your identifiable information for the purposes described above, you will not be allowed, in general, to participate in the research study.) Whether or not you provide your consent for participation in this research study will have no effect on your current or future relationship with the University of Zululand. Whether or not you provide your consent for participation in this research study will have no effect on your current or future medical care at a University of Zululand clinic or affiliated health care provider or your current or future relationship with a health care insurance provider. You may withdraw, at any time, your consent for participation in this research study, to include the use and disclosure of your de-identifiable information for the purposes described above. (Note, however, that if you withdraw your consent for the use and disclosure of your identifiable information for the purposes described above, you will also be withdrawn, in general, from further participation in this research study.) Any research information recorded for, or resulting from, your participation in this research study prior to the date that you formally withdrew your consent may continue to be used and disclosed by the investigators for the purposes described above. To formally withdraw your consent for participation in this research study you should provide a written and dated notice of this decision to the investigator of this research study at the address listed on the first page of this form.

It is possible that you may be removed from the research study by the researchers if, for example, your health status changes and it does not appear that it is safe for you to continue to reduce your food intake, exercise, or lose weight. You will also be removed if you should become pregnant during this study.

VOLUNTARY CONSENT The above information has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions, voice concerns or complaints about any aspect of this research study during the course of this study, and that such future questions, concerns or complaints will be answered by a qualified individual or by the investigator(s) listed on the first page of this consent document at the telephone number(s) given. I understand that I may always request that my questions, concerns or complaints be addressed a listed investigator. By signing this form, I agree to participate in this research study. A copy of this consent form will be given to me.

FREEDOM OF CONSENT:

Your permission to perform this test is voluntary. You are free to stop the testing at any time, if you so desire.

I have read this form and understand the test procedures that I will perform, as well as the related risks and possible discomforts. With full knowledge of this, and having had an opportunity to ask questions that have been answered to my satisfaction, I consent to participate in this testing procedure

_____________________ ___________________ _______________

Participant Signature Date

___________________ ___________________ _______________

Reseacher Signature Date

Appendix B: Data sheet

Name & Surname		Gender	
Age		Wt	
Ht		BMI	

Test/Measurement		1st Assessment	2nd Assessment	3rd Assessment
Date				
Weight				
Resting Heartrate				
Resting Blood Pressure				
Glucose:				
LDL				
HDL				
Tri				
Total Cholesterol				
Skin Folds	Triceps			
	Sub Scap			
	Supra iliac			
	Abdominal			
	Thigh			
	Calf			

Appendix C: General Health History Questionnaire

Subject name:______________________________ Student number: _______________________

Date of birth: ______________________________ Gender________________________________

Residence___________________________ Race: ____

Do you have, or have you been previously diagnosed with any of the following medical conditions? (√)					
	No	**Yes**	**Unsure**	**Approximate Date of Diagnosis**	**Describe the Problem**
1.Heart problem					
2.Stoke					
3.High blood pressure					
4.Obesity					
5.Diabetes					
6.Asthma or pulmonary diseases					
7.Lower back pain					
8.Pregnancy					
9.Osteoporosis					
10. Fainting spells					
11. Angina (Chest pain or exertion)					
12. Irregular heart problems					
13. Emotional/ Psychiatric Problems					
14. Drug/ Alcohol Problems					
15. Hypertension and cardiovascular diseases					

1. Do you have any medical problems that would prevent you from participating in the 10 week Tae-bo intervention program? _____yes ______no

If yes, please describe the problem:____ __________

2. Is it possible that you will leave the University in the next 10-week? ______yes ______no Please explain____
3. Are you currently pregnant? __yes __no
4. Were you pregnant in the past 6 months? __yes __no
5. Do you plan to become pregnant in the next 3 months? __yes __no
6. Have you gone through menopause or the change of life? __yes __no.
7. Have you had a hysterectomy? __yes __no.
8. When was your last menstrual period? DATE:____ /____/____.
9. Do you take: Birth Control Pills? __yes __no

Estrogens (ie.Premarin)? __yes __no
Progesterone (ie.Provera)? __yes __no

Exercise (Physical Activity)
The next few questions are about exercise, recreation, or physical activities other than your regular job duties.
1 Have you been active or involved in any sport or physical activities such as running (moderate or high intensities) for the past 6 months?

1 Yes 2 No 3 Don‘t know / Not sure 4 Refused

2. What type of physical activity or exercise did you spend the most time doing during the past month?

1 Don‘t know 2 Refused

3 How many times per week or per month did you take part in this activity during the past month?

1_ _ Times per week 2 _ _Times per month 3 _ _Don‘t know / Not sure

4 And when you took part in this activity, for how many minutes or hours did you usually keep at it?

1_:_ _ Hours and minutes 2_ _ _Don‘t know / Not sure 3_ _ _Refused

5 What other type of physical activity gave you the next most exercise during the past month?
1_ _ _ _ (Specify) **2_ _ _ _** No other activity **3_ _ _ _** Don‘t know / Not Sure
4_ _ _ _ Refused

6 How many times per week or per month did you take part in this activity during the past month?
1_ _ _ _Times per week 2_ _ _ _Times per month 3_ _ _ _Don‘t know / Not sure 4 _ _ _ _Refused

7 And when you took part in this activity, for how many minutes or hours did you usually keep at it?
1_:_ _ _ Hours and minutes 2_ _ _ _Don‘t know / Not sure 3_ _ _ _Refused

8 During the past month, how many times per week or per month did you do physical activities or exercises to STRENGTHEN your muscles? Do NOT count aerobic activities like walking, running, or bicycling. Count activities using your own body weight like yoga, sit-ups or push-ups and those using weight machines, free weights, or elastic bands.

1_ _ _ _Times per week 2_ _ _ _Times per month 3_ _ _ _Never 4_ _ _ _Don‘t know / Not sure 5_ _ _ _Refused

Disability

The following questions are about impairments you may have.
1 Are you limited in any way in any activities because of physical, mental, or emotional problems?
1 _ _ _ _Yes 2 _ _ _ _No 3 _ _ _ _Don‘t know / Not Sure 4 _ _ _ _Refused

2 Do you now have any health problem that requires you to use special equipment, such as a cane, a wheelchair, or a special telephone?

1_ _ _ _ Yes 2 _ _ _ _No 3 _ _ _ _Don‘t know / Not Sure 4 _ _ _ _Refused

Alcohol Consumption

1 Do you consume alcohol? 1_ _ _ _Yes 2_ _ _ _No

2. During the past 30 days, how many days per week or per month did you have at least one drink of any alcoholic beverage such as beer, wine, a malt beverage or liquor?

1 _ _ _ _ Days per week 2 _ _ _ _Days in past 30 days 3 _ _ _ _No drinks in past 30 days 4_ _ _ _ Don‘t know / Not sure 5 _ _ _ _Refused

3 _ _ _ _One drink is equivalent to a 12-ounce beer, a 5-ounce glass of wine, or a drink with one shot of liquor. During the past 30 days, on the days when you drank, about how many drinks did you drink on the average?

NOTE: A 40 ounce beer would count as 3 drinks, or a cocktail drink with 2 shots would count as 2 drinks.

1_ _ _ _ Number of drinks 2_ _ _ _ Don‘t know / Not sure 3 _ _ _ _Refused

4 _ _ _ _Considering all types of alcoholic beverages, how many times during the past 30 days did you have X [X = 4 for women] or more drinks on an occasion?

1_ _ _ _Number of times 2_ _ _ _None 3_ _ _ _Don‘t know / Not sure 4 _ _ _ _Refused

5 During the past 30 days, what is the largest number of drinks you had on any occasion?

1_ _ _ _Number of drinks 2_ _ _ _Don‘t know / Not sure 3_ _ _ _Refused

Smoke

1. Over the past 6 months, have you regularly smoked cigarattes, pipes, cigers, or used chewing tobacco?
Please describe daily habit
Cigarettes _ _ _ _ yes _ _ _how often a day _ _ _no ______________________
Pipe _ _ _ _ yes _ _ _how often a day _ _ _no ______________________
Chewing Tobacco _ _ _ yes _ _ _how often a day _ _ _no ______________________

Appendix D: Publication Letter

157 Summit View Drive

McDonough, Georgia 30253
USA

Telephone: 770-898-7910 or 770-940-0385

Ethnicity & Disease
Official Journal of ISHIB

November 4, 2013

Musa Mathunjwa
University of Zululand
KwaDLangezwa 3886 South Africa

Dear Dr. Mathunjwa,

Congratulations! Your manuscript, **MS #12-144** titled **"A 10-week aerobic exercise program reduces cardiometabolic disease risk in overweight/obese African female university students"** has completed the review process employed by the editorial board of *Ethnicity & Disease*. Your submission is tentatively schedule to be published in 2013 Volume 23 No 2 or Volume 23 No 3 of the journal. Please return the enclosed copyright transmittal agreement signed by all authors to our office as soon as possible. Your manuscript will be proofread and a galley proof will be sent to you. Note that the publisher will assess you a nominal fee for any changes you choose to make at the page-proof stage. You will receive correspondence from the managing editor near the time of publication.

We would also like to invite you to submit a brief (approximately 500 words), patient-friendly summary of your article for concurrent publication. This summary should emphasize the results of your work and link them to real-world health concerns, in a writing style and technical level that could be easily understood by a high-school graduate. Your summary will be published—with other summaries—in a special "For the Patient" section of the journal and may be made available for the general public to access electronically from our website. Please forward an electronic file to terry-jackson@ishib.org or ethndis@ishib.org within 2 weeks after receiving your acceptance letter.

Our most powerful tool to improve the health of all people is education. For 23 years our journal has been a potent educational tool for healthcare professionals, and our next step will be to extend this education to those who, ultimately, need it most. If you have any questions, please contact Terry E. Jackson, Asst. Managing Editor at 770-898-7910 or 770-940-0385 or via email to terry-jackson@ishib.org. Thank you for your interest in *Ethnicity & Disease*.

Sincerely,

Keith C. Norris, MD
Editor-in-Chief