Chapter One

Introduction and Literature Review

1.1 Introduction

A longstanding assumption has been that chronic and non-communicable diseases (NCDs) exist primarily in developed countries while communicable diseases (CDs) exist primarily in developing countries. In recent times, this assumption has proven incorrect as some developing countries have a large portion of their population facing a serious risk of chronic diseases due to the adoption of first world culture and lifestyle. As chronic and non-communicable diseases are often less visible, progress slowly, and are underdiagnosed, the reflected impact on the global burden is not overtly obvious (1).

Diseases of the western culture centre around personal lifestyle decisions with three main drivers being overnutrition, lack of physical activity and substance (tobacco and alcohol) abuse, which together or singly lead to obesity, Type 2 diabetes mellitus (DM) and hypertension (2). For decades medical research has focused on coronary artery disease (CAD), DM, hypertension and obesity as individual diseases. However, as urbanisation increases and the world becomes more industrialised, it is apparent that these conditions, together with physical inactivity have become more widespread, accounting for the major burden of disease in many westernized countries (2). Furthermore, the contribution of insulin resistance which may be induced directly by obesity may result in altered functions of insulin target cells (3). This target cells secrete pro-inflammatory mediates which heralds the beginning of the inflammatory milieu, translating into an increase in the prevalence of cardiovascular (CV) risk factors. When CV risk factors cluster together, the Metabolic Syndrome(MS) manifests, characterised by anthropometric as well as biochemical abnormalities (4). Diagnosis and treatment is complicated as the components vary, based on definition and ethnicity (5). The prevalence of MS in African countries is becoming unreasonably common; this is especially clear where the prevalence and patterns of diseases vary because of inherent cultural differences(4), (6).

Recent data indicate that the burden of disease in developing countries are on par with the western world (1), with the main determinants being obesity and insulin resistance, which is thought to be driven by physical inactivity (7). Coupled with a high susceptibility for the development of CV risk factors, it is anticipated that the prevalence of MS would be of epidemic proportions, placing tremendous additional burden on an already poorly resourced healthcare system (8).

1.2 Literature Review

1.2.1 The changing epidemiology of Cardiovascular Disease

To date, cardiovascular disease (CVD) remains one of the leading causes of morbidity and mortality worldwide, particularly in the developed world. In 2008, 57 million deaths were reported globally, with CVD accounting for 17.3million (30%) deaths per year, and myocardial infarcts and strokes responsible for 7.3 million deaths and 6.2 million deaths, respectively (9). There are now several reports which have emerged that show that CVD and its association with NCDs are major contributors to the burden of disease in developing countries (10).

The incidence of lifestyle related diseases has increased rapidly resulting in chronic NCDs having a major economic impact on individuals, families, the health system and society at large (10). As fewer people seek treatment, this has led to an increase in the morbidity and mortality rates from potentially preventable diseases (11). Non-communicable diseases accounted for 36 million (63%) of deaths globally in 2008 (9), affecting people in their productive years with a resultant decrease in productivity and earning capacity (10). Treatment of chronic diseases adds additional strain to an already overburdened health system because of the further costs and additional resources required (10). The burden is not just consequent upon adults, but also on the younger generation due to the effects of urbanisation (6).

1.2.2 The effects of urbanisation on risk profiles

Epidemiologic transitions are associated with the development of NCDs related to lifestyle, and are often characterised by a shift in communicable diseases and nutritional deficiencies to chronic diseases. Countries within Sub-Saharan Africa have experienced one of the most rapid epidemiological transitions driven by increased urbanisation and changed lifestyle factors, which in turn have also raised the incidence of NCDs, especially CVD (11). These transitions have created enormous public health challenges, and failure to address these problems may impose significant burden for the health sector and the economy of Sub-Saharan African countries. Urbanisation and economic development have also led to the emergence of a nutritional transition characterised by a shift to a higher caloric content diet and/or reduction of physical activity. Body habitus has played a vital role in tracking changes of lifestyle and the implications towards developing chronic diseases. However, as the epidemic intensifies, the need to modify anthropometric measures for more accurate assessments is essential to better manage lifestyle disease, particularly cohorts of different ethnic origin (12).

In South Africa, chronic diseases of lifestyle together with undernutrition and socio-economic conditions account for 28.5% mortality rate for all South Africans between the ages of 35 and 65 years (13). South Africa is in the unique situation of having an estimated 56% of its population living in an urban environment (10). As a result of the rapid increase in urbanisation, there has been a shift in the health patterns which contribute to the prevalence of NCDs (2). Many of the previously disadvantaged communities are undergoing rapid epidemiological, nutritional and demographic transitions. Astonishingly, more than 56% of all South Africans between the ages of 15 years and 65 years have been shown to have at least one risk factor for chronic diseases of lifestyle which is directly related to the demographic transition and changing lifestyle patterns associated with urbanisation (2). By 2020, it is anticipated that the burden of disease will increase by 120% of women and 137% for men for mortality by CV risk factors (11). However within South Africa itself, ethnicity plays a role in the

predisposition for the development of CV risk factors due to unhealthy lifestyle behaviour.

1.2.3 Ethnicity

In addition to degrees of urbanisation, social and economic conditions and nutrition transitions, ethnic and cultural subgroups also contribute significantly to the diversity within countries (14). For instance, the phenotype of obesity in several ethnic groups in developing countries appears to be different from that seen in Caucasians in developed countries. To illustrate, Raji et. al. (15) studied Asian Indians and Caucasians in which each individual was perfectly matched to another individual of the opposite group in terms of age, gender and body mass index (BMI). The results showed that Asian Indians had a significantly elevated fasting insulin and slightly higher fasting glucose than the Caucasian group. Although there were no significant differences in waist circumference (WC) measurements between the two groups, Asian Indians had a significantly greater total abdominal fat and visceral fat content (15). The research demonstrated that despite being healthy and of normal weight, Asian Indians were insulin resistant when compared to the Caucasian group. They also had lower high density lipoprotein (HDL) cholesterol and higher triglyceride and low density lipoprotein (LDL) levels. Although the BMI in both groups were average, the higher insulin resistance amongst Indians suggests that their adipose distribution was more visceral than general (15).

This was further substantiated by several other investigators, who also showed that body fat is higher in Asians, particularly south Asians, when compared with Caucasians for a similar level of BMI. Nishida et. al (2004), established that Asian Indians had higher deposits of visceral fat, which is associated with metabolic abnormalities (14), as compared with subcutaneous fat. Almost one fourth to one third of the urban population of India has been shown to have this body composition, manifesting with metabolic abnormalities and contributing to the development of cardiovascular disease (14).The International Day for Evaluation of Abdominal Obesity (IDEA) study showed that the highest prevalence of abdominal obesity (as assessed by waist circumference) was in South Asians compared with North Europeans and other Asian ethnic groups. Of note,

30.9% of men and 32.8% of women in the industrial population in India were reported to have abdominal obesity (16).

The prevalence of abdominal obesity has also shown to be on the increase in developing countries (16). Steyn and Bradshaw (2001) who conducted a surveillance of NCDs within South Africa found that 16% of adult women and 13% of adult men were hypertensive and there was an increased prevalence of obesity among women (29%) as compared to men (9%). Smoking and alcohol consumption were higher with men (52% and 45%) compared to women (17% and 17%) respectively (17).

Within the diverse population of South Africa, the incidence of disease differs amongst different ethnic groups. According to the technical report from the Medical Research Council (2007), respiratory disease was highest in the Coloured group followed by the African population. Caucasians were more prone to developing cancers and Africans had a high incidence of stroke and end stage renal failure (18). Asian Indians however were more prone to the development of CVD, hypertension and diabetes mellitus. This is thought to be due to their high genetic predisposition to CVD (15).

Recent data shows that other South African population groups are also showing an increased prevalence of CV risk factors (18). Less prudent dietary intake and lifestyle habits are believed to be contributory factors to the development of these conditions. In addition, occupational physical inactivity is at “its” highest level with most manual labour now being operated by machinery and thus the health benefits derived from such labour are now not experienced (19). This in turn has translated into the development of abnormal body morphometric measurements like increased waist and neck circumferences.

1.2.4 Anthropometric Measurements as a risk marker

Joubert et. al. (20), stated that underweight and undernutrition previously dominated the public health sector. Historically, obesity and excess body weight were regarded as "western" problem, but it is now recognised as a leading risk factor for disease in middle-income countries and in lower-income countries (20). It is now acknowledged that excess body weight is associated with an increase in the risk of CV disease and, in the last ten years has become a global crisis (20).

Addressing overweight and obesity has dominated health research aimed at preventing chronic diseases of lifestyle. This calls for population studies of body habitus before strategies to combat lifestyle patterns can be designed. More recent data have suggested that the current cut-offs for defining overweight and obesity are not suitable for Asians since Asians are at risk of developing lifestyle related disease at lower levels of measurements as discussed earlier (21). Thus new cut-offs to identify ethnic-specific measurements were developed in an attempt at detecting elevated body mass index and waist circumference as early risk factor markers (21).

1.2.4.1 Anthropometric measures of Obesity

BMI assesses weight relative to height and has been routinely employed in research settings for decades to identify individuals and populations at risk of future cardiovascular disease and diabetes. An increase in BMI beyond 25kg/m^2 is associated with an increased risk of hypertension, hypercholesterolemia, and CAD (22). Obesity and central body fat influences the risk of DM, CV morbidity and premature death and increasing mortality rates are associated with a BMI greater than 30kg/m^2 (12), (23). However, BMI fails to distinguish between body fat, muscle mass or bone (23) and because of this lack of accuracy in the assessment of body fat, there has been a growing amount of research to find other measures of fat percentage (24). More recent evidence suggests that abdominal (visceral) adiposity is a superior risk factor for cardiovascular and metabolic diseases than general (subcutaneous) adiposity (24). Although BMI

correlates well with other parameters such as waist and hip circumferences, the use of a combination may be better in identifying individuals at risk of CVD (21). It was further suggested that BMI and waist circumference should be used together with equal importance for the screening of cardiovascular and metabolic risk (21).

The current World Health Organisation (WHO) weight criteria based on BMI (table 1.1) was developed using the Caucasian population and may not apply to all ethnic groups. Recent research has shown that Asian Indians are more prone to developing insulin resistance and cardiovascular disease at lower levels of BMI. Asian Indians have a higher body fat percentage, abdominal adiposity at lower or similar BMI levels as compared to Caucasians. New cut-offs have been proposed by the WHO (table below) specific for Asians (21). These new cut-offs have serious implications for the predications of obesity and overweight in Asians, resulting in higher prevalences of obesity than was previously reported making it necessary for revised epidemiologic data in this group.

A more reliable measure of fat content than BMI is the actual distribution of body fat (25) which is measured by skin fold thickness at different sites of the body, however it is a limitation as only trained personnel can do proper measurements. Other measurements of fat distribution have been used to determine patterns of overweight but the simplest measure appears to be WC, which has been shown to be an independent risk factor for cardiovascular disease, with the cut-off values for high risk being 102 cm and 88 cm in men and women, respectively (26). Like the BMI, these WC cut-offs were also developed using the Caucasian population. As mentioned earlier, Asians appear to have a higher morbidity at lower cut-offs than Caucasians (27).

Table 1.1: Waist Circumference and Body Mass Index criteria

	Waist Circumference (cm)	WHO BMI Criteria (kg/m^2)	WHO Modified BMI Criteria (Asian Specific) (kg/m2)
Normal/ Healthy	M<94 F<80	18.5-24.9	18.0-22.9
Overweight /Increasing risk	M 94-102 F 80-88	25.0-29.9	23.0-24.9
Obese/ High risk	M>102 F>88	>30	>25

Modified from Van Der Merwe; 2004 (27) and Misra; 2009 (21)

1.2.4.2 Measures of subcutaneous fat

People grow and develop central patterns of body fat into the diseases they will suffer at a later stage of their lives (28). Excess fatness in most epidemiologic studies has been defined on the basis of overweight or obese according to BMI criteria (Table 1.1). However, it has often been debated whether BMI represents body fat adequately. Therefore it remains an open question as to whether the definition of obesity should be based on BMI or other measures of body fat. A better measure of overall body fat content is needed to measure peripheral fat mass (28) . Skin fold thickness, a measure of peripheral fat, has been found to correlate with overall body fat percentage.

Neck circumference, another marker for upper-body subcutaneous fat, has recently also been used to identify overweight and obesity. Neck circumference is considered as an index of upper body obesity and correlates positively with changes in systolic and diastolic blood pressure (29). There is evidence that neck circumference might have complementary clinical value to other body measurements with published studies demonstrating that increased neck circumference surpasses waist circumference as a marker of both visceral obesity and insulin resistance (28). There is very little local data on measures of body fat distribution in the South African community which is in the process of an epidemiological process leading to a change in disease patterns.

1.2.5 Evolution in Lifestyle and Behaviour

Several lifestyle-related factors account for the changing patterns which have resulted in a rapid increase in the incidence of lifestyle-related diseases (4). These risk patterns include changes in diet, smoking habit and physical activity patterns, which together with hypertension, diabetes and dyslipidaemia, account for 89.2% of the risk for myocardial infarction in South Africans (30). In South Africa, these conditions not only contribute to the increase in medical and health care costs but to the loss of productivity as well.

Tobacco smoking is responsible for a larger burden of premature morbidity and mortality causing 4.8 million adult deaths worldwide (31). In the INTERHEART Study, smoking was the risk factor with the highest hazard ratio for myocardial infarction (30). Worldwide, it is well established that males are more likely to smoke than females, and older males (age 30-49) are more likely to use tobacco products than younger males (11). Of interest, smoking prevalence is increasing among men and women in Sub-Saharan Africa (11). This was demonstrated in a local study of young patients with myocardial risk which showed that at least 81% of men presenting with MI were smokers (32). In a survey of deaths attributable to tobacco use in South Africa, ischemic heart disease comprised an estimated one-third of all vascular deaths, with smoking contributing to 20% of vascular deaths (31).

Similarly, the contribution of dietary patterns and alcohol intake to body physical characteristics has not been closely examined (33). South African diets are rich in unhealthy foods, as illustrated by a national survey among youth, which reported that learners frequently consume fast foods (38.8%), cakes and biscuits(47.4%), cool drinks and sweets (52.0%) at least four days a week (10). High dietary intakes of saturated fat, trans-fats and salt and low intake of fruits, vegetables and fish are linked to cardiovascular risk. Approximately 16 million of deaths worldwide are attributable to low fruit and vegetable consumption. Adequate consumption of fruit and vegetables reduces the risk of CVD. Examining the dietary patterns in the community setting will be

extremely useful in determining the predisposition to obesity and dyslipidaemia and how it relates to cardiovascular risk (34).

Alcohol accounts for nearly 10% of the calorie intake amongst adults who drink (35). To what extent alcohol intake contributes to obesity is dependent on individual characteristics including body weight, diet, genetic factors, gender and physical activity levels as well as frequency, pattern, amount of consumption and types of drinks consumed. The consumption of beer has been positively associated with an increase in waist circumference in males but not in females (36).

In addition to dietary patterns, low levels of physical activity have been associated with obesity, although physical activity only weakly predicts gain in body weight (37). Ekelund et.al.(38) conducted a study in ten European countries to determine whether physical activity independently predicts gain in body weight and abdominal adiposity. A total of 48.8% of men and 59.1% of women were categorized as inactive or moderately inactively at baseline. There was a clear increase in waist circumference across physical activity categories in men and women across age groups (38). This suggested that even relatively small changes in physical activity may have beneficial effects on central adiposity (37). Fox and Hillsdon stated that even in a case of severe overweight and obesity, participating in physical activity substantially reduces disease risk (39). Epidemiological studies have demonstrated that moderate-vigorous daily physical activity prevents both the incidence of chronic diseases and premature death (40). Indeed physical inactivity was cited as 1 of 9 major contributors to heart disease mortality worldwide in the 2004 INTERHEART study (41). It is also well documented that habitual leisure-time activity prevents elevated blood pressure, insulin resistance, glucose intolerance, elevated triglycerides, low levels of HDL and decreases body weight, preventing the development of CAD, DM and MS (40). Public health recommendations regarding the type and amounts of physical activity needed to improve and maintain health benefits among adults have been established in the USA (42), but are severely lacking in the South African environment.

Epidemiologic investigation into the health effects of a “sedentary lifestyle” has customarily focused on the adverse effects associated with a lack of participation in recommended levels of exercise, or moderate-vigorous physical activity. Time spent in sedentary behaviour has a significant effect on reducing overall physical activity with its potential adverse consequences. Time spent in sedentary behaviour reflects a wide range of pursuits that involve sitting or reclining and only low levels of energy expenditure (43).

Omar and Motala (1996) suggested in their research that obesity played a significant role in developing DM especially in Indian females (44). Overweight and obesity are the driving force behind the global diabetes epidemic and affect the majority of adults in most developed countries. Statistics show a rapidly increasing prevalence of obesity in developing countries such as India which is directly linked to obesity-related co-morbidities. Almost 30-65% of adults living in urban India are either overweight, obese or have abdominal obesity (21). The IDF reported that diabetes affects at least 285 million people worldwide with two-thirds of incidences occurring in low-to middle income countries (45). In South African Indian diabetics, two-thirds of patients reported a positive family history of diabetes which was more common in an obese than in the non-obese (44).

Obesity and diabetes have a complex and strong association, and are emerging pandemics of the 21st century. The risk of developing both diseases increase as BMI and waist circumference increases (46). It is important to distinguish that all individuals who are obese may not develop diabetes and many individuals who are diabetic, are not all obese, and in fact many have a lean body structure (47). The risk for developing diabetes is higher with weight gain in early adulthood than it is with weight gain between ages of 40 and 55 years (41). This is evident in current studies which show an increase in the prevalence of obesity in the young as a consequence of the reduced physical activity. Physical activity is the most important determinant of energy expenditure (48). Several studies have shown an association between physical activity and the dietary intake of adolescents and adults (49). In fact there is also a strong link between physical

activity, dietary intake and insulin resistance particularly in the young (50).To maintain energy balance: lower levels of physical activity should be accompanied by lower caloric intake. Dietary behaviours that have been associated with lower BMI include the consumption of fruit and vegetables.

Physical activity can also play an independent role in the prevention of DM separately from its effects of weight loss and body composition. Research on exercise and training have supported the contention that physical activity improves insulin sensitivity independently of any effect of activity on weight loss and fat distribution (49). Surprisingly few studies have examined the interaction between physical fitness and obesity and their association with DM. Greater adiposity and a sedentary lifestyle are independent risk factors for the development of DM. Obese individuals develop resistance to the cellular actions of insulin, characterized by an impaired ability of insulin to inhibit glucose output from the liver and to promote glucose uptake in fat and muscle (51). Changes in the dietary habits with westernization are often accompanied by decrease in physical activity with resultant obesity, and the development of insulin resistance and diabetes (51), (52).

A recent cross-sectional study of 1514 men and 1528 women without CVD explored the relationship between physical activity level, measures of adiposity, insulin sensitivity, as well as fasting blood glucose and insulin levels (51). Both physical activity and adiposity were found to be independent predictors of insulin sensitivity. A sedentary lifestyle was associated with a significantly higher blood glucose and insulin levels as well as lower insulin sensitivity. Overweight or obese individuals in the most physically active group had fasting glucose levels and insulin sensitivity similar to those of subjects who were lean but inactive.

Levels of physical activity have been linked to diabetes. A 2003 survey of 23 283 adults, of whom 1825 (7.8%) reported being diagnosed with diabetes, compared the prevalence of physical activity in diabetics and non-diabetics (53). Being physically active was defined as ≥30 minutes of moderate or vigorous activity, 3 times per week. Only 39% of diabetics were physically active compared to 58% of non-diabetics, a difference that was statistically significant. Being physically active was associated with

a lower prevalence of diabetes at any BMI. However, being overweight (BMI, 25-29.9), obese (BMI, 30-39.9), or extremely obese (BMI, ≥40) was associated with an increasingly greater prevalence of diabetes regardless of physical activity level (53).

There is also a significant association between obesity and blood pressure; with studies showing an increase in blood pressure with an increase in weight over time. Kotchen et.al. (2010), showed that obese individuals had a 3.5-fold increased possibility of having hypertension and 60% of hypertensive adults were overweight (54), while in the Framingham study, approximately 78% of the hypertension cases in men and 65% in women could be directly attributed to obesity. A 5% increase in weight was associated with 20-30% increase in hypertensive incidence (55, 56). Most studies suggest that abdominal obesity is a more important determinant of blood pressure elevation than peripheral body fat but peripheral fat also increases the risks for insulin resistance and dyslipidemia (54, 56).

Research in hypertension is currently investigating a new term “prehypertension”. This term is designated to individuals with a systolic blood pressure between 120-139 mmHg and a diastolic blood pressure between 80-89 mmHg. The introduction of prehypertension was developed as the risk of developing cardiovascular disease increases progressively with higher levels of blood pressure that are still within the ‘normal’ or the ‘normal-high’ range. The prevalence of insulin related abnormalities is frequent amongst individuals with prehypertension and this suggests that insulin resistance may be common to individuals with prehypertension and play a role in developing cardiovascular disease (57).

1.2.6 The Metabolic Syndrome

Clustering of metabolic abnormalities in association with obesity and hypertension has long been recognised as the Metabolic Syndrome (54). The prevalence of MS in adults is reaching epidemic proportions worldwide (4, 58-60). Over the past two decades, there has been a remarkable increase in the number of people with metabolic syndrome. In the USA, between one in three or one in five American adults currently have MS depending in the definition used. This factor is important because MS carries a two-fold increase in coronary disease mortality and 40% increase in all-cause mortality (61). The MS is no longer restricted to developed countries as previously thought. The transition to Western culture has now exposed developing countries to this epidemic as well.

Okafor (2012) stated that the prevalence of metabolic syndrome in African populations ranged from 0-50% depending on the population settings (6). There is limited data on the prevalence of MS in South Africa. Slabbert (2011) has shown that one in four South Africans may already have MS according to a recent survey (62). Erasmus has reported a much higher (55%-60%) prevalence of metabolic syndrome in the coloured population of the Western Cape (63). A much lower prevalence of 20-25% has been reported amongst Indian immigrants (60). Although the exact cause for this is not known, it is attributed to the high incidence of abdominal obesity and insulin resistance in this group. The established risk factors in Asian Indians which predispose them to develop various components of MS include: abdominal obesity, high prevalence of DM, hypertension, low concentrations of HDL, hypertriglyceridemia, hypercholesterolemia and sedentary lifestyle (64). This may account for the fact that migrant South Asian population have demonstrated a three-to-five fold increase in the risk for myocardial infarction and CV death when compared to other ethnic groups (14). This high risk for myocardial infarction suggest that the risk factor profiles of these communities may have change and calls for a review of the risk factor profile in the South African Indian community.

1.3 Rationale

The risk for CVD is dependent to a large extent on behavioural and psychological circumstances. The differences in lifestyle behaviour and attitudes among low income communities are poorly understood and the prevalence of physical inactivity, health beliefs and knowledge of the risks of inactivity has rarely been assessed across a wide range of developed and developing countries (65). Furthermore, it is known that the presence of common metabolic disorders is associated with physical inactivity, obesity, poor dietary intake and this in turn, are associated with increased in CV risk and MS. Considering the widespread prevalence of MS, and its projected rise, it would be desirable to predict/detect the metabolic status in subjects without the need for much invasive blood sampling. This study therefore aimed to identify markers of MS which are easily accessible and inexpensive to adopt in clinical settings. In addition, this study also aims to define the CV risk profile, especially the influences of the physical activity in determining body habitus. Another objective was to assess whether anthropometric measurements and physical activity affect the CV risk factor profile.

Chapter Two

2.1 Aim and objectives of the study

The aim of the study is to relate physical activity to the body morphometrics. The specific objectives are:

1. To describe the physical activity, behavioural and dietary patterns of adults in the Phoenix community
2. To describe the body anthropometric measurements (waist , waist/hip, BMI and triceps skin fold thickness) of adults in this community
3. To correlate the physical behaviour patterns with the anthropometric measurements
4. To assess the association between the physical behaviour patterns and the anthropometric measurements, and presence of metabolic syndrome as defined by NCEP ATP III and IDF criteria.

Chapter Three

Methodology

3.1 Plan of the Phoenix Lifestyle Project

The Phoenix Lifestyle Project entailed selecting residences from the community of Phoenix to participate in a study aimed to determine the cardiovascular risk factor profile of this Indian community. Field workers selected participants between age groups 15-65 according to the Kish Table (Appendix A) and excluded subjects who were bed-ridden or physically disabled, pregnant/ lactating and unable to give inform consent were excluded from the study. Consenting participants were subsequently interviewed using the WHO Steps questionnaire, which focused on the overall lifestyle of the participants. Appointments were then made for the participants to attend the lifestyle clinic at the Inkosi Albert Luthuli Central Hospital. On the day of the appointments, the study bus transported participants to the LIFESTYLE CLINIC at the hospital and back home. Details of the questionnaire as well as other testing are explained below. Echocardiography and 12 lead Electrocardiogram recordings were also performed and will be reported elsewhere.

3.2 Detailed Methodology

3.2.1 Study population and Sampling strategy

In this study, 2500 households were randomly selected from the last population census for Phoenix by a statistician using computer software. Phoenix is divided into 25 districts with the number of households varying in each district. The 2500 household addresses were randomly selected by the statistician and were then allocated a Kish table. A group of ten field workers underwent training in the administration of the questionnaire and

then visited the selected households where they applied the Kish table to select participants. Briefly, participants between age groups 15-65 in each household listed according to gender and age, and the one eligible for study was selected according to the Kish Table.

There were 1400 subjects who completed the evaluation. Two hundred and forty-six participants completed the Step 1 Questionnaire but did not attend the hospital for the measurements and blood sampling.

3.2.2 Administration of the STEPS Questionnaire (Appendix B)

At the initial visit the recruitment was done by trained field workers. If the selected individual agreed to participate in the study then informed consent was sought. Thereafter the field worker visited the participant as per appointment and completed STEP 1 of the STEPS questionnaire (demographic information and behavioural measurements). For this study, a modified STEPS Instrument for NCD Risk Factors, Version 1.3a.Questionnaire (Appendix B) was used (66). The questionnaire was modified to include the triceps skin fold measurement. After the questionnaire was applied, an appointment was made for the participant to attend the Lifestyle Clinic at the Inkosi Albert Luthuli Central Hospital where blood samples were taken and body measurements performed (Table 3.1)

Table 3.1 Study Plan: The Questionnaire and Investigative Assessment

DEMOGRAPHICS • Sex • Age	**TOBACCO USE** • Smoking in pack years
ALCOHOL CONSUMPTION • Average amount of alcohol in a single intake • Average for a year	**DIET** • Determine intake of fruit and vegetables • Fats and oils used to prepare meals • Salt Intake? • Carbonated Drinks? • Fast foods and take-away
PHYSICAL ACTIVITY • Determine hours spent at work, during travel and performing recreational and sedentary activities	**FAMILY HISTORY** • Obesity • Hypertension • Diabetes • Myocardial Infarction • Coronary Artery Disease • Peripheral Artery Disease Congestive Heart Failure
PHYSICAL MEASUREMENTS • Height Measurement • Weight Measurement • Blood Pressure (3 Readings) • Waist Circumference • Hip Circumference • Neck Circumference • Mid-Arm Circumference • Triceps Skin Fold Thickness (2 Measurements)	**BIOCHEMICAL MEASUREMENTS** • Fasting and 2hr Glucose • Fasting and 2hr Insulin • Total Cholesterol • Triglycerides • High Density Lipoprotein • Low Density Lipoprotein

3.3 Anthropometry Measurements

On the appointed day, the participant was transported by the project bus to the Lifestyle Centre where physical measurements, testing and blood sampling were performed. The following tests were performed:

Height was measured to the nearest 0.1 cm using a metal measuring tape applied to wall and a flat headboard at right angles to the wall to ensure correct reading. The subjects were measured without shoes, heels against the wall and the angle of the eye will be level with the external auditory meatus. Weight was determined to the nearest 0.5kg on a good quality balance scale with the subject in light clothing and without shoes. The scale was calibrated at the beginning of the study. Neck circumference was measured perpendicular to the major axis of the neck at the height below the laryngeal prominence (Adam's apple) using a non-stretchable tape. Mid-upper-arm circumference was measured from the acromion process to the olecranon process and a midway circumference was recorded to the nearest 0.1cm. Waist circumference was measured with the subjects standing comfortably. The smallest circumference between the xiphisternum and the iliac crest on expiration was taken as the waist circumference. Hip circumference was measured on the broadest diameter between the waist and the thigh. Care was taken that the tape measure was absolutely horizontal. One centimetre was deducted from this measurement to take the thickness of the clothing into account. Triceps skinfold thickness was measured on the marking of the mid-arm measurement with the arm held freely to the side of the body. Skinfold measurement were performed on the right side of the body.

3.4 Blood pressure and heart rate

Subjects were seated for at least 5 minutes prior to recording the blood pressure. The blood pressure was taken on 3 occasions at 1-minute intervals. The lowest diastolic with its matching systolic measurement were used for analyses.

3.5 Biochemistry

Fasting blood samples for lipids, glucose and insulin estimations were drawn from the cubital vein with minimal stasis. Thereafter each participant ingested 75g glucose

monohydrate in 250ml water over a 2-minute period or longer (approximate). A further blood sample for glucose and insulin estimation was drawn 2 hours later. Blood samples were delivered within a maximum of one hour of collection to the Chemical Pathology Laboratory at the hospital.

3.6 Metabolic Syndrome Criteria

In this study we focused on two international definitions of MS: National Cholesterol Education Programme Adult Teaching Panel III (NCEP ATP III) and International Diabetic Federation (IDF). IDF definition modified their definition regarding the waist circumference concluding it to be ethnic specific.

Table 3.2: The Metabolic Syndrome Criteria

	NCEP ATP III **(any 3 risk factors)**	IDF **(WC + any 2 risk factors)**
Central obesity: WC	≥102cm (males) ≥ 88cm (women)	≥ 90 cm (males) ≥ 80 cm (females)
Dyslipidaemia: TG	1.7mmol/L	*1.7mmol/L
Dyslipidaemia: HDL-C	<1.03 mmol/L (male) < 1.29 mmol/L (female)	*<1.03 mmol/L (male) *<1.29 mmol/L (female)
Blood Pressure	≥ 130/85 mmHg	*≥ 130/85 mmHg
Fasting glucose	≥ 6.1 mmol/L	*≥5.6 mmol/L

*For IDF: alternatively subject may be on treatment

3.7 Statistics: Data analysis

Descriptive statistics (means, medians, standard deviation (SD) an interquartile range (IQR) were used to describe continuous variables in the entire sample. Frequency counts and percentages were used to describe categorical variables. Pearson's correlation analyses were used to correlate continuous physical behaviour variables with anthropometric measurements. Mann-Whitney U or Kraskal-Wallis tests were used to compare continuous variables between groups, while Pearson's chi square test was used to compare between groups when the variables were categorical. Subjects were classified into those with and without metabolic syndrome using both NCEP panel and IDF criteria. Cut-off points for the determination of normality were determined for waist and BMI indices in this population and the relationship of physical activity to these parameters was determined. Stratified analysis of relationships between physical behaviour variables and anthropometric variables were carried out. Receiver operating characteristic (ROC) curves were generated to assess the extent of the diagnostic properties of certain variables on metabolic syndrome. Unadjusted and adjusted logistic regression analysis was performed with metabolic syndrome as the dependant variable in order to achieve the last objective. Independent variables included were physical behaviour variables, anthropometric variables, and any confounders identified, with the aim establishing the independent effects of these variables on metabolic syndrome. All data was captured on SPSS (version 16), which was also used for statistical analysis, along with SAS (version 9.3).

Chapter Four

Results

4.1 Demographic characteristics of the study sample

Table 4.1: Demographic Data

Age Group	Male (%)	Female (%)	Total
15-24 yrs.	49 (15,5)	66 (7,9)	115 (10,0)
25-34 yrs.	44 (13,9)	84 (10,0)	128 (11,1)
35-44 yrs.	67 (21,1)	190 (22,7)	257 (22,3)
45-54 yrs.	68 (21,5)	283 (33,8)	351 (30,4)
55-64 yrs.	89 (28,1)	214 (25,6)	303 (26,3)
Total	317 (100,0)	837 (100,0)	1154 (100,0)

There were 1154 subjects in this study, 317 males (28 %) and 837 (72 %) females. There were over 100 subjects who comprised the first two groups, and thereafter the numbers increased to approximately 300 in each group, with females being predominant in each group.

Table 4.2: Weight (kg) per age group

Age Group	Male		Female		Total		P value
	Mean	SD	Mean	SD	Mean	SD	
15-24 yrs.	63.0	15.4	59.7	19.4	61.1	17.8	0.964
25-34 yrs.	74.5	16.7	75.4	21.3	75.1	19.7	<0.001
35-44 yrs.	72.4	14.3	73.2	17.4	73.0	16.6	<0.001
45-54 yrs.	73.4	12.7	72.0	14.3	72.3	14.1	<0.001
55-64 yrs.	70.8	15.3	70.8	14.3	70.8	14.5	<0.001
Total	71.0	15.2	71.3	16.7	71.2	16.3	≥0.092

The mean body weight was similar in males and females (71.0 ±15.2kg vs. 71.3 ±16.7kg; p=0.964). In this cohort, there was a statistically significant 14 kg increase in weight

from the first age group (15-24yrs.) onwards ($p<0.001$). The mean weight appeared to stabilise in the older age groups ($p\geq0.092$).

Table 4.3: BMI Criteria illustrating the WHO and WHO Modified Criteria

	WHO Criteria		WHO Modified Criteria (Asian-Pacific)	
	Number	**Percentage**	**Number**	**Percentage**
Underweight	60	5.2%	-	-
Normal	333	29.0%	200	18.2%
Overweight	367	31.8%	150	13.6%
Obese	390	33.8%	751	68.2%
***Total**	1150	100.0%	1101	100.0%

Footnote: *varies due to missing values

Using the WHO criteria based on Caucasians (21), only 29 % of subjects fell into the normal BMI category. The remaining subjects were categorized as either overweight (31.9%) or obese (23.9%). Using the modified criteria (which does not have an underweight category), the percentage of normal subjects (BMI < 23) fell further to 18.2%. The Asian-Pacific cut-off resulted in most participants being re-categorized into the obese category (68.2%).

Table 4.4: BMI Criteria with Gender

		Males		Females	
		Number	**Percentage**	**Number**	**Percentage**
WHO Criteria	**Underweight**	36	11.5%	24	2.9%
	Normal	132	41.9%	201	24.1%
	Overweight	106	33.7%	261	31.3%
	Obese	41	13.1%	249	41.8%
	***Total**	315	100.0%	835	100.0%
		Number	**Percentage**	**Number**	**Percentage**
WHO Modified Criteria (Asian Pacific)	**Normal**	87	30.4%	113	13.9%
	Overweight	54	18.9%	96	11.8%
	Obese	145	50.7%	606	74.4%
	***Total**	286	100.0%	815	100.0%

Footnote: * varies due to missing values

The WHO criteria showed that 33.7% of males and 31.3% of females were overweight with 13.1% of males and 41.8% of females being obese (Table 4.4). When the Asian-Pacific cut-offs were applied, the overweight category decreased to 18.9% in males and 11.8% in females while the obese category increased to 50.7% in males and 74.4% in females.

4.2 Cardiovascular risk profile of the sample

Table 4.5: Family History of Participants

		Male (%)	Female (%)	*Total (%)
Obesity	Yes	21 (6.7)	95 (11.4)	116(10.1)
	No	292 (93.3)	738 (88.6)	1030 (89.9)
Hypertension	Yes	215 (68.3)	664 (79.7)	879 (76.6)
	No	100 (31.7)	169 (20.3)	269 (23.4)
DM	Yes	205 (65.1)	578 (69.3)	783 (68.1)
	No	110 (34.9)	256 (30.7)	366 (31.9)
CAD	Yes	131(42.0)	422 (50.7)	553 (48.3)
	No	181 (58.0)	410 (49.3)	591 (51.7)

Footnote: DM= Diabetes Mellitus, CAD= Coronary Artery Disease, *varies due to missing values

There was a high prevalence of a positive family history of hypertension (76.6%), diabetes mellitus (68.1%) and coronary artery disease (48.3%) in this sample. Of interest, 89.9% of participants reported no family history of obesity.

Table 4.6: Fruit and vegetable intake per week per age and gender

Age Group	Gender	Fruit per week – Median (IQR)	Vegetables per week – Median (IQR)
15-24 yrs.	Male	2 (0-4)	3 (2-6)
	Female	2 (1-4)	5 (3-6)
25-34 yrs.	Male	2 (0-3)	4 (1-8)
	Female	2 (1-4)	6 (3-6)
35-44 yrs.	Male	1 (1-4)	4 (2-8)
	Female	2 (1-6)	6 (4-8)
45-54 yrs.	Male	2 (1-7)	6 (4-9)
	Female	3 (1-7)	6 (4-8)
55-64 yrs.	Male	2 (1-7)	6 (4-8)
	Female	3 (1-7)	6 (4-8)

There was a higher intake of vegetables in the older age group with females eating more vegetables than males.

Table 4.7: Dietary Habits of participants

Dietary Habits		Number	Percentage (%)
Type of Oil	Veg Oil	1130	97.9
	Other	24	2.1
	Total	1154	100
Additional Salt Intake	Never/Rarely	938	81.4
	Sometimes	215	18.6
	Total	1153	100
Carbonated Drinks	None in <30days	257	22.3
	<1 per day	592	51.3
	1 per day	153	13.3
	2 or more per day	152	12.2
	Total	1154	100
Food high in fat	Don't eat	209	18.1
	<1 per day	773	67.0
	2 per day	149	12.9
	3 or more per day	23	2.1
	Total	1154	100

Most participants used vegetable oil (97.9%) when preparing meals and 81.4% of participants indicated that they never or rarely used additional salt in their meals. Half of the participants (51.3%) reported having less than one carbonated drink per day while 22.3% indicating no carbonated drinks in the last month prior to interview date. The majority of participants in this cohort reported eating at least one meal with a high fat content per day (67%).

Table 4.8: Salt Intake and Median Blood Pressure for overall

	Additional Salt Intake	Median Systolic BP (IQR)	Median Diastolic BP (IQR)
Male	Never/Rarely	131 (120-145)	80 (72-89)
	Sometimes	132 (116-145)	82 (69-92)
	Usually	135 (116-152)	83 (72-93)
Female	Never/Rarely	131 (118-146)	81 (74-89)
	Sometimes	123 (114-144)	82 (71-90)
	Usually	133 (120-146)	82 (74-90)

There was no significant difference observed in males for systolic blood pressure (p=0.8772) or diastolic blood pressure (p=0.6795) between the different levels of salt intake. A similar trend was observed in females for systolic (p=0.2267) and diastolic blood pressure (p=0.7382).

Table 4.8.1: Salt Intake and Median Blood Pressure for participants aged less than 45 years

Gender	Additional Salt Intake	Median Systolic BP (IQR)	Median Diastolic BP (IQR)
Male	Never/Rarely	125 (117-136)	75 (70-86)
	Sometimes	128 (110-136)	81 (67-90)
	Usually	126 (110-147)	79 (65-98)
Female	Never/Rarely	120 (111-134)	79 (71-87)
	Sometimes	123 (112-133)	76 (71-87)
	Usually	116 (108-138)	76 (67-87)

There was no significant difference observed in males for systolic blood pressure (p=0.9008) or diastolic blood pressure (p=0.7844) between the different levels of salt intake. A similar trend was observed in females for systolic (p=0.8980) and diastolic blood pressure (p=0.7921).

Table 4.8.2: Salt Intake and Median Blood Pressure for participants aged 45 years or older

Gender	Additional Salt Intake	Median Systolic BP (IQR)	Median Diastolic BP (IQR)
Male	Never/Rarely	140 (127-155)	85 (78-91)
	Sometimes	140 (124-149)	83 (74-94)
	Usually	138 (123-160)	86 (75-93)
Female	Never/Rarely	137 (125-153)	82 (76-91)
	Sometimes	142 (117-152)	84 (76-90)
	Usually	139 (129-150)	85 (78-93)

There was no significant difference observed in males for systolic blood pressure (p=0.9182) or diastolic blood pressure (p=0.9901) between the different levels of salt intake. A similar trend was observed in females for systolic (p=0.8273) and diastolic blood pressure (p=0.5382).

4.3. Behavioural and Lifestyle Patterns

Table 4.9: Behavioural Lifestyle

		Male	(%)	Female	(%)	Total	(%)	P value
Smoking	Yes	73	23.0	67	8.0	140	12.1	<0.001
	No	244	77.0	770	92.0	1014	87.9	<0.001
***Alcohol**	Yes	147	46.4	48	5.8	195	17.0	<0.001
	No	170	53.6	785	94.2	955	83.0	<0.001

Footnote: * varies due to missing values

The majority of participants did not smoke (87.9%) or consume alcoholic beverages (83.0%). There were significantly more males than females who consumed alcohol and smoked tobacco products (p=<0.001).

Table 4.10: Physical and Recreational Activity

		Male	(%)	Female	(%)	Total	(%)	P value
Physical Activity V	Yes	31	10	82	10	113	10	0.993
	No	286	90	755	90	1041	90	
Physical Activity M	Yes	101	32	351	42	452	39	0.002
	No	216	68	486	58	702	61	
Recreation V	Yes	54	17	33	4.0	87	8.0	<0.001
	No	263	83	804	96	1067	92	
Recreation M	Yes	44	14	80	10	124	11	0.034
	No	273	86	757	90	1030	89	

Footnote: Two levels of activity were noted: Vigorous (V) and Moderate (M)

Physical and recreational activity was measured at two levels: vigorous (V) and moderate (M). Only 9.8% of participants engaged in vigorous physical activity with 39.2% participating at a moderate level. Fewer women (4% vs. 17%) performed vigorous recreation activity levels than men (p<0.001).

Table 4.11: Physical exercise versus BMI

Variable	Correlation coefficient	p-value	Effect estimate (Standard error)	p-value
Hours of moderate exercise per week	-0.0271	0.3586	-0.0842 (0.0916)	0.3586
Hours of vigorous exercise per week	-0.1241	<0.0001	-0.4882 (0.1151)	<0.0001

Vigorous exercise was significantly associated with decreased BMI, with BMI being 0.5 m/kg^2 less for every 1 hour of vigorous exercise performed ($p<0.0001$). Moderate weekly exercise was not significantly associated with BMI decline ($p=0.3586$).

Table 4.12: Physical exercise versus Waist circumference

Variable	Correlation coefficient	p-value	Effect estimate (Standard error)	p-value
Hours of moderate exercise per week	-0.0294	0.3192	-0.2173 (0.2181)	0.3192
Hours of vigorous exercise per week	-0.1379	<0.0001	-1.2883 (0.2735)	<0.0001

Vigorous exercise was significantly associated with decreased waist circumference, with waist circumference being 1.3 cm smaller for every 1 hour of vigorous exercise performed ($p<0.0001$). Moderate weekly exercise was not significantly associated with BMI decline ($p=0.3192$).

Table 4.13: Body anthropometry per gender

Gender	MALES	FEMALES	
	Median (IQR)	Median (IQR)	P-values
BMI	24.72 (21.34 – 27.75)	28.63 (24.62 – 32.96)	p<0.000
Waist Circum.	91.00 (80.70 – 98.60)	96.90 (87.75 – 106.10)	p<0.000
Hip Circum.	95.00 (89.00 – 101.50)	104.50 (96.20 – 114.30)	p<0.000
Waist-to-Hip Ratio	0.94 (0.88 – 0.99)	0.93 (0.88 – 0.96)	p<0.000
Neck Circum.	37.00 (35.00 – 39.00)	34.00 (32.00 – 36.00)	p<0.000
Mid-Arm Circum.	31.00 (28.00 – 33.00)	33.00 (30.00 – 36.00)	p<0.000
Triceps Skin Fold	127.00 (92.00 – 172.00)	252.00 (205.50 – 301.00)	p<0.000

Although females had a higher BMI, waist circumference and hip circumference measurement than males their waist-to-hip ratio was lower (p<0.000). Males had a larger neck circumference than females and there was only a 2cm difference in the mid-arm circumference measurements (p<0.000). The triceps skin fold thickness measurement foe females was double that of the males (p<0.000).

Table 4.14 Body anthropometry per age group

Age Group	*BMI Median (IQR)	*Waist Circum. Median (IQR)	*Hip Circum. Median (IQR)	*Waist-to-Hip Median (IQR)	*Neck Circum. Median (IQR)	*Mid-arm Circum. Median (IQR)	*Triceps Skin Fold Median (IQR)
15-24	21.74 (18.51 -26.49)	77.20 (69.50 – 87.90)	92.30 (85.00 – 102.00)	0.84 (0.80 – 0.88)	33 (31 – 35)	28 (25 – 31)	142 (98 – 236)
25-34	27.52 (22.71 – 32.69)	92.80 (81.45 – 106.20)	103.00 (92.80 – 113.00)	0.91 (0.86 – 0.94)	35 (33 – 38)	33 (28 – 36)	219.50 (160.50 – 275.00)
35-44	28.12 (23.95 – 32.11)	94.60 (85.60 – 105.00)	103.00 (94.40 – 112.00)	0.92 (0.87 – 0.96)	35 (33 -38)	33 (30 – 36)	239. (160 – 298)
45-54	28.13 (24.97 – 32.25)	97.20 (89.70 – 105.50)	102.60 (96.00 – 113.00)	0.94 (0.90 – 0.97)	35 (33 – 37)	33 (31 – 36)	240 (190 – 297)
55-64	27.48 (23.94 – 31.65)	96.10 (89.00 – 104.00)	101.00 (94.00 – 110.00)	0.95 (0.91 – 0.98)	35 (33 – 37)	32 (29 – 35)	212.50 (153.00 – 270.00)

Footnote:*all values were p<0.000 for each age group. Age: years, Waist circumference: cm, Hip circumference: cm, Neck circumference: cm and Mid-arm circumferences: cm. Triceps skin fold: mm.

In the age group of 15-24 years, the BMI was within the normal and then increased to the level of obesity in the older age groups (p<0.000). There were drastic increases in the waist and hip circumferences from the first age group to the older groups (p<0.000). There was a 2cm increase in neck circumference and a 5cm increase in mid-arm circumference from age group 15-24 to the next age group of 25-34 thereafter stabilising (p<0.000).

Table 4.15: Metabolic syndrome: NCEP ATP III criteria (gender means)

	Males		Females		Total		P value
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Waist Circumference (cm)	100	10	103	13	102	12	0.590
Mean SBP (mm Hg)	145	18	143	25	144	24	0.370
Mean DBP (mm Hg)	88	12	86	11	86	11	0.047
Fasting Glucose (mmol/L)	7.52	3	7.54	3	7.54	3	0.813
Triglycerides (mmol/L)	2.68	1	2.20	1	2.29	1	<0.001
HDL Cholesterol (mmol/L)	1.00	0.24	1.19	0.24	1.15	0.25	<0.001
Metabolic syndrome n (%)	**97 (30.6)**		**421 (50.3)**		**518 (44.9)**		-

In this cohort, 44.9% of subjects were diagnosed with MS using the NCEP ATP III category. The mean values for each of the components of MS between males and females were similar, except for triglycerides which were higher in men and HDL levels which were lower in men compared to women (p= <0.001).

Table 4.16: Metabolic syndrome IDF criteria (gender means)

	Males		Females		Total		P value
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Waist Circumference (cm)	100	8	102	13	102	12	0.118
Mean SBP (mm Hg)	143	19	142	25	142	24	0.356
Mean DBP (mm Hg)	88	12	85	11	86	11	0.019
Fasting Glucose (mmol/L)	7.18	3	7.38	3	7.33	3	0.432
Triglycerides (mmol/L)	2.37	1	2.12	1	2.18	1	0.001
HDL Cholesterol (mmol/L)	1.09	0.65	1.20	0.26	1.18	0.38	<0.001
Metabolic syndrome n (%)	**128 (40.4)**		**465 (55.6)**		**593 (51.4)**		

Using the IDF category, there was an increase in the number of participants diagnosed with MS (51.4%). A similar trend of raised mean triglycerides and lowered values of HDL cholesterol seen in men (p=<0.001).

Table 4.17: Prevalence of criteria for metabolic syndrome (NCEP ATP III and IDF)

	NCEP ATP III MS		IDF MS	
	Yes (%)	**No (%)**	**Yes (%)**	**No (%)**
Waist Circumference (cm)	682 (59)	472 (41)	900 (78)	254 (22)
Triglycerides (mmol/L)	473 (41)	681 (59)	473 (41)	681 (59)
HDL Cholesterol (mmol/L)	524 (45)	630 (55)	524 (45)	630 (55)
Blood Pressure (mm Hg)	643 (56)	511 (44)	643 (56)	511 (44)
Fasting Glucose (mmol/L)	339 (29)	815 (71)	450 (39)	704 (61)
MS	518 (45)	636 (55)	593 (51)	561 (49)

Footnote: HDL= High Density Lipoprotein, MS= metabolic syndrome

Table 4.13 shows the frequency of metabolic or biochemical abnormalities for each criterion applied. Waist circumference increased by almost 20% which resulted in 78% of subjects had an increased waist circumference with the IDF criteria. As triglycerides, HDL cholesterol and BP have the same cut-offs in both criteria, the results were the same for both, while an increase in the fasting glucose rose from 29 to 39%.

Table 4.18: Body anthropometry in Metabolic Syndrome (NCEP ATP III and IDF)

	NCEP ATP III Risk Factor				IDF Risk Factor				P Value
	Yes		No		Yes		No		
	Median	(IQR)	Median	(IQR)	Median	(IQR)	Median	(IQR)	
Body Mass Index (BMI)	30	(27-34)	25	(22-29)	30	(27-34)	25	(22-30)	<0.001
Waist Circumference (cm)	102	(94-109)	88	(79-98)	100	(94-108)	87	(78-97)	<0.001
Arm Circumference (cm)	34	(31-37)	30	(27-34)	34	(31-37)	31	(27-34)	<0.001
Neck Circumference (cm)	36	(34-38)	34	(32-36)	36	(34-38)	34	(32-36)	<0.001
Mean Triceps Skinfold (mm)	250	(196-305)	198	(127-263)	264	(194-300)	202	(130-271)	<0.001

A further breakdown of body anthropometry was done to determine which measurements could best indicate the risk of MS. All body morphometry measurements were significantly different between subjects with and without MS using either definition of MS. All measures were statistically significantly higher in subjects with MS ($p<0.001$).

4.4. Lifestyle Patterns and Body Anthropometry

Analysis of whether lifestyle patterns had any effect on body anthropometry was done using Spearman's RHO and are shown in these are summarised below:

1. Strong correlations were noted between age and mean systolic blood pressure (OR=0.425, p<0.001), while a lower correlation was observed with mean diastolic blood pressure (OR=0.240, p<0.001).

2. Smoking had a strong negative correlation with weight (OR=-0.590, p=0.044). Weaker correlations were noted between smoking and waist circumference (OR=-0.104, p<0.001), hip circumference (OR=-0.141, p<0.001), arm circumference (OR=-0.108, p<0.001) and mean triceps skinfold (OR=-0.207, p<0.001).

3. Except for a positive correlation with neck circumference (OR=0.218, p<0.001), average alcohol intake had negative weak correlations with BMI (OR=-0.141, p<0.001), hip circumference (OR=-0.156, p<0.001), mean triceps skinfold (OR=-0.266, p<0.001). Similarly, maximum alcohol intake had weak negative correlations with all anthropometric measurements except neck circumference (OR=0.191, p<0.001).

4. Fruit intake per week had significant but weak positive correlations with BMI (OR=0.090, p=0.002), waist circumference (OR=0.086, p=0.003), and mean triceps skinfold (OR=0.089, p=0.003). Hours of sleep had negative weak correlations with waist circumference (OR= -0.093, p=0.002) and mid-arm circumference (OR= -0.090, p=0.002).

5. Total exercise per week was correlated with all the body measurements, including blood pressure. The correlations observed were weak and negative which is expected for this relationship. The following results were significant: BMI (OR=-0.106, p<0.000), waist circumference (OR=-0.094, p=0.001), hip circumference (OR=-0.087, p=0.003), mid-arm circumference (OR=-0.085, p=0.004), mean triceps skinfold (OR=-0.179, p<0.000) and diastolic blood pressure (OR=-0.120, p<0.000). Sedentary behaviour had a weak positive correlation with neck circumference (OR=0.096, p<0.001) and a negative weak correlation with mean triceps skinfold (OR=-0.075, p=0.011).

Table 4.19: Correlation of Lifestyle Patterns with Body Anthropometry

	Age	Smoking	Average Alcohol Intake	Maximum Alcohol Intake	Fruit Per Week	Hours of Sleep	Total Exercise Per Week	Total Sedentary Time Per Week
Height r =	-0.169	0.170	-	-	-	-	0.195	0.121
p =	<0.001	<0.001	-	-	-	-	<0.000	<0.000
Weight r =	0.062	-0.590	-	-	-	-0.068	-	-
p =	0.034	0.044	-	-	-	0.022	-	-
BMI r =	0.133	-0.133	-0.141	-0.138	0.090	-0.076	-0.106	-
p =	<0.001	<0.001	<0.001	<0.001	0.002	0.010	<0.000	-
Waist Circum. r =	0.223	-0.104	-0.082	-0.085	0.086	-0.093	-0.094	-
p =	<0.001	<0.001	0.005	0.004	0.003	0.002	0.001	-
Hip Circum. r =	0.071	-0.141	-0.156	-0.157	0.081	-0.078	-0.087	-
p =	0.016	<0.001	<0.001	<0.001	0.006	0.008	0.003	-
Mid-arm Circum. r =	0.111	-0.108	-0.099	-0.103	0.074	-0.090	-0.085	-
p =	<0.001	<0.001	<0.001	<0.001	0.012	0.002	0.004	-
Neck Circum. r =	0.101	0.062	0.218	0.191	-	-	-	0.096
p =	0.001	0.036	<0.001	<0.001	-	-	-	0.001
MTS r =	-	-0.207	-0.266	-0.251	0.089	-	-0.179	-0.075
p =	-	<0.001	<0.001	<0.001	0.003	-	<0.000	0.011
Mean SBP r =	0.425	-	-	-	-	-0.052	-	-
p =	<0.001	-	-	-	-	0.082	-	-
Mean DBP r =	0.240	-	-	-	-	-0.041	-0.120	-
p =	<0.001	-	-	-	-	0.167	<0.000	-

Footnote: BMI: Body Mass Index, MTS: Mean Triceps Skinfold, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure. Only significant results reflect on the table

4.5 Biochemical parameters and Body Anthropometry

1. All glycaemic indices (fasting glucose, fasting insulin, 2 hour glucose, 2 hour insulin and HBA1C) had significant correlations with body measurements. The strongest correlations were observed between fasting insulin and all body measurements. Body weight had strong correlations with fasting insulin (OR=0.514, p<0.001) but BMI had stronger correlations than weight with all biochemical parameters except HDL (OR=-0.139, p<0.001).

2. Waist circumference had a strong significant correlation with fasting insulin (OR=0.557, p<0.001) and with all other glycemic indices, as well as with triglycerides (OR=0.328 p<0.001). A weak negative correlation was noted between waist circumference and HDL.

3. Hip circumference had a strong significant correlation with fasting insulin (OR=0.546, p<0.001) and with other glycemic indices as well as triglycerides but was not as strong as waist circumference. Arm circumference had similar correlations as hip circumference but a strong significant correlation with triglycerides (OR=0.276, p<0.001).

4. Neck circumference had weaker correlations with the glycemic parameters: than hip circumference but had strong correlation with triglycerides (OR= 0.315, p<0.001) and a strong negative correlation with HDL Cholesterol (OR= -0.295, p<0.001). Mean triceps skinfold had three moderate correlations with biochemistry: fasting insulin (OR=0.452, p<0.001); 2 hour glucose (OR= 0.303, p<0.001) and 2 hour insulin (OR=0.340, p<0.001) as well as weak correlation with triglycerides.

5. Total exercise per week had negative weak correlation with all biochemistry parameters except HDL Cholesterol: fasting glucose (OR=-0.086, p=0.004), fasting insulin (OR=-0.088, p=0.003), 2 hour glucose (OR=-0.134, p<0.000), 2 hour insulin (OR=-0.089, p=0.007), total cholesterol (OR=-0.128, p<0.000), triglycerides (OR=-0.083, p=0.005), LDL cholesterol (OR=-0.107, p=0.000) and HbA1C (OR=-0.080, p=0.007).

Table 4.20: Correlation of Biochemical parameters with body anthropometry and physical activity

	Height	Weight	BMI	Waist Circumference	Hip Circumference	Arm Circumference	Neck Circumference	Mean Triceps Skinfold	Total Exercise Per Week
Fasting Glucose r =	-	0.237	0.255	0.323	0.214	0.239	0.215	0.163	-0.086
p =	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
Fasting Insulin r =	-0.104	0.514	0.557	0.546	0.520	0.532	0.359	0.452	-0.088
p =	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
2HR Glucose r =	-0.195	0.295	0.378	0.397	0.321	0.341	0.202	0.303	-0.134
p =	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.000
2HR Insulin r =	-0.183	0.293	0.373	0.377	0.339	0.344	0.200	0.340	-0.089
p =	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007
Total Cholesterol r =	-0.105	-	0.90	0.132	-	0.110	0.087	0.086	-0.128
p =	<0.001	-	0.002	<0.001	-	<0.001	0.003	0.004	<0.000
Triglycerides r =	-	0.279	0.269	0.328	0.199	0.276	0.315	0.134	-0.083
p =	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
HDL Cholesterol r =	-0.161	-0.226	-0.139	-0.189	-0.100	-0.151	-0.295	-	-
p =	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
LDL Cholesterol r =	-0.088	-	0.076	0.100	-	0.099	0.073	0.062	-0.107
p =	0.003	-	0.011	0.001	-	0.001	0.014	0.040	0.000
HbA1C r =	-0.129	0.238	0.293	0.324	0.223	0.223	0.181	0.188	-0.080
p =	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007

Footnote: 2HR: two hour, BMI: Body Mass Index, HDL: High Density Lipoprotein, LDL: Low Density Lipoprotein. Only significant results reflect on the table

4.6 Inter-correlation of Body Anthropometry

1. When anthropometric and physiologic measures were correlated with each other, BMI had positive correlations with all anthropometric measurements and blood pressure measurements, the strongest being waist circumference (OR=0.882), hip circumference (OR=0.913), arm circumference (OR=890) and mean triceps skinfold (OR=0.737).

2. Waist circumference was positively correlated with all body measurements. Strong correlations were reported with hip circumference (OR=0.847), arm circumference (OR=0.809), as well as with neck circumference (OR=0.537) and mean triceps skinfold (OR=0.618). All measurements were significant.

3. Mid-arm circumference had significantly strong positive correlations with: BMI (OR=0.890, $p<0.001$); waist circumference (OR=0.809, $p<0.001$); and hip circumference (OR=0.827, $p<0.001$).

4. Neck circumference had strong correlations with waist circumference (OR= 0.537, $p<0.001$) and mid-arm circumference (OR=0.546, $p<0.001$).

5. Mean triceps skinfold has strong positive correlations with BMI (OR=0.737, $p<0.001$); waist circumference (OR=0.618, $p<0.001$); hip circumference (OR=0.726, $p<0.001$) and mid-arm circumference (OR=0.705, $p<0.001$).

Table 4.21: Inter-correlation of Body Anthropometry

	Waist Circumference	Hip Circumference	Mid-Arm Circumference	Neck Circumference	Mean Triceps Skinfold	Mean Systolic BP	Mean Diastolic BP
Body Mass Index r =	0.882	0.913	0.890	0.498	0.737	0.294	0.311
p =	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Waist Circumference r =	-	-	0.809	0.537	0.618	0.332	0.324
p =	-	-	<0.001	<0.001	<0.001	<0.001	<0.001
Hip Circumference r =	-	-	0.827	0.415	0.726	0.231	0.251
p =	-	-	<0.001	<0.001	<0.001	<0.001	<0.001
Mid-arm Circumference r =	-	-	-	0.546	0.705	0.292	0.294
p =	-	-	-	<0.001	<0.001	<0.001	<0.001
Neck Circumference r =	-	-	-	-	0.152	0.287	0.250
p =	-	-	-	-	<0.001	<0.001	<0.001

Footnote: Only significant results reflect on the table

4.7. Inter-correlation of Biochemistry

1. Fasting glucose had a weak positive correlation with fasting insulin (OR=0.270, p<0.001). 2 hour glucose had a strong positive correlation with fasting glucose (OR=0.505, p<0.001) and a weak positive correlation with fasting insulin (OR=0.380, p<0.001), both these findings were significant. 2 hour insulin had a strong correlation with fasting insulin (OR=0.536, p<0.001) and a weak correlation with 2 hour glucose (OR=0.440, p<0.001).

2. Total cholesterol had weak correlations with other biochemistry parameters, a significant correlation was observed between total cholesterol and 2 hour glucose (OR=0.212, p<0.001).

3. Triglycerides had significant and moderate correlations with the following biochemistry components: fasting glucose (OR=0.335, p<0.001); fasting insulin (OR=0.290, p<0.001); 2 hour glucose (OR=0.384, p<0.001); 2 hour insulin (OR=0.234, p<0.001); total cholesterol (OR=0.442, p<0.001).

4. HDL Cholesterol had negative weak significant correlations with biochemistry parameters: fasting glucose (OR=-0.117, p<0.001); fasting insulin (OR=-0.238, p<0.001); 2 hour glucose (OR=-0.089, p<0.001); 2 hour insulin (OR=-0.102, p<0.001); triglycerides (OR=-0.358, p<0.001).

5. LDL Cholesterol had a strong significant correlation with total cholesterol (OR=0.831, p<0.001) and weaker yet significant correlations with 2 hour glucose (OR=0.138, p<0.001) and triglycerides (OR=0.245, p<0.001).

6. HbA1C had significant correlations with all biochemical parameters, the strongest of which was with fasting glucose (OR=0.668, p<0.001).

7. For HbA1C, weaker correlations were seen with fasting insulin (OR=0.224, p<0.001); 2 hour glucose (OR=0.497, p<0.001); 2 hour insulin (OR=0.148, p<0.001); total cholesterol (OR=0.236, p<0.001); triglycerides (OR=0.359, p<0.001); LDL Cholesterol (OR=0.203, p<0.001); and a negative correlation was seen with HDL Cholesterol (OR=-0.107, p<0.001).

Table 4.22: Intercorrelation of Biochemistry

	Fasting Insulin	2HR Glucose	2HR Insulin	Total Cholesterol	Triglycerides	HDL Cholesterol	LDL Cholesterol	HbA1C
Fasting Glucose r =	0.270	0.505	0.128	0.241	0.335	-0.117	0.155	0.668
p =	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	0.040	<0.001
Fasting Insulin r =	-	0.380	0.536	-	0.290	-0.238	-	0.224
p =	-	<0.001	<0.001	-	<0.001	<0.001	-	<0.001
2HR Glucose r =	-	-	0.440	0.212	0.384	-0.089	0.138	0.497
p =	-	-	<0.001	<0.001	<0.001	0.007	<0.001	<0.001
2HR Insulin r =	-	-	-	0.092	0.234	-0.102	0.095	0.148
p =	-	-	-	0.005	<0.001	<0.001	0.002	<0.001
Total Cholesterol r =	-	-	-	-	0.442	0.208	0.831	0.236
p =	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Triglyceride r =	-	-	-	-	-	-0.358	0.245	0.359
p =	-	-	-	-	-	<0.001	<0.001	<0.001
HDL Cholesterol r =	-	-	-	-	-	-	-	-0.107
p =	-	-	-	-	-	-	-	<0.001
LDL Cholesterol r =	-	-	-	-	-	-	-	0.203
p =	-	-	-	-	-	-	-	<0.001
HbA1C r =	-	-	-	-	-	-	-	-
p =	-	-	-	-	-	-	-	-

Footnote: HDL: High Density Lipoprotein, LDL: Low Density Lipoprotein

4.8 HOMA- IR for Metabolic Syndrome

Table 4.23: HOMA- IR for IDF criteria

	IDF MS Yes (N=468)	IDF MS No (N=671)	Total
HOMA-IR ≤ 2.7	110	405	515
HOMA-IR > 2.7	358	266	624

Of the 624 participants with HOMA-IR > 2.7, 57.4% (358) had IDF MS, compared to 21.4% (110) of participants with HOMA-IR ≤ 2.7, p<0.001.

Table 4.24: HOMA-IR for NCEP ATP III criteria

	NCEP MS Yes (N=513)	NCEP MS No (N=626)	Total
HOMA-IR ≤ 2.7	106	409	515
HOMA-IR > 2.7	407	217	624

Of the 624 participants with HOMA-IR > 2.7, 65.2% (407) had NCEP MS, compared to 20.6% (106) of participants with HOMA-IR ≤ 2.7, p<0.001.

4.9 Body Anthropometry and HOMA-IR

1. Waist circumference was strongly correlated with BMI (OR=0.882, p<0.001), hip circumference (OR=0.848, p<0.001) and mid-arm circumference (OR=0.809, p<0.001). There was also good correlation with neck circumference (OR=0.537, p<0.001), mean triceps skinfold (OR=0.618, p<0.001) and HOMA-IR (OR=0.559, p<0.001).

2. BMI was strongly correlated with all body measurements and also showed good correlation with HOMA-IR (OR=0.544, p<0.001).

3. Mid-arm circumference was positively correlated with neck circumference (OR=0.547, p<0.001), mean triceps skinfold (OR=0.705, p<0.001) and HOMA-IR (OR=0.514, p<0.001). Neck circumference (OR=0.363, p<0.001) and mean triceps skinfold (OR=0.426, p<0.001) had a fair correlation with HOMA-IR.

Table 4.25: **Inter-correlation of anthropometric measurement and the correlation of anthropometric measurements with HOMA-IR**

	Body Mass Index	Waist Circumference	Hip Circumference	Mid-Arm Circumference	Neck Circumference	Mean Triceps Skinfold	HOMA-IR >2.7
Body Mass Index r =	-	0.882	0.913	0.890	0.498	0.737	0.544
p =	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Waist Circumference r =	-	-	0.848	0.809	0.537	0.618	0.559
p =	-	-	<0.001	<0.001	<0.001	<0.001	<0.001
Hip Circumference r =	-	-	-	0.827	0.416	0.726	0.494
p =	-	-	-	<0.001	<0.001	<0.001	<0.001
Mid-arm Circumference r =	-	-	-	-	0.547	0.705	0.514
p =	-	-	-	-	<0.001	<0.001	<0.001
Neck Circumference r =	-	-	-	-	-	0.152	0.363
p =	-	-	-	-	-	<0.001	<0.001
Mean Triceps Skinfold r =	-	-	-	-	-	-	0.426
p =	-	-	-	-	-	-	<0.001
HOMA-IR r =	-	-	-	-	-	-	-
p =	-	-	-	-	-	-	-

4.10 Metabolic Syndrome: IDF Males

Table 4.26a: Odds Ratio table for IDF Males with all variables

	Unadjusted analysis		Adjusted analysis	
Variable	**Odds Ratio (95% CI)**	**p-value**	**Odds Ratio (95% CI)**	**p-value**
BMI	1.40 (1.29 - 1.51)	<.0001	0.75 (0.53 - 1.08)	0.1198
Waist Circumference	1.19 (1.15 - 1.24)	<.0001	1.30 (1.15 - 1.46)	<.0001
Hip Circumference	1.15 (1.11 - 1.19)	<.0001	1.10 (1.01 - 1.20)	0.0374
Mid-Arm Circumference	1.04 (0.98 - 1.10)	0.1645	0.98 (0.93 - 1.04)	0.5102
Neck Circumference	1.67 (1.48 - 1.88)	<.0001	0.99 (0.77 - 1.29)	0.9627
Mean Triceps Skinfold	1.01 (1.01 - 1.02)	<.0001	0.99 (0.98 - 1.00)	0.2314
Mean Systolic BP	1.05 (1.03 - 1.06)	<.0001	1.04 (1.00 - 1.08)	0.0642
Mean Diastolic BP	1.08 (1.06 - 1.10)	<.0001	0.99 (0.93 - 1.06)	0.8690
Fasting Glucose	1.44 (1.26 - 1.64)	<.0001	0.97 (0.40 - 2.34)	0.9505
Fasting Insulin	1.12 (1.08 - 1.17)	<.0001	0.61 (0.34 - 1.09)	0.0931
2hr Glucose	1.18 (1.10 - 1.28)	<.0001	0.90 (0.70 - 1.14)	0.3755
2hr Insulin	1.01 (1.00 - 1.01)	<.0001	1.00 (1.00 - 1.01)	0.1486
Total Cholesterol	1.38 (1.14 - 1.68)	0.0013	1.14 (0.72 - 1.81)	0.5749
Triglycerides	4.40 (3.00 - 6.46)	<.0001	5.57 (2.48 - 12.51)	<.0001
Decreasing HDL Cholesterol	4.99 (2.19 - 11.37)	0.0001	1.57 (0.82 - 3.02)	0.1730
LDL Cholesterol	1.01 (0.97 - 1.05)	0.6276	0.95 (0.84 - 1.08)	0.4348
HbA1C	1.37 (1.19 - 1.57)	<.0001	0.93 (0.54 - 1.61)	0.8045
HOMA-IR >2.7	1.64 (1.42 - 1.90)	<.0001	6.83 (0.67 - 70.17)	0.1059
Total exercise per week (per hour increase)	0.90 (0.83 - 0.99)	0.0249	1.01 (0.90 - 1.14)	0.8856

Univariate analysis revealed that all parameters except for mid-arm circumference and LDL Cholesterol were predictors of MS. In multivariate analysis, only WC, triglycerides and hip circumference remain significant determinants of MS in males.

Table 4.26b: Odds Ratio table for IDF Males with excluding criteria for definition

	Unadjusted analysis		Adjusted analysis	
Variable	**Odds ratio (95% CI)**	**p-value**	**Odds ratio (95% CI)**	**p-value**
BMI	1.40 (1.29 - 1.51)	<.0001	1.22 (1.00 - 1.49)	0.0478
Hip Circumference	1.15 (1.11 - 1.19)	<.0001	1.04 (0.97 - 1.11)	0.2505
Mid-Arm Circumference	1.04 (0.98 - 1.10)	0.1645	0.99 (0.83 - 1.19)	0.9562
Neck Circumference	1.67 (1.48 - 1.88)	<.0001	1.22 (1.02 - 1.47)	0.0306
Mean Triceps Skinfold	1.01 (1.01 - 1.02)	<.0001	1.00 (0.99 - 1.00)	0.2407
Fasting Insulin	1.12 (1.08 - 1.17)	<.0001	0.87 (0.77 - 0.98)	0.0218
Total Cholesterol	1.38 (1.14 - 1.68)	0.0013	1.25 (0.94 - 1.67)	0.1215
LDL Cholesterol	1.01 (0.97 - 1.05)	0.6276	0.99 (0.95 - 1.04)	0.8074
HbA1C	1.37 (1.19 - 1.57)	<.0001	1.02 (0.80 - 1.32)	0.8595
Total recreational exercise per week (per hour increase)	0.90 (0.83 - 0.99)	0.0249	0.95 (0.86 - 1.04)	0.2643
HOMA-IR >2.7	1.64 (1.42 - 1.90)	<.0001	2.00 (1.24 - 3.23)	0.0047

After excluding the criteria used in the definition of MS, multivariate analysis showed that linear increases in BMI, neck circumference and HOMA-IR were significantly associated with an increased risk of being diagnosed with metabolic syndrome. The odds ratios revealed a doubling of the risk for MS with HOMA-IR >2.7.

4.11 Metabolic Syndrome: IDF Females

Table 4.27a: Odds Ratio table for IDF Females with all variables

	Unadjusted analysis		Adjusted analysis	
Variable	**Odds Ratio (95% CI)**	**p-value**	**Odds Ratio (95% CI)**	**p-value**
BMI	1.13 (1.10 - 1.16)	<.0001	1.03 (0.92 - 1.16)	0.6194
Waist Circumference	1.07 (1.06 - 1.08)	<.0001	1.04 (1.00 - 1.08)	0.0853
Hip Circumference	1.05 (1.03 - 1.06)	<.0001	0.97 (0.93 - 1.02)	0.2134
Mid-Arm Circumference	1.17 (1.13 - 1.21)	<.0001	1.01 (0.93 - 1.10)	0.8358
Neck Circumference	1.25 (1.18 - 1.32)	<.0001	1.02 (0.98 - 1.05)	0.3388
Mean Triceps Skinfold	1.01 (1.00 - 1.01)	<.0001	1.00 (0.99 - 1.00)	0.3661
Mean Systolic BP	1.06 (1.05 - 1.07)	<.0001	1.06 (1.04 - 1.09)	<.0001
Mean Diastolic BP	1.08 (1.06 - 1.09)	<.0001	1.04 (1.00 - 1.08)	0.0691
Fasting Glucose	1.82 (1.60 - 2.08)	<.0001	8.10 (3.55 - 18.46)	<.0001
Fasting Insulin	1.07 (1.05 - 1.09)	<.0001	1.25 (1.06 - 1.49)	0.0091
2hr Glucose	1.39 (1.30 - 1.50)	<.0001	1.04 (0.91 - 1.19)	0.5506
2hr Insulin	1.00 (1.00 - 1.01)	<.0001	1.00 (1.00 - 1.00)	0.5491
Total Cholesterol	1.56 (1.37 - 1.78)	<.0001	1.08 (0.72 - 1.64)	0.7107
Triglycerides	8.12 (5.78 - 11.43)	<.0001	11.99 (6.45 - 22.29)	<.0001
Decreasing HDL Cholesterol	20.37 (11.50 - 36.07)	<.0001	191.48 (54.89 - 667.93)	<.0001
LDL Cholesterol	1.45 (1.25 - 1.69)	<.0001	0.92 (0.61 - 1.39)	0.7042
HbA1C	1.96 (1.71 - 2.25)	<.0001	1.50 (1.03 - 2.19)	0.0326
HOMA-IR >2.7	1.39 (1.29 - 1.49)	<.0001	0.42 (0.21 - 0.83)	0.0126
Total exercise per week (per hour increase)	0.94 (0.87 - 1.00)	0.0643	0.96 (0.85 - 1.08)	0.4630

Similar to males, univariate analysis showed that all parameters except for total exercise per week were significant in predicting MS. In contrast to males, multivariate analysis revealed that mean systolic BP, fasting glucose, fasting insulin, triglycerides, decreasing HDL cholesterol, HbA1C and HOMA-IR remained significant determinants of MS.

Table 4.27b: Odds Ratio table for IDF Females with excluding criteria for definition

	Unadjusted analysis		Adjusted analysis	
Variable	**Odds ratio (95% CI)**	**p-value**	**Odds ratio (95% CI)**	**p-value**
BMI	1.13 (1.10 - 1.16)	<.0001	1.08 (1.00 - 1.17)	0.0621
Hip Circumference	1.05 (1.03 - 1.06)	<.0001	0.99 (0.96 - 1.02)	0.3678
Mid-Arm Circumference	1.17 (1.13 - 1.21)	<.0001	1.09 (1.01 - 1.17)	0.0264
Neck Circumference	1.25 (1.18 - 1.32)	<.0001	1.03 (0.96 - 1.10)	0.4375
Mean Triceps Skinfold	1.01 (1.00 - 1.01)	<.0001	1.00 (0.99 - 1.00)	0.0371
Fasting Insulin	1.07 (1.05 - 1.09)	<.0001	0.99 (0.96 - 1.03)	0.7877
Total Cholesterol	1.56 (1.37 - 1.78)	<.0001	1.39 (1.17 - 1.64)	0.0002
LDL Cholesterol	1.45 (1.25 - 1.69)	<.0001	1.03 (0.95 - 1.12)	0.5288
HbA1C	1.96 (1.71 - 2.25)	<.0001	1.58 (1.36 - 1.85)	<.0001
Total recreational exercise per week (per hour increase)	0.94 (0.87 - 1.00)	0.0643	0.97 (0.90 - 1.05)	0.4498
HOMA-IR >2.7	1.39 (1.29 - 1.49)	<.0001	1.20 (1.03 - 1.39)	0.0166

After excluding the criteria used in the definition of MS, the factors associated with increased risk of metabolic syndrome in females (adjusted model) were different than males. These were mid-arm circumference (OR=1.09, p=0.0264), mean triceps skinfold (OR=1.00, p=0.0371), total cholesterol (OR=1.39, p=0.0002) and HOMA-IR (OR=1.20, p=0.0166). HbA1C was also significantly associated with women being at 58% greater odds of being diagnosed with metabolic syndrome for every 1 unit increase in HbA1C (p<0.0001). Variables such as hip and neck circumference were significant in unadjusted analysis; however after adjustment fell away.

4.12 Metabolic Syndrome: NCEP ATP III Males

Table 4.28a: Odds Ratio table for NCEP ATP III Males with all variables

	Unadjusted analysis		Adjusted analysis	
Variable	**Odds Ratio (95% CI)**	**p-value**	**Odds Ratio (95% CI)**	**p-value**
BMI	1.27 (1.19 - 1.36)	<.0001	1.21 (0.83 - 1.77)	0.3186
Waist Circumference	1.11 (1.08 - 1.14)	<.0001	1.04 (0.93 - 1.17)	0.4580
Hip Circumference	1.10 (1.06 - 1.13)	<.0001	0.96 (0.86 - 1.07)	0.4413
Mid-Arm Circumference	1.28 (1.19 - 1.38)	<.0001	1.04 (0.91 - 1.20)	0.5573
Neck Circumference	1.42 (1.28 - 1.57)	<.0001	1.09 (0.81 - 1.48)	0.5606
Mean Triceps Skinfold	1.01 (1.01 - 1.01)	<.0001	0.99 (0.98 - 1.01)	0.4387
Mean Systolic BP	1.04 (1.03 - 1.06)	<.0001	1.04 (1.00 - 1.08)	0.0669
Mean Diastolic BP	1.06 (1.04 - 1.09)	<.0001	1.00 (0.94 - 1.06)	0.9207
Fasting Glucose	1.41 (1.26 - 1.59)	<.0001	1.52 (0.59 - 3.92)	0.3875
Fasting Insulin	1.12 (1.08 - 1.16)	<.0001	0.82 (0.61 - 1.09)	0.1679
2hr Glucose	1.18 (1.10 - 1.28)	<.0001	1.29 (0.98 - 1.70)	0.0727
2hr Insulin	1.01 (1.00 - 1.01)	<.0001	1.00 (1.00 - 1.01)	0.2428
Total Cholesterol	1.33 (1.08 - 1.63)	0.0068	1.69 (0.88 - 3.23)	0.1143
Triglycerides	8.33 (5.09 - 13.65)	<.0001	5.84 (2.43 - 14.01)	<.0001
Decreasing HDL Cholesterol	48.31 (14.09 - 165.59)	<.0001	1782.10 (29.61 - 107250.59)	0.0003
LDL Cholesterol	1.01 (0.98 - 1.05)	0.5156	0.95 (0.80 - 1.13)	0.5831
HbA1C	1.37 (1.20 - 1.57)	<.0001	0.21 (0.06 - 0.67)	0.0090
HOMA-IR >2.7	1.59 (1.39 - 1.81)	<.0001	2.55 (0.81 - 8.05)	0.1105
Total exercise per week (per hour increase)	0.80 (0.68 - 0.95)	0.0110	0.91 (0.73 - 1.13)	0.4026

Univariate analysis showed that all parameters except for LDL Cholesterol were significant in predicting MS. After adjusting the model, only triglycerides, decreasing HDL cholesterol and HbA1C remain significant determinants of MS.

Table 4.28b: Odds Ratio table for NCEP ATP III Males excluding criteria for definition

	Unadjusted analysis		Adjusted analysis	
Variable	**Odds ratio (95% CI)**	**p-value**	**Odds ratio (95% CI)**	**p-value**
BMI	1.27 (1.19 - 1.36)	<.0001	1.07 (0.90 - 1.26)	0.4392
Hip Circumference	1.10 (1.06 - 1.13)	<.0001	0.98 (0.92 - 1.04)	0.4934
Mid-Arm Circumference	1.28 (1.19 - 1.38)	<.0001	1.06 (1.01 - 1.10)	0.0134
Neck Circumference	1.42 (1.28 - 1.57)	<.0001	1.30 (1.09 - 1.55)	0.0033
Mean Triceps Skinfold	1.01 (1.01 - 1.01)	<.0001	1.00 (0.99 - 1.01)	0.8439
Fasting Insulin	1.12 (1.08 - 1.16)	<.0001	0.90 (0.81 - 1.01)	0.0678
Total Cholesterol	1.33 (1.08 - 1.63)	0.0068	1.11 (0.84 - 1.48)	0.4555
LDL Cholesterol	1.01 (0.98 - 1.05)	0.5156	1.00 (0.96 - 1.04)	0.9904
HbA1C	1.37 (1.20 - 1.57)	<.0001	0.94 (0.73 - 1.23)	0.6708
Total recreational exercise per week (per hour increase)	0.80 (0.68 - 0.95)	0.0110	0.82 (0.65 - 1.03)	0.0850
HOMA-IR >2.7	1.59 (1.39 - 1.81)	<.0001	1.88 (1.23 - 2.88)	0.0035

After excluding the criteria used in the definition, in the adjusted model, liner increases in mid-arm and neck circumference, HOMA-IR were significantly associated with an increased risk of being diagnosed with metabolic syndrome with odds ratios of OR=1.06 (p=0.0134), OR=1.30 (p=0.0033), OR=1.88 (p=0.0035), respectively.

4.13 Metabolic Syndrome: NCEP ATP III Females

Table 4.29a: Odds Ratio table for NCEP ATP III females with all variables

	Unadjusted analysis		Adjusted analysis	
Variable	**Odds Ratio (95% CI)**	**p-value**	**Odds Ratio (95% CI)**	**p-value**
BMI	1.12 (1.10 - 1.15)	<.0001	0.99 (0.87 - 1.12)	0.8201
Waist Circumference	1.07 (1.05 - 1.08)	<.0001	1.04 (1.00 - 1.08)	0.0731
Hip Circumference	1.05 (1.04 - 1.06)	<.0001	1.01 (0.96 - 1.05)	0.7988
Mid-Arm Circumference	1.15 (1.12 - 1.19)	<.0001	1.00 (0.90 - 1.11)	0.9871
Neck Circumference	1.27 (1.20 - 1.34)	<.0001	1.04 (0.89 - 1.23)	0.5897
Mean Triceps Skinfold	1.01 (1.00 - 1.01)	<.0001	1.00 (0.99 - 1.00)	0.1845
Mean Systolic BP	1.06 (1.05 - 1.07)	<.0001	1.06 (1.03 - 1.09)	<.0001
Mean Diastolic BP	1.08 (1.06 - 1.09)	<.0001	1.05 (1.00 - 1.09)	0.0378
Fasting Glucose	1.74 (1.55 - 1.95)	<.0001	3.76 (1.77 - 8.01)	0.0006
Fasting Insulin	1.07 (1.05 - 1.09)	<.0001	1.18 (1.01 - 1.37)	0.0403
2hr Glucose	1.38 (1.29 - 1.47)	<.0001	1.14 (1.00 - 1.30)	0.0449
2hr Insulin	1.00 (1.00 - 1.01)	<.0001	1.00 (1.00 - 1.00)	0.5056
Total Cholesterol	1.53 (1.34 - 1.74)	<.0001	1.07 (0.65 - 1.75)	0.7983
Triglycerides	9.31 (6.57 - 13.20)	<.0001	15.92 (8.20 - 30.92)	<.0001
Decreasing HDL Cholesterol	23.20 (12.88 - 41.79)	<.0001	268.84 (71.88 - 1005.46)	<.0001
LDL Cholesterol	1.38 (1.19 - 1.60)	<.0001	1.02 (0.60 - 1.75)	0.9392
HbA1C	1.87 (1.66 - 2.12)	<.0001	1.28 (0.86 - 1.89)	0.2197
HOMA-IR	1.45 (1.35 - 1.56)	<.0001	0.54 (0.29 - 1.00)	0.0501
Total exercise per week (per hour increase)	0.97 (0.91 - 1.04)	0.3729	1.00 (0.87 - 1.15)	0.9452

Univariate analysis showed that all parameters except for total exercise per week were significant in predicting MS. After adjusting the model, all variables except mean systolic BP, mean diastolic BP, fasting glucose, fasting insulin, triglycerides, decreasing HDL cholesterol, HbA1C lost their significance. The NCEP and IDF models were similar for prediction except NCEP included mean diastolic BP.

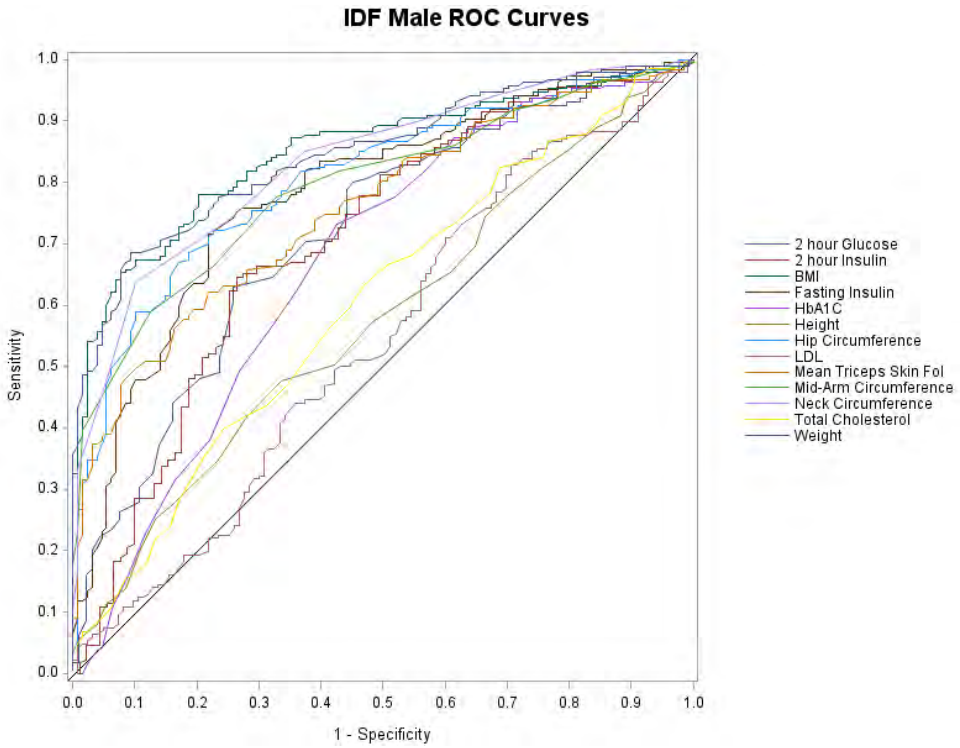
Table 4.29b: Odds Ratio table for NCEP ATP III females excluding criteria for definition

	Unadjusted analysis		Adjusted analysis	
Variable	**Odds ratio (95% CI)**	**p-value**	**Odds ratio (95% CI)**	**p-value**
BMI	1.12 (1.10 - 1.15)	<.0001	1.06 (0.98 - 1.15)	0.1369
Hip Circumference	1.05 (1.04 - 1.06)	<.0001	1.00 (0.97 - 1.03)	0.9008
Mid-Arm Circumference	1.15 (1.12 - 1.19)	<.0001	1.04 (0.98 - 1.11)	0.1846
Neck Circumference	1.27 (1.20 - 1.34)	<.0001	1.06 (0.99 - 1.14)	0.0895
Mean Triceps Skinfold	1.01 (1.00 - 1.01)	<.0001	1.00 (0.99 - 1.00)	0.0564
Fasting Insulin	1.07 (1.05 - 1.09)	<.0001	0.94 (0.89 - 1.00)	0.0489
Total Cholesterol	1.53 (1.34 - 1.74)	<.0001	1.37 (1.16 - 1.62)	0.0002
LDL Cholesterol	1.38 (1.19 - 1.60)	<.0001	1.03 (0.95 - 1.11)	0.5215
HbA1C	1.87 (1.66 - 2.12)	<.0001	1.36 (1.17 - 1.59)	<.0001
Total recreational exercise per week (per hour increase)	0.97 (0.91 - 1.04)	0.3729	1.02 (0.94 - 1.11)	0.6345
HOMA-IR	1.45 (1.35 - 1.56)	<.0001	1.57 (1.25 - 1.98)	0.0001

After excluding the criteria used in the definition, in the adjusted model for females, only biochemical parameters were significant in predicting of MS in the adjusted model: fasting insulin (OR=0.94, p=0.0489), total cholesterol (OR=1.37, p=0.0002) and HOMA-IR (OR=1.57, p<0.0001). Women had 36% greater odds of being diagnosed with metabolic syndrome for every 1 unit increase in HbA1C (p<0.0001).

Table 4.30 IDF Male ROC Curve

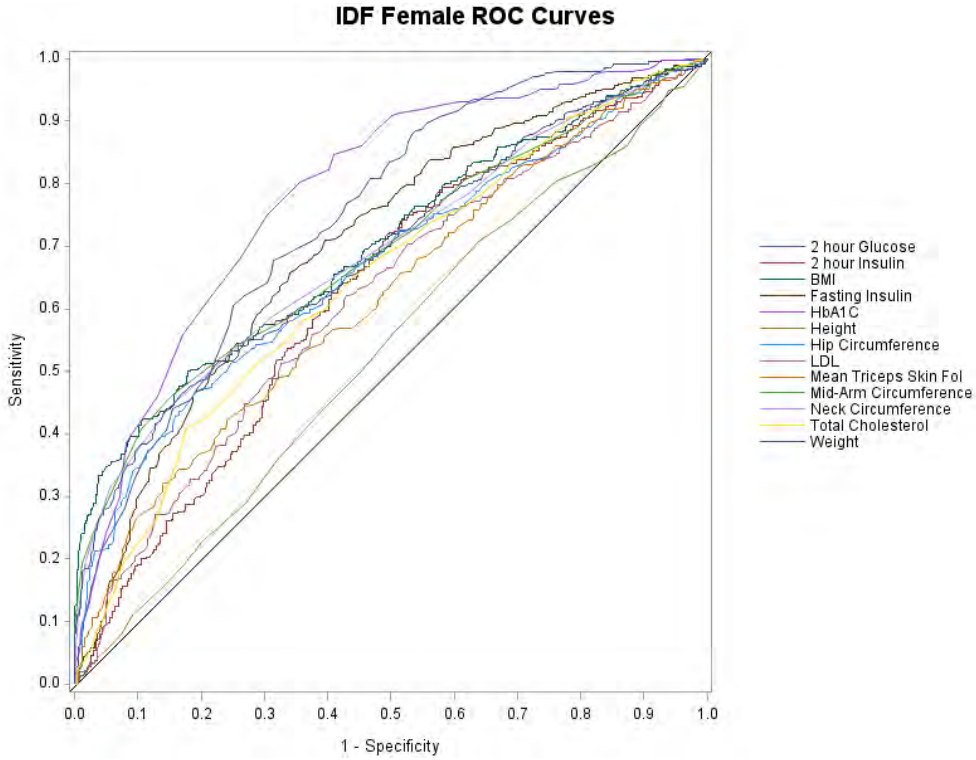
Area under the Curve



Test Result Variable(s)	Area
BMI	0.850
Weight	0.846
Neck Circumference	0.832
Hip Circumference	0.805
Mid-Arm Circumference	0.793
Fasting Insulin	0.784
Mean Triceps Skin Fold	0.757
2 hour Glucose	0.717
2 hour Insulin	0.706
HbA1C	0.670
Total Cholesterol	0.601
Height	0.575
LDL	0.542

The ROC curve shows the incapacity of biochemical, anthropometric and physiological components to predict the presence of the MS. BMI (0.850) showed the highest area under the curve when referring to the IDF category for male, followed by weight (0.846) and the neck circumference (0.832).

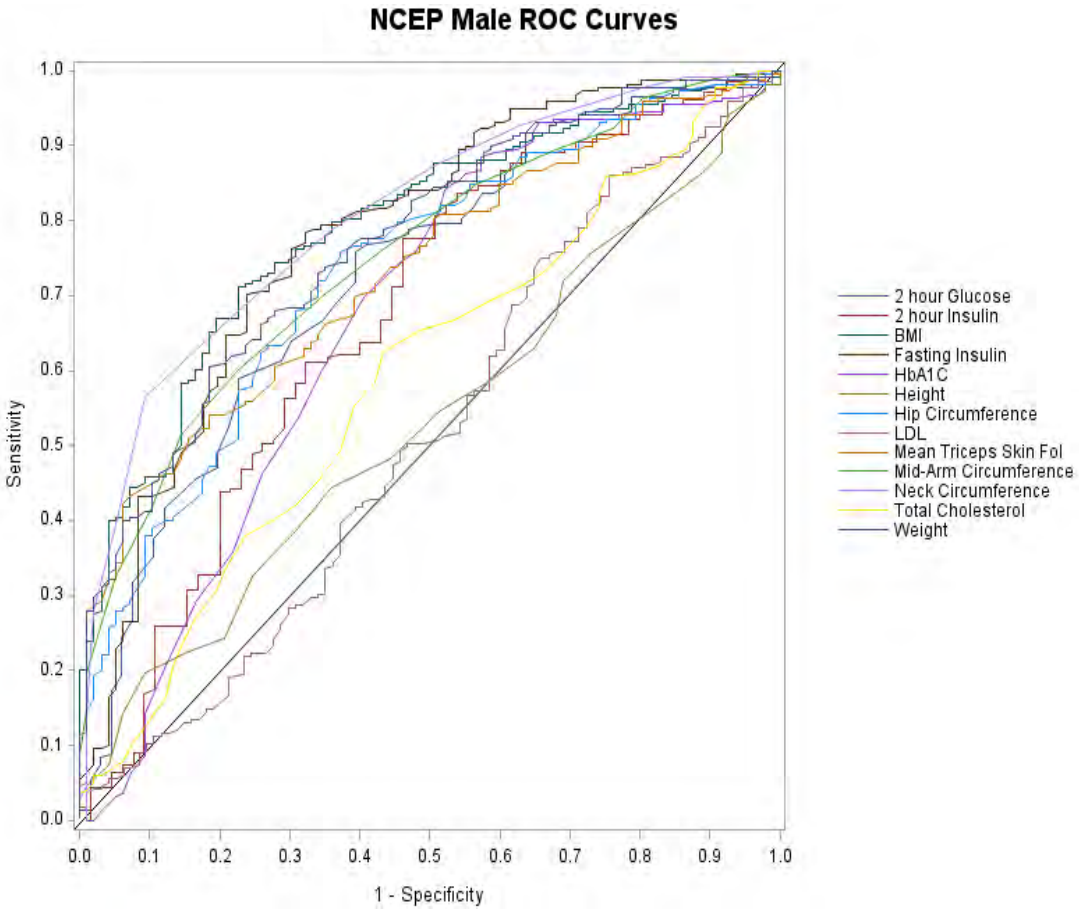
Table 4.31 IDF Female ROC Curve **Area under the Curve**



Test Result Variable(s)	Area
HbA1C	0.784
2 hour Glucose	0.745
Fasting Insulin	0.700
BMI	0.699
Mid-Arm Circumference	0.688
Neck Circumference	0.687
Weight	0.686
Hip Circumference	0.666
Total Cholesterol	0.645
2 hour Insulin	0.626
Mean Triceps Skin Fold	0.618
LDL	0.616
Height	0.530

HbA1C (0.784) showed the highest area under the curve when referring to the IDF category for females, followed by 2 hour Glucose (0.745) and fasting insulin (0.700)

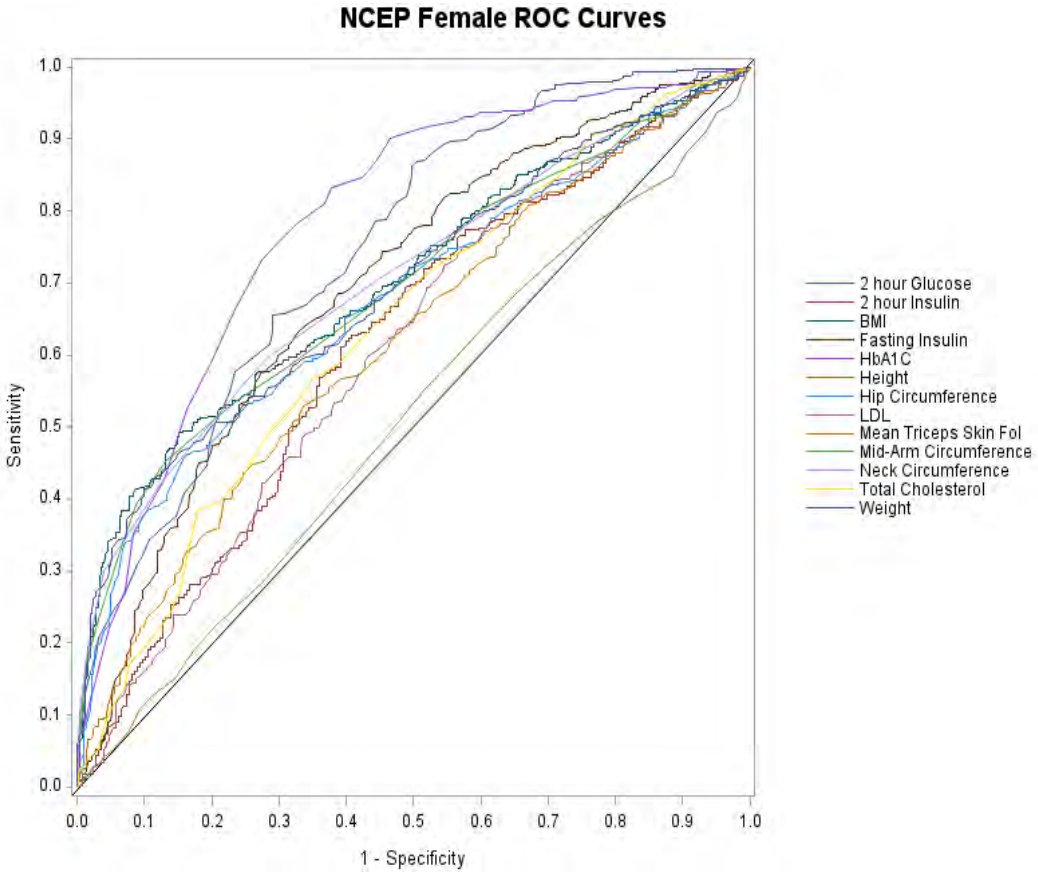
Table 4.32 NCEP ATP III Male ROC Curve **Area under the Curve**



Test Result Variable(s)	Area
Neck Circumference	0.806
BMI	0.791
Fasting Insulin	0.779
Weight	0.771
Mid-Arm Circumference	0.751
Hip Circumference	0.735
Mean Triceps Skin Fold	0.731
2 hour Glucose	0.727
2 hour Insulin	0.671
HbA1C	0.669
Total Cholesterol	0.590
Height	0.533
LDL	0.516

The neck circumference (0.806) showed the highest area under the curve when referring to the NCEP category, followed by BMI (0.791) and fasting insulin.

Table 4.33 NCEP ATP III Female ROC Curve **Area under the Curve**



Test Result Variable(s)	Area
HbA1C	0.784
2 hour Glucose	0.745
Neck Circumference	0.703
BMI	0.702
Fasting Insulin	0.695
Weight	0.694
Mid-Arm Circumference	0.692
Hip Circumference	0.677
Total Cholesterol	0.638
Mean Triceps Skin Fold	0.618
2 hour Insulin	0.615
LDL	0.603
Height	0.511

HbA1C (0.784) showed the highest area under the curve when referring to the NCEP category, followed by 2 hour glucose (0.745) and neck circumference (0.703).

Chapter Five

Discussion, Conclusion and Recommendation

5.1 Discussion

This study shows a high prevalence of MS in this randomly selected sample in the Phoenix Indian community. As expected, the IDF criteria revealed more individuals with MS that NCEP ATP III (51.4% vs. 44.9%). This was due to more subjects having waist circumference (IDF=78%, NCEP=59%) and fasting glucose (IDF=39%, NCEP= 29%) as components of their metabolic syndrome (Table 4.17). Our findings are significantly higher than those reported in the USA, where it is estimated that the prevalence of MS is 35% and 39% according to the NCEP and IDF definitions respectively, and in the United Kingdom where up to 25% of the population have MS (67).

Epidemiological studies have reported a high prevalence of metabolic syndrome and cardiovascular mortality among Indians settled abroad. In a study conducted on Indian immigrants settled in the USA for more than thirteen years, 40% of men and 28% of women were diagnosed with MS (NCEP criteria) (68). Similar studies have reported 26% of Indian Canadian and 12% of Mauritians with MS (NCEP criteria) (69). Clearly changes in the environment with emigration and urbanisation are associated with a significant increase in risk factor prevalence accounting for the high prevalence of MS in our study of a low income community of South African Indians (67, 68).

In India, studies on the prevalence of metabolic syndrome vary from 11% to 41% depending on the geographical environment as well as the definition of MS that was applied and continues to rise particularly with the adoption of modernised lifestyle (68), (69). The main drivers influencing the rapid transitions are nutrition requirements, lifestyle and socioeconomic shifts, consequent to increasing affluence, and rural-to-urban migration (69). Deepa et. al., reported that rate of urbanisation for India has become exponential, with a 20% increase over a fifty year period (15% to 35%) (68).

The high prevalence of MS amongst the Indian population in our study are in keeping with the data reported in other population groups in South Africa. Erasmus et. al. (2012), have reported a prevalence of 60.6% (IDF) and 55.4% (NCEP) for the coloured population in Cape Town (63). Amongst corporate executives, however, a lower prevalence of 35% was reported by Ker et. al (2007), using NCEP criteria (70). Another study focusing on Caucasian and African women, who were equally matched for age and BMI, similarly revealed that 30.4% of Caucasian and 24.8% of African women has MS (IDF) (71).

To date most epidemiological studies on South African Indians have reported the major CV risk factor prevalences, but there have been no reports of the prevalence of MS in this race group (32). A study reported by Ranjith et. al. (2002) showed a very high prevalence of MS (NCEP 60% and IDF 57%) in young Indians with myocardial infarction (72). Ranjith et. al. showed that MS was more predominant in females compared to males (NCEP) ($p=0.043$), but there were no significant gender difference when the IDF definition was applied (72). In our analysis, regardless of which criteria were used, MS was also more common in females. IDF yielded more females with metabolic syndrome than males (55.6% vs. 40.4%) (Table 4.16), while the NCEP yielded lower prevalence in both groups (50.3% vs. 30.6%) (Table 4.15).

The present study also showed significant increases in all morphometric measurements in participants with MS as compared to those without (Table 4.18). In this study we determined whether measures other than those defined in the NCEP and IDF criteria could predict MS in our sample. ROC curves were constructed for other morphometric measurements as well as biochemistry data in both males and females to determine their discriminating capacity in the diagnosis of MS. Of all the measures assessed, body morphometrics i.e. BMI and neck circumference emerged as the best predictors for MS in males. Analysis of ROC curves for females showed lower prevalences for these predictors with HbA1C emerging as the strongest predictor followed by the 2 hour glucose tolerance test further validating the impact of impaired glucose metabolism in the development of MS in females (Table 4.31, 4.33).

Univariate and multivariate analysis were performed in order to identify the major determinants in this sample. Table 4.26.a-4.29.b shows that all variables that were considered in unadjusted (including the MS criteria) and in adjusted models (without the MS criteria). In the multivariate analysis (adjusted model) in males waist and hip circumference, and triglycerides emerged as significant determinants of MS (IDF criteria) (Tables 26.a). In addition to triglycerides, decreasing HDL and HbA1C emerged as significant determinants using the NCEP criteria (Table 28a). After excluding the criteria in the definition for MS (Tables 4.26.b and 4.28.b), multivariate analysis revealed neck circumference and HOMA-IR as independent predictors of MS. For both MS criteria, there was a 1.8-2.0 fold increase in the risk of developing MS with a HOMA-IR of >2.7.

As in the males, all criteria considered emerged as significant determinants in the unadjusted model (Tables 4.27.a and 4.29.a). In the multivariate analysis, mean systolic BP, fasting glucose, fasting insulin, triglycerides, decreasing HDL and HbA1C emerged as significant determinants for MS (both NCEP and IDF).after the exclusion of the criteria used in the definition (tables 4.27.b and 4.29.b), HOMA-IR, HbA1C and total cholesterol emerged as significant determinants for MS. Using the IDF criteria, females had 58% greater odds of being diagnosed with metabolic syndrome for every 1 unit increase in HbA1C ($p<0.0001$) compared to the NCEP criteria which revealed a 36% greater risk ($p<0.0001$).

There was an alarmingly high prevalence of obesity in this sample. In fact 41.8% of the sample were obese when using the WHO criteria and increased markedly to 74.4% when using the Asian-specific cut-offs of 23kg/m^2 (Table 4.4). In this study, we examined BMI using both the WHO and the modified criteria (Tables 4.3, 4.4). When the participants were re-categorised using the Asian-specific cut-offs, the percentage of obese subjects increased from 24% to 68.2%. Using the Asian specific criteria the percentage of obese subjects increased from 13% to over 50% in males and from 42% to almost 75% in females.

These results show that BMI should be categorised specific for each ethnic group for a true representation of the data and reflection of the cardiovascular risk. While large prospective studies such as Framingham Heart Study, Nurses' Health Study, Buffalo Heart Study and Second Cancer Prevention Study have established the importance of using anthropometric measures as indices for cardiovascular risk (73), the employment of ethnic specific cut-offs for Asians will better determine the risk in an Asian population (21).

There is a larger amount of research pointing to the contribution of an increased BMI and waist circumference in the development of CVD. Gupta et. al. (2007), reported that BMI, WC and waist to hip ratio are important determinants of cardiovascular risk associated with obesity and that the presence of any type of physical activity showed an inverse relation to these markers of obesity (22). Changes of occupations, introduction of newer technologies, and rapid pace of urban life have increasingly resulted in more sedentary work and less energy expenditure. Leisure time activities have also shifted from outdoor play to indoor entertainment; television viewing and computer games (43). Steyn et. al. (74), states there is strong evidence that sedentary lifestyle is a risk factor for heart disease along with associated risk factors such as overweight, high blood pressure, diabetes and high blood cholesterol while Matthews et. al. (43), reported that higher amounts of sedentary behaviour was positively associated with mortality.

In our study, an important objective was to investigate the subjects' physical activity level and relate this to body morphometrics. This was measured at two intensities: vigorous and moderate; and encircled the participants' daily activities in a work, home and social setting (physical and recreation activity). Overall, 39% of subjects partook in some form of moderate physical activity and 11% indulged in moderate recreational activity. A significant finding was far fewer women than men (4% vs. 17%) indulged in the vigorous recreation activity levels ($p<0.0001$). Of those subjects who exercised at a vigorous intensity, there were significant associations observed with exercise and BMI ($p<0.001$) and exercise and waist circumference ($p<0.0001$) for every hour of exercise performed per week (Table 4.11 and 4.12). Moderate exercise per week had no

significant association on BMI and waist circumference. In table 4.18, total exercise per week had negative correlations with all biochemical parameters except for HDL and all these results were significant which advocates previously stated literature on the importance of physical activity. In this sample both men and women are at a high risk of developing chronic diseases of lifestyle because they are leading very sedentary lifestyles which supports data of another local study showing that 62% of men and 42% of women led a sedentary lifestyle (74).

Recent studies report that higher amounts of sedentary time are independently associated with increased risk of weight gain and obesity, poor metabolic health, and mortality. Two studies reported similar findings on the independent and combined effects of activity and overall sitting time and television viewing (75), (76). Matthews et. al. (2012), has shown that sitting during leisure time was positively associated with mortality even after overall physical activity levels were managed and that high levels of total activity did not minimize the risk related to sedentary behaviour (43). In our study, sedentary activity was measured in the form of sitting in a reclined position. We showed a significant relationship between sedentary activity and an increase neck circumference ($r= 0.096$, $p= <0.001$).

Health problems related to a sedentary lifestyle have now become a global phenomenon, affecting individuals from different age and ethnic groups. A large panel of research points to the significant health effects of the “built” environment (77). Recent studies report that the design, forms and use of the developed environment play a role in fostering or hindering physical activity. The availability of places to engage in physical activity is an important environmental characteristic that influences physical activity levels (78). Babey et. al. (2008), conducted a survey investigating physical activity levels in adolescents and the influence of safe environments. Analysis from the study revealed that access to a safe park was positively associated with regular physical activity and negatively associated with inactivity for adolescents in urban areas (78). In this regard, the community of investigation, Phoenix, was established as a township in 1976, located some 20km northwest of central Durban, and is said to be one of the oldest Indian settlements in South Africa with very little integration having taken place (79). While the Phoenix Community Centre established in 1989 has embarked on numerous

development programmes aimed at the youth, women, sport and early childhood education. Our study has shown very little effect of these programmes on risk factor prevalences in this community.

Contribution of positive family history on development of CV risk factors plays a vital role in the development of chronic diseases (67),(80). There was a high prevalence of a positive family history for CV risk factors in this sample. There was a positive family history for hypertension and DM in 76.6% and 68.1% of the sample respectively. A family history of CAD was present in almost 50% of the sample. Interestingly the majority of participants (89.9%) reported a negative family history of obesity, yet 68.2% of the participants were considered obese according to the Asian-specific BMI category (Table 4.3). We can only conclude that this cohort has had a drastic shift in lifestyle behaviour and have become more inactive individuals than the generation before them, in some part due to failure of community health programmes. Within only a few generations, leisure time activity has decreased so dramatically as to be nearly non-existent in this urbanised environment.

As physical activity is a vital component to CV risk, diet is another important component. The increasing prevalence of overweight and obesity has been attributed to changes to physical activity behaviour patterns as well as simultaneous quantitative and qualitative changes in the diet. It has been suggested in the past that consumption of fruit and vegetable might prevent excess weight gain but there is inconclusive evidence to support this theory. Research has shown that people with a high consumption of fruit also tend to have a high consumption of vegetables (34). Individuals who consume a high volume of fruit and vegetable also tend to eat less meat (processed meat, saturated fat) which has been positively associated with increased weight gain (81). In contrast, poor fruit and vegetable consumption has been associated with increase in CV risk. In the INTERHEART study, the results showed that individuals who ate fruit and vegetables every day compared with those who did not, had a reduction of 30% in the risk of myocardial infarction (41). Table 4.6 and 4.7 reflects dietary habits of the cohort. On average, the participants on our study consumed more vegetable than fruit per week.

However 67% of participants stated at least one meal per day contained food high in fat. Although 97.9% used vegetable oil when preparing meals, 81.4% reported to never or rarely using additional salt in their food, over 50% of participants stated that they had at least one carbonated drink per day respectively. Interestingly examination of the participant's dietary intake revealed that participants in the older age groups consumed more fruit and vegetables per week, reflecting the increased awareness of the need for healthy food choices amongst the elderly. According to results, participants were more knowledgeable about healthy food choices in terms of types of oil used in preparing meals, additional salt intake, amount of carbonated drinks and fat content consumed but the data may be skewed as the questionnaire does not measure oil and salt usage during the preparation of meals. The same argument could be made about fatty food; the participant's perception of food high in fat is not accounted for in the study.

In this study, we also analysed the effect of salt intake on blood pressure. Table 4.8 (4.8.1 – 4.8.2) illustrates the effect of additional salt intake on the blood pressure per gender. The blood pressures of the subjects below the age of 45 were within the norm range and not considered to be hypertensive. Participants over the age of 45 had higher blood pressures on average. A moderate correlation was distinguished between age and mean systolic blood pressure ($r= 0.425$, $p= <0.001$). Dietary salt appears to be the most important contributing factor behind raising blood pressure (82). An increase in salt intake increases the stiffness of arteries with recent studies showing a decrease in salt intake reduces the artery wall thickness independent of the blood pressure (83). From this analysis, we can surmise that older participants in this cohort do make conscious healthier choices regarding their dietary patterns.

The other lifestyle patterns investigated in this study were smoking and alcohol consumption which are known to exacerbate CV risk (84). Although males accounted for a third of the sample population, they had a higher percentage of the smoking (23%) and alcohol intake (46, 4%) as compared to females (17%). This is in keeping with Wallace et. al. (2002) (85) and Nolen-Hoeksema (2004) (86), who found similar results. The relationship between smoking and body weight has been studied for many years with most studies finding that smoking and body weight are inversely related (84, 87).

Our results indicate a strong negative correlation between smoking and weight (r= -0.590, p=0.044).

It is well described that Indians have higher body fat or abdominal obesity even at normal levels of BMI (16). The strongest correlations (Table 4.21) suggest that increase in waist circumference was actually a manifestation of general obesity (as indicated by neck circumference, mid-arm circumference and mean triceps skinfold thickness) in these subjects. This indicates that adipose tissue this cohort is not only distributed centrally but also there is an overall increase in body fat in keeping with general obesity. Our findings indicate this cohort is characterised not only by abdominal obesity secondary to insulin resistance and MS, but also increased BMI levels.

In this study we also investigated the relationship between body morphometrics and glycemic indices (Table 4.20). The strongest correlations were seen between fasting insulin and body weight, waist circumference, hip circumference and mean triceps skinfold, with significant but weaker correlations for other glycemic indices. The results reinforce the effect that dysglycemia has on the body's ability to control weight.

5.2 Conclusion and recommendation

This is the first epidemiological study in South African Indians that has revealed a high prevalence of physical inactivity and obesity in this cohort, both in metabolic syndrome subjects and in controls. The majority of participants had developed both central and general obesity. Our study has also shown a high prevalence of insulin resistance and increased body morphometric measures all of which contributed to the development of MS. In addition, new independent determinants of metabolic syndrome (neck circumference in males and glycemic indices in females) were identified.

Health problems related to physical inactivity have become a global health challenge affecting people across the spectrum of income, age, and ethnicity. While advances in medicine have been accompanied by an increase in life span, at the same time, modernisation and western patterns of lifestyle have led to an increase in the exposure to risk factors for chronic diseases (1). Although genetic factors and age contribute to the risk of CVD, our sample shows other factors such as hypertension, hypercholesterolemia, insulin resistance, diabetes, and a predominance of lifestyle factors such as smoking, diet and physical inactivity which are also associated with CVD (88). The relationship of physical inactivity to CVD mortality is independent of the combination of the abovementioned risk factors (37). Although physical inactivity has pronounced effects on CV risk, the prevalence of physical inactivity, health beliefs and knowledge of the risks of inactivity has rarely been assessed in both developed and developing countries (65). This study addresses the gap in our knowledge base for CV risk factor management: physical inactivity is a risk factor for obesity and modifiable risk factor for cardiovascular disease (89).

Our study revealed that the majority of subjects were physical inactive, which predisposed them to developing abdominal and general obesity. In fact both increased BMI and abdominal obesity were highly prevalent in this cohort with 50.7% of males and 74.4% of females fulfilling the modified WHO criteria for obesity. These findings are alarming since over 90% of the cohort had a negative family history of obesity thus implying the sedentary behaviour pattern this generation has adopted with significant

changes to their dietary habits. This pattern is echoed by the fact 90% of the cohort did not participate in vigorous physical activity.

The study calls for regular vigorous physical exercise and dietary modifications to prevent clustering of risk factors into the metabolic syndrome. These measures are important especially since obesity and physical inactivity are modifiable. Most studies of physical activity have focused on moderate-vigorous leisure-time activity, because it involves higher energy expenditure and increase physical fitness, and has been demonstrated to decrease the risk of MS. However, for most people it is difficult to get a significant amount of physical activity from moderate-vigorous leisure-time activity, so that other types of physical activity improve health need to be explored. For example, workplace activity may be an option for working populations, because, although workplace activities may not be as vigorous in terms of cardio-respiratory effort, they do make up a considerable proportion of the total daily physical activity with important energy expenditure (42).

Our study shows that the Indian community of Phoenix is at high risk of developing cardiovascular non-communicable diseases. The development and implementation of community intervention programme to combat physical inactivity and obesity is urgently required in this group. There is an exceptional need for health care workers to recognise the importance of MS especially given the high prevalence of coronary artery disease and diabetes in South African Indians (72).

References

1. Nugent R. Chronic Diseases in Developing Countries: Health and Economic Burdens. Annals of the New York Academy of Sciences. 2008;1136(70-79).
2. Yusuf S, Reddy S, Ôunpuu S, Anand S. Global Burden of Cardiovascular Diseases: Part 1: Generation Considerations, the Epidemiologic Transition, Risk Factors, and Impact of Urbanization. Circulation. 2001;104:2746-53.
3. Olefsky JM, Glass CK. Macrophages, Inflammation, and Insulin Resistance. Annual Review of Physiology. 2010;72:219-46.
4. Handelsman Y. Metabolic Syndrome Pathophysiology and Clinical Presentation. Toxicologic Pathology. 2009;37(18):18-21.
5. Alberti KGMM, Zimmet P, Shaw J. Metabolic syndrome- a new world-wide defition. A Consensus Statement from the International Diabetes Federation. Diabetes Medicine. 2006;23:469-80.
6. Okafor CI. The metabolic syndrome in Africa: Current Trends. Indian Journal of Endocrinology and Metabolism. 2012;16(1):56-66.
7. Longo-Mbenza B, Kasiam Lasi On'kin JB, Nge Okwe A, Kangola Kabangu A, Mbungu Fuele S. Metabolic syndrome, aging, physical inactivity, and incidence of type 2 diabetes in general African population. Diabetes & Vascular Disease Research. 2010;7(1):28-39.
8. Brunner E, Shipley MJ, Blane D, Smith GD, Marmot MG. When does cardiovascular risk start? Past and present socioeconomic circumstances and risk factors in adulthood. J Epidemiol Community Health. 1999;53(12):757-64.
9. Mendis S, Puska P, Norrving B. Global Atlas on cardiovascular disease prevention and control. World Health Organization in collaboration with the World Heart Federation and the World Stroke Organization; 2011. p. 1-164.
10. Puoane T, Tsolekile L, Sanders D, Parker W. Chapter 5: Chronic Non-Communicable Diseases. http://wwwhstorgza/uploads/files/chap5_08pdf. Accessed 08 June 2011.
11. BeLue R, Okoror TA, Lwelunmor J, Taylor KD, Degboe AN, Agyemang C, et al. An overview of cardiovascular risk factor burden in sub-Saharan Africa countries: a socio-cultural perspective. Globalization and Health. 2009;5(10):1-12.
12. Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in Asian Indian Adults. Diabetes Care. 2003;26(5):1380-4.
13. Lambert EV, Bohlmann I, Kolbe-Alexander T. Be Active- Physical activity for health in South Africa. South African Journal of Clinical Nutrition. 2001;14(3):S12-6.
14. Nishida C. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363:157-63.
15. Raji A, Seely EW, Arky RA, Simonson D. Body Fat Distrubition and Insulin Resistance in Healthy Asian Indians and Causcasians. Journal of Clinical Endocrinology and Metabolism. 2001;86:5366-71.
16. Balkau B, Deanfield JE, Després J-P, Bassand J-P, Fox KAA, Smith SC, Jnr, et al. International Day for the Evaluation of Abdominal Obesity (IDEA): A Study of Waist Circumference, Cardiovascular Disease, and Diabetes Mellitus in 168 000 Primary Care Patients in 63 Countries Circulation. 2007;116:1942-51.
17. Steyn K, Bradshaw D. Non-communicable disease surveillance in developing countries. Scandinavian Journal of Public Health. 2001;29(61):161-5.
18. Steyn K, Fourie J, Temple N. Chronic diseases of lifestyle in South Africa 1995-2005. Steyn K, editor. Capetown 2006.
19. Joubert J, Norman R, Lambert EV, Groenewald P, Schneider M, Bull F, et al. Estimating the burden of disease attributable to physical inactivity in South Africa in 2000. South African Medical Journal. 2007;97(8):725-31.
20. Joubert J, Norman R, Bradshaw D, Goedecke JH, Steyn NP, Puoane T. Estimating the burden of disease attributable to excess body weight in South Africa in 2000. S Afr Med J. 2007;97(8 Pt 2):683-90.
21. Misra A, Chowbey P, Makkar BM, Vikram NK, Wasir JS, Chadha D, et al. Consensus Statement for Diagnosis of Obesity, Abdominal Obesity and the Metabolic Syndrome for Asian Indians and

Recommendations for Physical Activity, Medical and Surgical Management. Association of Physicians-India. 2009;57:163-70.
22. Gupta R, Rastogi P, Sarna M, Gupta VP, Sharma SK, Kothari K. Body-Mass Index, Waist-Size, Waist-Hip Ratio and Cardiovascular Risk Factors in Urban Subjects. Journal of the Association of Physicians of India. 2007;55:621-7.
23. Armstrong L, Balady GJ, Berry MJ, et al. ACSM's Guidelines for Exercise Testing and Prescription. In: Whaley MH, Brubaker PH, Otto RM, editors. ACSM's Guidelines for Exercise Testing and Prescription Seventh Edition 7. 7th ed: Lippincott Williams and Wilkins; 2006. p. 55-63.

24. Taylor AE, Ebrahim S, Ben-Shlomo Y, Martin R, Whincup PH, Yarnell JW, et al. Comparison of the associations of body mass index and measures of central adiposity and fat mass with coronary heart disease, diabetes, and all-cause mortality: a study using data from 4 UK cohorts. American Journal of Clinical Nutrition. 2010;91:547-56.

25. Ketel IJ, Volman MN, Seidell JC, Stehouwer CD, Twisk JW, Lambalk CB. Superiority of skinfold measurements and waist over waist-to-hip ratio for determination of body fat distribution in a population-based cohort of Caucasian Dutch adults. Eur J Endocrinol. 2007;156(6):655-61.
26. WHO. Obesity: Preventing and Managing the Global Epidemic. . Report of a WHO Consultation on Obesity [Internet]. 1997.
27. Van Der Merwe MT. The importance and predictive value of BMI and waist circumference in the development of type 2 diabetes. South African Family Practice. 2004;46(6):10-4.
28. Alfie J, Díaz M, Pȩez O, Cufaro P, Rodríguez P, Fȩbregues G, et al. Relationship between neck circumference and hypertension in the National Health Registery (the RENATA study). Revista Argentina De Cardiologia. 2012;80(4):1-6.
29. Hingorjo MR, Qureshi MA, Mehdi A. Neck circumference as a useful marker of obesity: A comparison with body mass index and waist circumference. Journal of Pakistan Medical Association. 2012;62(1):36-40.
30. Steyn K, Sliwa K, Hawken S, Commerford P, Onen C, Damasceno A, et al. Risk Factors Associated with Myocardial Infarction in Africa: The INTERHEART Africa Study. Journal of Circulation. 2005;112:3554-61.
31. Groenewald P, Vos T, Norman R, Laubscher R, Van Walbeek C, Saloojee Y, et al. Estimating the burden of disease attributable to smoking in South Africa in 2000. South African Medical Journal. 2007;97(8):674-81.
32. Ranjith N, Verho NK, Verho M, Winkelmann BR. Acute myocardial infarction in a young South African Indian-based population: patient characteristics on admission and gender-specific risk factor prevalence. Curr Med Res Opin. 2002;18(4):242-8.
33. Lucas DL, Brown RA, Wassef M, Giles TD. Alcohol and the cardiovascular system: research challenges and opportunities. J Am Coll Cardiol. 2005;45(12):1916-24.
34. Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Fruit and vegetable intakes, C-reactive protein, and the metabolic syndrome. American Journal of Clinical Nutrition. 2006;84:1489-97.
35. Bates B, Lennox A, Bates C, Swan G. National Diet and Nutrition Survey: Headline results from Year 1 and 2 (combined) of the Rolling Programme (2008/2009 - 2009/10). London: Food Standards Agency, 2010.
36. Observatory NO. Obesity and alcohol: an overview England: Public Health Observatories; 2012.
37. Jacinta RI, Arden CI, Riddell MC, Kuk JL. Relation of Physical Activity to Cardiovascular Disease Mortality and the Influence to Cardiometabolic Risk Factor. American Journal of Cardiology. 2011;108(1426-1431).
38. Ekelund U, Beesson H, Luan J, May AM, Sharp SJ, Brage S, et al. Physical activity and gain in abdominal adiposity and body weight: prospective cohort study in 288,498 men and women. American Journal of Clinical Nutrition. 2011;93:826-35.
39. Fox KR, Hillsdon M. Physical activity and obesity. Obesity Reviews. 2007;8 (Suppl. 1):115-21.

40. Thompson PD, Buchner D, Piña IL, Balady GJ, Williams MA, Marcus BH, et al. Exercise and Physical Activity in the Prevention and Treatment of Atherosclerotic Cardiovascular Disease: A Statement From the Council on Clinical Cardiology (Subcommittee on Exercisem Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity). Circulation. 2003;107:3109-16.
41. Yusuf S, Hawken S, Ôunpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364:937-52.
42. Méndez-Hernández P, Flores Y, Siani C, Lamure M, Dosamantes-Carrasco LD, Halley-Castillo E, et al. Physical activity and risk of Metabolic Syndrome in an urban Mexican cohort. Biomedical Central Public Health. 2009;9(276):1-10.
43. Matthews CE, Goerge SM, Moore SC, Bowles HR, Blair A, Park Y, et al. Amount of time spent in sedentary behaviors and cause-specific mortality in US Adults. American Journal of Clinical Nutrition. 2012;95:437-45.
44. Omar MAK, Motala AA. Diabetes in South African Indians. International Journal of Diabetes in Developing Countries. 1996;16:45-7.
45. Federation ID. IDF Diabetes Atlas: Epidemiology and Mobidity.
46. Ansari RM. Effects of Physical Activity and Obesity on Type 2 Diabetes in a Middle-Aged Population. Journal of Environmental and Public Health. 2009:1-5.
47. Gómez-Ambrosi J, Silva C, Galofré JC, Santos S, Gil MJ, Valentí V, et al. Body Adiposity and Type 2 Diabetes: Increased Risk with a High Body Fat Percentage Even Having a Normal BMI. Obesity. 2011;19:1439-44.
48. Zhang K, Pi-sunyer FX, Boozer CN. Improving Engery Expenditure Estimation for Physical Activity. Offical Journal of the American College of Sport Medicine. 2004;36(5):1-7.
49. Jago R, Baranoski, T., Yoo, S., Cullen, K.W., Zakeri, I., Watson, K., Himes,J.H., Pratt, C., Sun, W., Pruitt, L.A., Matheson, D.M. Relationship between physical activity and diet among African-American girls. Obesity Research. 2004;12:55S-63S.
50. Steinberger J, Daniels SR. Obesity, Insulin Resistance, Diabetes, and Cardiovascular Risk in Children: An American Heart Association Scientific Statement from the Atherosclerosis, Hypertension, and Obesity in the Young Committee (Council on Cardiovascualar Disease in the Young) and the Diabtes Committee (Council on Nutrition, Physical Activity, and Metabolism). Circulation. 2003;107:1448-53.
51. Kavouras SA, Panagiotakos DB, Pitsavos C, Chrysohoou C, Anastasiou CA, Lentzas Y, et al. Physical activity, obesity status, and glycemic control: The ATTICA study. Med Sci Sports Exerc. 2007;39(4):606-11.
52. Louie JCY, Buyken AE, Brand-Miller JC, Flood VM. The link between dietary glycemic index and nutrient adequacy. American Journal of Clinical Nutrition. 2012;95:694-702.
53. Morrato EH, Hill JO, Wyatt HR, Ghushchyan V, Sullivan PW. Physical activity in U.S. adults with diabetes and at risk for developing diabetes, 2003. Diabetes Care. 2007;30(2):203-9.
54. Kotchen TA. Obesity-Related Hypertension: Epidemiology, Pathophysiology, and Clinical Management. American Journal of Hypertension. 2010;23(11):1170-8.
55. Garrison RJ, Kannel WB, Stokes III J, Castelli WP. Incidence and precursors of hypertension in young adults: The Framingham offspring study. Preventive Medicine. 1987;16(2):235-51.
56. Francishetti EA, Genelhu VA. Obesity-hypertension: an ongoing pandemic. International Journal of Clinical Practice. 2006;61(2):259-80.
57. Knobler H, Abbasi F, Lamendola C, Reaven GM. Insulin resistance and cardiovascular disease risk factors in subjects with prehypertension. Diabetes and Vascular Research. 2011;8(1):43-6.
58. Balasubramanyam A, Rao S, Misra R, Sekhar RV, Ballantyne CM. Prevalence of Metabolic Syndrome and associated risk factor in Asian Indians. Journal of Immigrant and Minority Health. 2007.
59. Motala AA, Mbanya J, Ramaiya KL. Metabolic syndrome in Sub-Saharan Africa. Ethnicity Disease. 2009;19:S2-S10.

60. Eapen D, Kalra GL, Merchant N, Arora A, Khan BV. Metabolic syndrome and cardiovascular disease in South Asians. Vascular Health and Risk Management. 2009;5:731-43.
61. Churilla JR, Fitzhugh EC. Relationship between leisure-time physical activity and metabolic syndrome using varying definitions: 1999-2004 NHANES. Diabetes and Vascular Research. 2009;6(2):100-9.
62. Slabbert S. One in four South Africans may have metabolic syndrome2011 06 June 2013. Available from: http://www.citizen.co.za/citizen/content/en/citizen/local-news?oid=234650&sn=Detail&pid=146824&One-in-four-South-Africans--may-have-metabolic-syndrome.
63. Erasmus RT, Soita DJ, Hassan M, Blanco-Blanco E, Vergotine Z, Kengne AP, et al. High prevalence of diabetes mellitus and metabolic syndrome in a South African coloured population: Baseline data of a study in Bellville, Cape Town. South African Medical Journal. 2012;102(11):841-4.
64. Kanjilal S, Shanker J, Rao VS, Khadrinarasimhaih NB, Mukherjee SS, Iyengar S, et al. Prevalence and component analysis of metabloic syndrome: An Indian artherosclerosis research study perspective. Vascular Health and Risk Management. 2008;4(1):189-97.
65. Haase A, Steptoe A, Sallis JF, Wardle J. Leisure-time physical activity in university students from 23 countries: associations with health beliefs, risk awareness, and national economic development. Prev Med. 2004;39(1):182-90.
66. WHO. WHO: STEPS Instrument for NCD Risk Factors

2005.
67. Dunkley AJ, Taub NA, Davies MJ, Stone MA, Khunti K. Is having a family history to type 2 diabetes or cardiovascular disease a predictive factor for metabolic syndrome? Primary Care Diabetes. 2009;2:49-56.
68. Deepa M, Pradeepa R, Rema M, Mohan A, R. D, S. S, et al. The Chennai Urban Rural Epidemiology Study (CURES) - Study Design and Methodology (Urban Component) (CURES - I). Journal of the Association of Physicians of India. 2003;51:863-70.
69. Lavanya KM, Thomas V, Roa M, Roa N. Metabolic Syndrome (Ms) among Adults in Urban Slums - A cross section study in Hyderabad, Andhra Pradesh, India Journal of Community Medical Health Education. 2012;2(11):1-4.
70. Ker J, Rheeder P, Van Tonder R. Frequency of the metabolic syndrome in screened South African corporate executives. Cardiovasc J S Afr. 2007;18(1):30-3.
71. Schutte AE, Olckers A. Metabolic Syndrome risk in Black South African women compared to Caucasian women. Hormone Metabolism Reseach. 2007;39(9):651-7.
72. Ranjith N, Pegoraro RJ, Naidoo DP, Esterhuizen TM. Metabolic syndrome in young Asian Indian patients with myocardial infarction. Cardiovascular Journal of Africa. 2002;18(4):228-33.
73. Al-Lawati JA, Barakat NM, Al-Lawati AM, Mohammed AJ. Optimal cut-points for body mass index, waist circumference and wasit-to-hip ratio using the Framingham coronary heart diesease risk score in an Arab population of the Middle East. Diabetes and Vascular Disease Reseach. 2008;5:304-9.
74. Steyn K. Heart Disease in South Africa. Department of Medicine, University of Cape Town. 2007:1-29.
75. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting Time and Mortality from All Causes, Cardiovascular Disease, and Cancer Official Journal of the American College of Sport Medicine: Medicine and Science in Sports and Exercise. 2009;41:998-1005.
76. Dunstan DW, Barr ELM, Healy GN, Salmon J, Shaw JE, Balkau B, et al. Television Viewing Time and Mortality: The Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Circulation. 2010;121:384-91.
77. Bauman AE, Bull FC. Enviromental correlates of physical activity and walking in Adults and Children: A review of review. United Kingdom: Loughborough University; 2007.
78. Babey SH, Hastert TA, Yu H, Brown R. Physical Activity Among Adolescents: When do parks matter? American Journal of Preventive Medicine. 2008;34(4):345-8.

79. Makhatini M, Moodley S. Phoenix [20 June 2013]. Available from: http://www.durban.gov.za/Discover_Durban/History_Communities/Our_Town/Pages/Phoenix.aspx.
80. Buttar HS, Li T, Ravi N. Prevention of cardiovascular diseases: Role of exercise, dietary interventions, obesity and smoking cessation. Experimental Clinical Cardiology. 2005;10(4):229-49.
81. Vergnaud A, Norat T, Romaguera D, Mouw T, May AM, Romieu I, et al. Fruit and vegetable consumption and prospective weight change in participants of the European Prospective Investigation into Cancer and Nutrition-Physical Activtiy, Nurtrition, Alcohol, Cessation of smoking, Eating Out of Home, and Obesity study. American Journal of Clinical Nutrition. 2012;95:184-93.
82. Beevers G, Lip GYH, O'Brien E. ABC of Hypertension. British Medical Journal. 2001;322:912-6.
83. De Wardener HE, MacGregor GA. Harmful effects of dietary salt in addition to hypertension. Journal of Human Hypertension. 2002;16:213-23.
84. Santos AC, Ebrahim S, Barros H. Alcohol intake, smoking, sleeping hours, physical activity and the metabolic syndrome. Preventive Medicine-Elservier. 2007;44:328-34.
85. Wallace JM, Bachman JG, O'Malley PM, Schulenberg JE, Cooper SM, Johnston LD. Gender and ethnic differences in smoking, drinking and illicit drug use among American 8th, 10th and 12th grade students, 1976-2000. Addiction. 2003;98:225-34.
86. Nolen-Hoeksema S. Gender differences in risk factors and consequences for alcohol use and problems. Clinical Psychology Review. 2004;24:981-1010.
87. Jitnarin N, Kosulwat V, Boonpraderm A, Haddock CK, W.S.C P. The Relationship between Smoking, BMI, Physical Activity, and Dietary Intake among Thai Adults in Central Thailand. Journal of Medical Association of Thailand. 2008;91(7):1109-16.
88. Ignarro LJ, Balestrieri ML, Napoli C. Nutrition, physical activity, and cardiovascular disease: an update. Cardiovasc Res. 2007;73(2):326-40.
89. Mirsa A, Khurana L. Obesity and the Metabolic Syndrome in Developing Countries. Journal of Clinical Endocrinology and Metabolism. 2008;93:S9-S30.

APPENDIX A: KISH METHOD OF SELECTION

Directions to fill out Adult No. as per Kish cover sheet

List all persons ages 15-64 : MALES IN ORDER DECREASING AGE & FEMALES IN ORDER OF DECRESING AGE

SEX	AGE		ADULT No	PERSON SELECTED
M	55		1	
F	51		3	
M	31		2	
F	29		4	
F	24		5	

Kish Tables

Selection Table A	
If n° of adults is:	Select adult n°
1	1
2	1
3	1
4	1
5	1
6 or more	1

Selection Table B1	
If n° of adults is:	Select adult n°
1	1
2	1
3	1
4	1
5	2
6 or more	2

Selection Table B2	
If n° of adults is:	Select adult n°
1	1
2	1
3	1
4	2
5	2
6 or more	2

Selection Table C	
If n° of adults is:	Select adult n°
1	1
2	1
3	2
4	2
5	3
6 or more	3

Selection Table D	
If n° of adults is:	Select adult n°
1	1
2	2
3	2
4	3
5	4
6 or more	4

Selection Table E1	
If n° of adults is:	Select adult n°
1	1
2	2
3	3
4	3
5	3
6 or more	5

Selection Table E2	
If n° of adults is:	Select adult n°
1	1
2	2
3	3
4	4
5	5
6 or more	5

Selection Table F	
If n° of adults is:	Select adult n°
1	1
2	2
3	3
4	4
5	5
6 or more	6

APPENDIX B: THE MODIFIED WHO STEPS QUESTIONNARIE

Step 1 Demographic Information

Demographic Information

Questions		Response	Code
14	Sex (*Record Male / Female as observed*)	Male 1 Female 2	C1
15	What is your date of birth? *Don't Know 77 777 7777*	⌊⌊⌋⌋ ⌊⌊⌋⌋ ⌊⌊⌋⌋⌋⌋ *If known, go to C4* dd mm year	C2
16	How old are you?	Years ⌊⌊⌋	C3
17	In total, how many years have you spent at school or in full-time study (excluding pre-school)?	Years ⌊⌊⌋	C4
18	What is the highest level of education you have completed?	No formal schooling 01 Less than primary school 02 Primary school completed 03 Secondary school completed 04 High school completed 05 College/University completed 06 Post graduate degree 07 Refused 08	C6
19	Which of the following best describes your main work status over the last 12 months? *(USE SHOWCARD)*	Government employee 01 Non-government employee 02 Self-employed 03 Non-paid 04 Student 05 Homemaker 06 Retired 07 Unemployed (able to work) 08 Unemployed (unable to work) 09 Refused 88	C7
20	How many people 15 years and older, including yourself, live in your household?	Number of people ⌊⌊⌋	C8
21	Taking **the past year**, can you tell me what the average earnings of the household have been? *(RECORD ONLY ONE, NOT ALL 4)*	Per week ⌊⌊⌋⌋⌋⌋⌋⌋ *Go to T1* C9a OR per month ⌊⌊⌋⌋⌋⌋⌋⌋ *Go to T1* C9b OR per year ⌊⌊⌋⌋⌋⌋⌋⌋ *Go to T1* C9c Refused 8 C9d	
22	If you don't know the amount, can you give an **estimate** of the annual household income if I read some options to you? Is it *(READ OPTIONS)*	≤R4800 1 More than R4800, ≤ R19200 2 More than R19200, ≤ R38400 3 More than R38400, ≤R76800 4 More than R76800 5 Don't Know 6 Refused 8	C10

Participant Identification Number ⌊⌋⌊⌋⌊⌋

Step 1 Behavioural Measurements

Tobacco Use

Now I am going to ask you some questions about various health behaviours. This includes things like smoking, drinking alcohol, eating fruits and vegetables and physical activity. Let's start with tobacco.

Questions		Response	Code
23	Do you currently smoke any **tobacco products**, such as cigarettes, cigars or pipes?	Yes 1 No 2 *If No, go to T6*	T1
24	**If Yes,** Do you currently smoke tobacco products **daily**?	Yes 1 No 2 *If No, go to T6*	T2
25	How old were you when you **first started** smoking daily?	Age (years) ⌊⌋⌊⌋ *If Known, go to T5a* Don't remember 777	T3
26	Do you remember how long ago it was? *(RECORD ONLY 1, NOT ALL 3)* Don't remember 777	In Years ⌊⌋⌊⌋ *If Known, go to T5a*	T4a
		OR in Months ⌊⌋⌊⌋ *If Known, go to T5a*	T4b
		OR in Weeks ⌊⌋⌊⌋	T4c
27	On average, **how many** of the following do you smoke each day? *(RECORD FOR EACH TYPE)* Don't remember 777	Manufactured cigarettes ⌊⌋⌊⌋	T5a
		Hand-rolled cigarettes ⌊⌋⌊⌋	T5b
		Pipes full of tobacco ⌊⌋⌊⌋	T5c
		Cigars, cheroots, cigarillos ⌊⌋⌊⌋	T5d
		Other ⌊⌋⌊⌋ *If other, go to T5 other*	T5e
		Other (please specify): ⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋	T5other
28	In the past, did you **ever** smoke **daily**?	Yes 1 No 2 *If No, go to T9*	T6
29	**If Yes,** *How* old were you when you **stopped** smoking **daily**?	Age (years) ⌊⌋⌊⌋ *If Known, go to T9* Don't remember 777	T7
30	How **long ago** did you stop smoking daily? *(RECORD ONLY 1, NOT ALL 3)* Don't remember 777	Years ago ⌊⌋⌊⌋ *If Known, go to T9*	T8a
		OR Months ago ⌊⌋⌊⌋ *If Known, go to T9*	T8b
		OR Weeks ago ⌊⌋⌊⌋	T8c
31	Do you **currently use** any **smokeless tobacco** such as [*snuff, chewing tobacco, betel*]?	Yes 1 No 2 *If No, go to T12*	T9
32	**If Yes,** Do you **currently use smokeless tobacco** products **daily?**	Yes 1 No 2 *If No, go to T12*	T10

Participant Identification Number ⌊_⌋⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋

33	On average, how many **times a day** do you use			
			Snuff, by mouth ⌊_⌋⌊_⌋⌊_⌋	T11a
			Snuff, by nose ⌊_⌋⌊_⌋⌊_⌋	T11b
			Chewing tobacco ⌊_⌋⌊_⌋⌊_⌋	T11c
	(RECORD FOR EACH TYPE)		Betel, quid ⌊_⌋⌊_⌋⌊_⌋	T11d
	Don't Know 777		Other ⌊_⌋⌊_⌋⌊_⌋ *If Other, go to T11 other*	T11e
			Other (specify) ⌊_⌋⌊_⌋⌊_⌋⌊_⌋⌊_⌋⌊_⌋⌊_⌋⌊_⌋	T11other
34	In the past, did you **ever use** smokeless tobacco such as [*snuff, chewing tobacco, or betel*] **daily**?		Yes 1 No 2	T12
35	During the past 7 days, on how many days have people smoked in your presence, where you live?		Number of days ⌊_⌋	X3
36	During the past 7 days, on how many days have people smoked in your presence, other than where you live?		Number of days ⌊_⌋	X4

Alcohol Consumption

The next questions ask about the consumption of alcohol.

Questions		Response	Code
37	Have you consumed alcohol (such as beer, wine, spirits, fermented cider or *[add other local examples]* within the **past 12 months**? *(USE SHOWCARD OR SHOW EXAMPLES)*	Yes 1 No 2 *If No, go to D1*	A1
38	In the past 12 months, **how frequently** have you had at least one drink? *(READ RESPONSES USE SHOWCARD)*	Daily 1 5-6 days per week 2 1-4 days per week 3 1-3 days per month 4 Less than once a month 5	A2
39	When you drink alcohol, **on average**, how many drinks do you have during one day?	Number ⌊_⌋⌊_⌋ Don't know 77	A3
40	Have you consumed alcohol (such as beer, wine, spirits, fermented cider or *[add other local examples]* within the **past 30 days**? *(USE SHOWCARD OR SHOW EXAMPLES)*	Yes 1 No 2 *If No, go to A 6*	A4
41	During each of the **past 7 days**, how many standard drinks of any alcoholic drink did you have each day? *(RECORD FOR EACH DAY USE SHOWCARD)* Don't Know 77	Monday ⌊_⌋⌊_⌋	A5a
		Tuesday ⌊_⌋⌊_⌋	A5b
		Wednesday ⌊_⌋⌊_⌋	A5c
		Thursday ⌊_⌋⌊_⌋	A5d
		Friday ⌊_⌋⌊_⌋	A5e
		Saturday ⌊_⌋⌊_⌋	A5f
		Sunday ⌊_⌋⌊_⌋	A5g
42	In the past 12 months, what was the **largest number** of drinks you had on a single occasion, counting all types of standard drinks together?	Largest number ⌊_⌋⌊_⌋	A6

Participant Identification Number ⌊_⌋⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋

43	**For men only:** In the past 12 months, on how many days did you have **five or more** standard drinks in a single day?	Number of days ⌊_⌋⌊_⌋	A7
44	**For women only**: In the past 12 months, on how many days did you have **four or more** standard drinks in a single day?	Number of days ⌊_⌋⌊_⌋	A8

Diet

The next questions ask about the fruits and vegetables that you usually eat. I have a nutrition card here that shows you some examples of local fruits and vegetables. Each picture represents the size of a serving. As you answer these questions please think of a typical week in the last year.

Questions		Response	Code
45	In a typical week, on how many days do you **eat fruit**? *(USE SHOWCARD)*	Number of days ⌊_⌋⌊_⌋ *If Zero days, go to D3* Don't Know 77	D1
46	How many **servings** of fruit do you eat on **one** of those days? *(USE SHOWCARD)*	Number of servings ⌊_⌋⌊_⌋ Don't Know 77	D2
47	In a typical week, on how many days do you **eat vegetables**? *(USE SHOWCARD)*	Number of days ⌊_⌋⌊_⌋ *If Zero days, go to D5* Don't Know 77	D3
48	How many **servings** of vegetables do you eat on one of those days? *(USE SHOWCARD)*	Number of servings ⌊_⌋⌊_⌋ Don't Know 77	D4
4	What type of **oil or fat is most often** used for meal preparation in your household? *(USE SHOWCARD SELECT ONLY ONE)*	Vegetable oil 0 1 Lard or suet 0 2 Butter or ghee 0 3 Margarine 0 4 Other 0 5 *If Other, go to D5 other* None in particular 0 6 None used 0 7 Don't know 7 7	D5
		Other ⌊_⌋⌊_⌋⌊_⌋⌊_⌋⌊_⌋⌊_⌋	D5other
50	How often do you add **salt** to your food after it is cooked or prepared?	Never/ rarely 0 1 Sometimes 0 2 Usually 0 3	X5
51	During the past 30 days, how many times per day did you **usually** drink carbonated soft drinks, such as Coke, Fanta *[INSERT COUNTRY-SPECIFIC EXAMPLES]*	I did not drink carbonated drinks during the past 30 days 0 1 Less than one time a day 0 2 One time a day 0 3 Twice a day 04 3 times per day 05 4 times per day 06 5 or more times per day 07	X6

Participant Identification Number ⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋

52	During the past 30 days, how many times per day did you **usually** eat food high in fat? *[INSERT COUNTRY-SPECIFIC EXAMPLES]*	I did not eat food high in fat 0 1 Less than 1 time per day 0 2 Twice a day 0 3 3 times per day 04 4 times per day 05 5 or more times per day 06	X7
53	During the past 7 days, on how many days did you eat at a fast food restaurant, such as McDonalds, KFC Whimpy, Nandos etc? INSERT EXAMPLES	Number of days ⌊_⌋⌊_⌋ Don't Know 77 ⌊_⌋⌊_⌋	X8

Physical Activity

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

Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, household chores, harvesting food/crops, fishing or hunting for food, seeking employment. *[Insert other examples if needed].* In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.

Questions		Response	Code
Activity at work			
54	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like *[carrying or lifting heavy loads, digging or construction work]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 4*	P1
55	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days ⌊_⌋	P2
56	How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P3 (a-b)
57	Does your work involve moderate-intensity activity, that causes small increases in breathing or heart rate such as brisk walking *[or carrying light loads]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 7*	P4
58	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days ⌊_⌋	P5
59	How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P6 (a-b)
Travel to and from places			
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship. [insert other examples if needed]			
60	Do you walk or use a bicycle (*pedal cycle*) for at least 10 minutes continuously to get to and from places?	Yes 1 No 2 *If No, go to P 10*	P7
61	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days ⌊_⌋	P8

Participant Identification Number ⌊_⌊_⌋ ⌊_⌊_⌋ ⌊_⌊_⌋

62	How much time do you spend walking or bicycling for travel on a typical day?	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs mins	P9 (a-b)
Recreational activities			
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure),[insert relevant terms].			
63	Do you do any vigorous-intensity sports, fitness or recreational (*leisure*) activities that cause large increases in breathing or heart rate like [*running or football,*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 13*	P10
64	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?	Number of days ⌊_⌋	P11
65	How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs mins	P12 (a-b)

Physical Activity (recreational activities) contd.			
Questions		**Response**	**Code**
66	Do you do any moderate-intensity sports, fitness or recreational *(leisure*) activities that causes a small increase in breathing or heart rate such as brisk walking,(*cycling, swimming, volleyball*)for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P16*	P13
67	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (*leisure*) activities?	Number of days ⌊_⌋	P14
68	How much time do you spend doing moderate-intensity sports, fitness or recreational (*leisure*) activities on a typical day?	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs mins	P15 (a-b)
Sedentary behaviour			
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but do not include time spent sleeping. *[INSERT EXAMPLES] (USE SHOWCARD)*			
69	How much time do you usually spend sitting or reclining on a typical day?	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs min s	P16 (a-b)

Participant Identification Number ⌊⌋⌊⌋⌊⌋

Stress

The next questions ask about stress and how you cope with things in your life.

Questions		Response	Code
70	How often have you been upset because of something that happened unexpectedly?	Never 01 Almost Never 02 Sometimes 03 Fairly often 04 Very often 05	X9
71	How often have you felt that you were unable to control the most important things in your life?	Never 01 Almost Never 02 Sometimes 03 Fairly often 04 Very often 05	X10
72	How often have you felt nervous or stressed?	Never 01 Almost Never 02 Sometimes 03 Fairly often 04 Very often 05	X11
73	How often have you found that you could not cope with all the things that you had to do?	Never 01 Almost Never 02 Sometimes 03 Fairly often 04 Very often 05	X12

Participant Identification Number ⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋

Sleep			
The next questions ask about sleep apnoea and sleeping disorders.			
Questions		**Response**	**Code**
74	Do you snore?	Yes 1 No 2 Don't know 7	X13
75	Has anyone ever told you that you quit breathing during your sleep?	Yes 1 No 2	X14
76	During the past 30 days, how often did you have a problem with sleeping, such as falling asleep, waking up frequently during the night or waking up too early in the morning?	Never 01 Almost Never 02 Sometimes 03 Fairly often 04 Very often 05	X15
77	During the past 30 days, how often did you have a problem with not feeling rested and refreshed during the day (e.g. feeling tired, not having energy)?	Never 01 Almost Never 02 Sometimes 03 Fairly often 04 Very often 05	X16
78	How many hours do you sleep during a 24-hour period?	⌊⌋⌊⌋ hrs	X17

Participant Identification Number ⌊⌊⌋ ⌊⌊⌋ ⌊⌊⌋

History of High Blood Pressure			
Questions		**Response**	**Code**
79	When was your blood pressure last measured by a health professional?	Within past 12 months 1 1-5 years ago 2 Not within past 5 years 3	H1
80	During the past 12 months or before have you been told by a doctor or other health worker that you have elevated blood pressure or hypertension?	Yes 1 No 2	H2
81	Are you currently receiving any of the following treatments/advice for high blood pressure prescribed by a doctor or other health worker?		
	Drugs (medication) that you have taken in the last 2 weeks	Yes 1 No 2	H3a
	Special prescribed diet	Yes 1 No 2	H3b
	Advice or treatment to lose weight	Yes 1 No 2	H3c
	Advice or treatment to stop smoking	Yes 1 No 2	H3d
	Advice to start or do more exercise	Yes 1 No 2	H3e
82	During the past 12 months have you seen a traditional healer for elevated blood pressure or hypertension	Yes 1 No 2	H4
83	Are you currently taking any herbal or traditional remedy for your high blood pressure?	Yes 1 No 2	H5

History of Diabetes			
Questions		**Response**	**Code**
84	Have you had your blood sugar measured in the last 12 months?	Yes 1 No 2	H6
85	During the past 12 months or before, have you ever been told by a doctor or other health worker that you have diabetes?	Yes 1 No 2	H7
86	Are you currently receiving any of the following treatments/advice for diabetes prescribed by a doctor or other health worker?		
	Insulin	Yes 1 No 2	H8a
	Oral drug (medication that you have taken in the last 2 weeks	Yes 1 No 2	H8b
	Special prescribed diet	Yes 1 No 2	H8c
	Advice or treatment to lose weight	Yes 1 No 2	H8d
	Advice or treatment to stop smoking	Yes 1 No 2	H8e
	Advice to start or do more exercise	Yes 1 No 2	H8f
	During the past 12 months have you seen a traditional healer for diabetes?	Yes 1 No 2	H9
	Are you currently taking any herbal or traditional remedy for your diabetes?	Yes 1 No 2	H10

Participant Identification Number ⌊_⌋⌊_⌋⌊_⌋

Family history			
Questions		**Response**	**Code**
87	Have some of your family members (father, mother, brother, sister, son, daughter, paternal and maternal grandparents) been diagnosed with the following diseases?		X18
	Obesity	Yes 1 No 2	X18a
	Raised Blood pressure	Yes 1 No 2	X18b
	Diabetes mellitus	Yes 1 No 2	X18c
	Myocardial infarction/stroke	Yes 1 No 2	X18d
	Coronary artery disease	Yes 1 No 2	X18e
	Peripheral vascular disease	Yes 1 No 2	X18f
	Congestive heart failure	Yes 1 No 2	X18g

Participant Identification Number ⌊_⌊_⌋ ⌊_⌊_⌋ ⌊_⌊_⌋

Step 2 Physical Measurements

Height and Weight		Response		Code
88	Technician ID		⌊_⌊_⌊_⌋	M1
89	Device IDs for height and weight	Height	⌊_⌊_⌋	M2a
		Weight	⌊_⌊_⌋	M2b
90	Height	in Centimetres (cm)	⌊_⌊_⌊_⌋.⌊_⌋	M3
91	Weight *If too large for scale, code 666.6*	in Kilograms (kg)	⌊_⌊_⌊_⌋.⌊_⌋	M4
92 ✓	***(For women)*** Are you pregnant?	Yes No	*1 If Yes, go to M 9* 2	M5

Waist				
93	Device ID for waist		⌊_⌊_⌋	M6
94	Waist circumference	in Centimetres (cm)	⌊_⌊_⌊_⌋.⌊_⌋	M7

Blood Pressure				
95	Technician ID		⌊_⌊_⌊_⌋	M8
96	Device ID for blood pressure		⌊_⌊_⌋	M9
97	Cuff size used	Small Normal Large	1 2 3	M10
98	Reading 1	Systolic (mmHg)	⌊_⌊_⌊_⌋	M11a
		Diastolic (mmHg)	⌊_⌊_⌊_⌋	M11b
99	Reading 2	Systolic (mmHg)	⌊_⌊_⌊_⌋	M12a
		Diastolic (mmHg)	⌊_⌊_⌊_⌋	M12b
100	Reading 3	Systolic (mmHg)	⌊_⌊_⌊_⌋	M13a
		Diastolic (mmHg)	⌊_⌊_⌊_⌋	M13b
101	During the past two weeks, have you been treated for high blood pressure with drugs (medication) prescribed by a doctor or other health worker?	Yes No	1 2	M14

Other measures				
102	Hip circumference	in Centimetres (cm)	⌊_⌊_⌊_⌋.⌊_⌋	M15
103	Mid Arm circumference	in Centimetres (cm)	⌊_⌊_⌊_⌋.⌊_⌋	X19
104	Neck circumference	in Centimetres (cm)	⌊_⌊_⌊_⌋.⌊_⌋	X20
105	Triceps Skinfold Thickness			
	Reading 1	in millimetres (mm)	⌊_⌊_⌊_⌋	X21a
	Reading 2	in millimetres (mm)	⌊_⌊_⌊_⌋	X21b
	Reading 3	in millimetres (mm)	⌊_⌊_⌊_⌋	X21c

Participant Identification Number ⌊_⌋⌊_⌋⌊_⌋

106	Heart Rate (Record if automatic blood pressure device is used)		
	Reading 1	Beats per minute ⌊_⌋⌊_⌋⌊_⌋	M16a
	Reading 2	Beats per minute ⌊_⌋⌊_⌋⌊_⌋	M16b
	Reading 3	Beats per minute ⌊_⌋⌊_⌋⌊_⌋	M16c

Step 3 Biochemical Measurements

Blood Glucose		Response	Code
107	During the last 12 hours have you had anything to eat or drink, other than water?	Yes 1 No 2	B1
108	Technician ID	⌊_⌊_⌊_⌋	B2
109	Device ID	⌊_⌊_⌋	B3
110	Time of day blood specimen taken (24 hour clock)	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs mins	B4
111	Fasting blood glucose	mmol/l ⌊_⌊_⌋ . ⌊_⌊_⌋	B5
112	Fasting blood insulin	mmol/l ⌊_⌊_⌋ . ⌊_⌊_⌋	X22
113	2 hour blood glucose level	mmol/l ⌊_⌊_⌋ . ⌊_⌊_⌋	X23
114	2 hour insulin level	pmol/l ⌊_⌊_⌊_⌊_⌋	X24

Blood Lipids			
115	Device ID	⌊_⌊_⌋	B6
116	Total cholesterol	mmol/l ⌊_⌊_⌋ . ⌊_⌊_⌋	B7
117	Triglycerides	mmol/l ⌊_⌊_⌋ . ⌊_⌊_⌋	B8
118	HDL Cholesterol	mmol/l ⌊_⌋ . ⌊_⌊_⌋	B9
119	Urine Microalbumin	mg/mMCRT ⌊_⌋ . ⌊_⌊_⌋	X25