

THESIS TITLE

Coronary artery disease risk factors among fire-fighters in the
Western Cape Province

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Declaration

I hereby declare that “Coronary artery disease risk factors among fire-fighters in the Western Cape Province” is my own work, that it has not been submitted before for any other degree in any other university, and that the sources I have used have been indicated and acknowledged as complete references.

Ghaleelullah Achmat

January 2017



Signed

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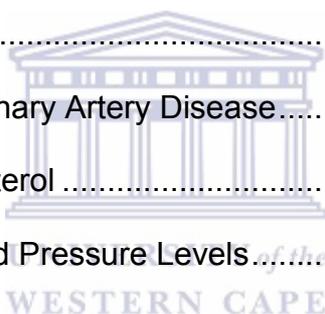


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List of Acronyms, Abbreviations, Units of Measurement, Statistical Units and Miscellaneous Notation

List of Acronyms

ACSM	=	American College of Sports Medicine
AHA	=	American Heart Association
CAD	=	coronary artery disease
CDL	=	chronic diseases of lifestyle
CHD	=	coronary heart disease
CVD	=	cardiovascular disease
LODD's	=	Line-on-duty-deaths
WCFRD	=	Western Cape Fire and Rescue Department
WHO	=	World Health Organization
WP	=	Western Province

List of Scientific Abbreviations

BMI	=	body mass index
BP	=	blood pressure
DBP	=	diastolic blood pressure
SBP	=	systolic blood pressure
Chol	=	cholesterol
FBG	=	fasting blood glucose
HDL	=	high density lipoprotein
HDL C	=	high density lipoprotein cholesterol
HR	=	heart rate
HR _{max}	=	maximal heart rate
HTN	=	hypertension
LDL	=	low density lipoprotein
LDLC	=	low density lipoprotein cholesterol
RHR	=	resting heart rate
Trig	=	triglycerides
$\dot{V}O_2$ max	=	maximal volume of oxygen consumed per minute
$\dot{V}O_2$ peak	=	peak volume of oxygen consumed per minute
WHR	=	waist-to-hip ratio
TC	=	total cholesterol

Units of Measurement

bpm	=	beats per minute
cm	=	centimetres
d·wk ⁻¹	=	days per week
kg	=	kilogram
kg·m ⁻²	=	kilograms per square metre
m	=	metre
MET·min·wk ⁻¹	=	metabolic minutes per week
min	=	minutes
mm	=	millimetres
mmol·L ⁻¹	=	millimoles per litre
mm Hg	=	millimetres of mercury
ml·kg ⁻¹ ·min ⁻¹	=	millilitres per kilogram per minute



List of Statistical Units

SD	=	standard deviation
X	=	mean
%	=	percent

Miscellaneous Notation

email	=	electronic mail
vs	=	verses

ABSTRACT

Background: The work demands involved in fire-fighting place significant stress on the cardiovascular system. Cardiovascular disease is the leading cause of on-duty death among fire fighters and is a major cause of morbidity. This study investigated the prevalence of coronary artery disease risk factors among career fire fighters in the Western Cape.

Methods: A quantitative descriptive research design with convenient sampling was used for the study. Coronary artery disease risk factors were measured in 219 male fire fighters. These measurements consisted of eight risk factors, namely, age, a family history of heart disease, cigarette smoking, obesity, resting blood pressure, fasting total cholesterol and blood glucose, and a sedentary lifestyle. Fire fighters were then stratified as having a low, moderate or high coronary artery disease risk. Statistical analysis (SPSS) version 22 was used for data analysis with a significance level of $p < 0.05$.

Results: Less than a quarter (21.00%) of male fire-fighters were stratified as low risk. The most prevalent risk category was moderate risk, i.e., 65.29%. The remaining 14.15% of fire-fighters were stratified as high risk. Fire fighters with a sedentary lifestyle occurred as the most frequent risk factor, with more than half (51.14%) having low levels of physical activity. Obesity was the second highest risk factor with a prevalence of 45.90%. This was followed by cigarette smoking in 38.30% of fire fighters. A family history of coronary artery disease was present in 32.80%. Elevated fasting total cholesterol levels occurred in 31.00%. This was followed by elevated blood pressure in 27.30%. Fire fighters over the age of 45 years totalled 20.51%. Elevated fasting blood glucose level was the least prevalent in 17.35%. A statistically significant relationship was found between the various coronary artery disease risk factors, i.e., systolic and diastolic blood pressure, waist and hip circumference, elevated fasting blood glucose levels and BMI.

Conclusion: The majority of the fire-fighters screened in the study were at moderate risk for coronary artery disease, which indicated a presence of multiple modifiable risk factors. Fire departments should focus on promoting coronary artery disease education and wellness/fitness programmes in order to reduce the presence of modifiable risk factors in fire-fighters.



CHAPTER ONE: STATEMENT OF THE PROBLEM

1.1 Introduction

Globally, it is understood that fire-fighting is a physically challenging occupation (Risavi & Staszko, 2016). Studies have shown that coronary artery disease (CAD) is more prevalent among fire-fighters than any other occupation in the United States (Glueck, Kelley, Wang, Gartside, Black, & Tracy., 1996; Bates, 1987). Approximately 50 percent of fire fighter line-of-duty-deaths (LODDs) reported occurs as a result of heart attacks. These cardiovascular events do not only happen at random, but mostly occur during very physically demanding situations, such as fire suppression (Soteriades et al., 2011).

Furthermore, the majority of fire-fighters who experienced these events possess one or more of the following risk factors for CAD, namely, obesity, prediabetes, dyslipidemia, high blood pressure (hypertension), cigarette smoking, and/or a sedentary lifestyle. The risk of heart attacks among fire-fighters is dependent on many factors, including factors such as a low level of physical activity, and chronic exposure to smoke. In addition, the high temperatures present during fire suppression significantly increase physiological strain and the potential to over exert the cardiovascular system (Soteriades et al., 2011).

Many countries in Africa bear a heavy burden from cardiovascular disease more especially in sub-Saharan Africa (Almahmeed et al., 2012). In South Africa, the prevalence of CAD has been aggravated by an increased prevalence of cardiovascular risk factors, such as cigarette smoking, hypertension, dyslipidemia, diabetes and sedentary lifestyles (Mayosi et al., 2010). The majority of the persons affected are those who are younger and at their productive age, and constitute the largest number of the workforce of a nation, fire-fighters included (Glueck et al., 1996). Fire-fighters in South Africa have been known to assist neighbouring countries

in battling wild fires, due to their effectiveness and high levels of professionalism on the job (Mia, 2016).

Despite the hazardous and strenuous nature of the emergency fire service, there is a dearth of information regarding their health. Risavi and Staszko (2016) stated that many of the fire-fighters who had died did not have an up-to-date medical evaluation. Furthermore, some of those who were older than 45 years could have up to six-times the increased risk of cardiovascular disease, with hypertension, prior occlusive disease, and cigarette smoking presenting as significant risk factors for on-duty-death (Risavi and Staszko 2016). Therefore, the purpose of this study was to determine the prevalence of coronary artery disease risk factors among fire-fighters in the Western Cape Province.



1.2 Statement of the Problem

The prevalence of CAD risk factors among fire-fighters was investigated. Primary CAD risk factors are early indicators of prospective heart disease (McGill et al., 2000). The primary CAD risk factors are divided into two categories, namely, modifiable and non-modifiable risk factors. Modifiable risk factors are those that can be reduced through personal intervention and health behaviour change. The non-modifiable risk factors are those factors, such as age and family history (genetics) that cannot be controlled through lifestyle change. Even though uncontrollable, the non-modifiable risk factors need to be considered in the overall management of CAD risk. The strength of the relationship between modifiable and non-modifiable CAD risk factors among fire-fighters indicates overlapping (Poston et al., 2011).

The nature of the link between CAD risk factors and fire-fighters in Cape Town has been largely unclear, and has potential for research. The present study was undertaken to address this problem, both from a theoretical viewpoint, and within a specific organisational setting.

Communities in resource-poor settings cannot afford to ignore the major health problem of CVD (Beaglehole, 2008). Implementing, cost-effective, strategic efforts that are community-wide have shown to be effective (Beaglehole, 2008). Economically and educationally sound prevention programmes by developed nations have been shown to be effective (Beaglehole, 2008). The emphasis on treating and preventing CAD and non-communicable disease (NCD) has potential benefits in reducing morbidity and mortality rates in the Western Cape (Beaglehole, 2008). By prioritising cost-effective strategies for the public through early detection and timely treatment, these can help to improve the individuals' quality of life (Beaglehole, 2008). Gaziano (2000) recommends that the total cardiovascular risk assessment approach be adopted as a cost effective first line strategy in the effective prevention, treatment, and management of CVDs.

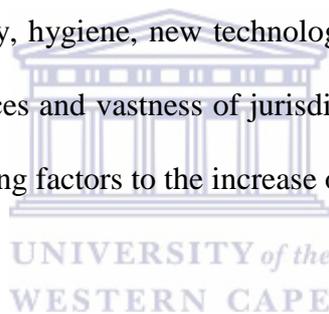
The presence of multiple CAD risk factors is considered to be a reflection of poor community health and well-being (Pearson, 1999). According to Soteriades et al. (2011), early detection will enable fire fighters to reduce their risk and the incidence of CAD, and assist in reducing the LODDs. Fire-fighters need to focus on the modifiable risk factors that can be controlled in order to minimize the risk of sustaining a sudden cardiac event.

Fires are common in the city of Cape Town during the summer months. For long periods of time, fire fighters prevent these fires from spreading on the ground, even utilizing helicopters and spotter planes to water bomb the blazes. People in frequent, life-threatening challenges,

e.g., fire fighters, experience prolonged stress, which may have negative effects on both job performance and personal adjustment (Glass, Singer and Pennebaker, 1973).

However, the recent winter fires in Knysna have destroyed homes and businesses could easily have been brought under control. According to the fire fighters assisting with the Knysna fire, the department had insufficient resources and usage of appropriate equipment could have stopped the blaze earlier (Alexander, 2017).

Oosthuizen (2009) reported similar incidents regarding insufficient equipment and resources, poor physical working conditions, inadequate lightning, noise, vibration, climate, temperature, ventilation, humidity, hygiene, new technology, exposure to risks and dangers, travel, shortage of human resources and vastness of jurisdiction areas were also identified as major job stressors and contributing factors to the increase of CAD amongst fire fighters.



1.3 Aim of the Study

The aim of this study is to determine the prevalence of coronary artery disease (CAD) risk factors among male fire-fighters in the Western Cape Province of South Africa.

1.4 Objectives of the Study

The objectives of the study are to:

- Assess the prevalence of CAD risk factors among municipal male fire-fighters in the Western Cape Province;
- Stratify the CAD risk of fire-fighters in the Western Cape Province.

- Determine the relationship between the various CAD risk factors among municipal fire-fighters in the Western Cape Province; and

1.5 Study Hypotheses

The hypotheses of the study are that:

- Fire-fighters have multiple risk CAD factors;
- A large majority of fire-fighters are at moderate risk for CAD; and
- There is a positive relationship between the various CAD risk factors among municipal fire-fighters in the Western Cape Province.



1.6 Significance of the Study

No previous study has investigated the prevalence of CAD risk factors among fire-fighters in the Western Cape. The screening for CAD risk factors is intended to benefit the fire department and its employees by identifying risk factors early and ensuring intervention to reduce the risk. The results of this study will provide information to the Western Cape Fire and Rescue Department on CAD risk of fire-fighters within the WCFRD. Hopefully, this will have a positive impact on the personnel effectiveness and longevity of fire-fighters in the Western Cape Fire and Rescue Department (WCFRD). In addition, the findings of this study may help mitigate the potential loss of life and property by ensuring that fire-fighters are able to perform difficult tasks associated with an emergency. The topic warrants further research, due to the scarcity of research information and data within the last five years, specifically focusing on risk factors relating to CAD amongst fire-fighters in Africa generally and, particularly, in South Africa.

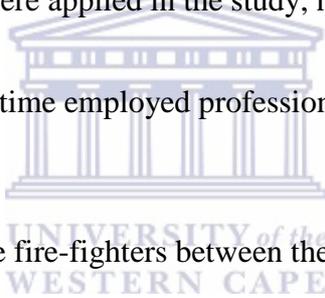
1.7 Delimitations of the Study

The delimitations of the study are divided into two categories, namely, the inclusion and exclusion criteria. The former relates to factors that determine whether participants would be included in the study, and the latter to factors that exclude participants from participating in the study.

1.7.1 Inclusion Criteria

The following inclusion criteria were applied in the study, namely:

- Participants had to be full-time employed professional fire-fighters in the Western Cape Province; and
- Participants had to be male fire-fighters between the ages of 18 and 65 years.



1.7.2 Exclusion Criteria

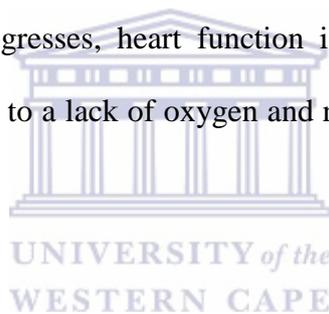
The following exclusion criteria were applied in the study, namely:

- Participants who were administrative clerks and who are not active fire-fighters;
- Participants who were volunteer fire-fighters or workers on short-time (i.e., fire-fighters contracted only for the peak season);
- Fire-fighters who had not given their consent; and
- Fire-fighters absent on the day of testing and data collection for the study.

1.8 Definitions of terms

Cardiovascular disease (CVD) refers to any disease of the heart and blood vessels, with the most common being heart attacks, heart failures and strokes (Heart and Stroke Foundation of South Africa, 2007).

Coronary heart disease (CHD) is synonymous with (CAD), and is a component of CVD that pertains specifically to pathology of the arteries of the heart. It is the progressive build-up of fatty deposits in the lining of the arteries supplying blood to the heart. Due to the process called atherosclerosis, the narrowed arteries cannot maintain a healthy flow of blood to the heart. As arterial narrowing progresses, heart function is adversely affected, resulting in damage to myocardial tissue, due to a lack of oxygen and nutrients. (McArdle et al., 2010, p. 893).



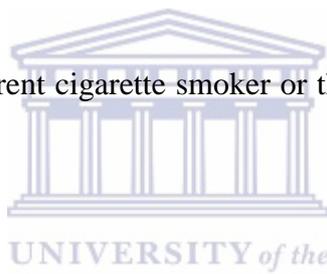
Chronic diseases of lifestyle (CDL) are a group of diseases such as obesity, metabolic syndrome, diabetes, hypertension and hypercholesterolemia that develop gradually over time due to regular exposure to risk factors, such as unhealthy diets, smoking, lack of physical activity and stress. These risks result in various long-term disease processes, culminating in cancers, chronic bronchitis, emphysema, renal failure and many others (Steyn, 2006).

Hypercholesterolemia is a high level of total cholesterol ($\geq 5.2 \text{ mmol}\cdot\text{L}^{-1}$) in the blood and is a major risk factor for CAD. Cholesterol is transported in the blood in different forms depending upon the types of lipoproteins. The most important lipoproteins are low-density lipoprotein (LDL), known as the “bad” cholesterol”, and high-density lipoprotein (HDL),

known as the ‘good’ cholesterol”. A high level of LDL cholesterol increases the risk of heart disease. Therefore, the lower the LDL cholesterol concentration, the lower is the risk of CAD, and vice versa. Alternatively, high HDL levels indicate good health, and give some protection against CAD (Steyn, 2007).

Family history refers to myocardial infarction, coronary revascularization or sudden death that occurs before 55 years of age in the father or other male first-degree relative (i.e., brother or son), or before 65 years of age in the mother or other female first-degree relative (i.e., sister or daughter) (ACSM, 2013, p. 28).

Cigarette smoking refers to a current cigarette smoker or those who quit within the previous six months (ACSM, 2013, p. 28).



Hypertension refers to a systolic blood pressure of more than or equal to 140 mm Hg and/or a diastolic blood pressure of more than or equal to 90 mm Hg, confirmed by measurements on at least two separate occasions or participants on prescribed antihypertensive medication (ACSM, 2013, p. 28).

Dyslipidemia is defined as a total cholesterol concentration of more than $5.18 \text{ mmol}\cdot\text{L}^{-1}$ determined by means of a lipogram (using arterial blood) (ACSM, 2013, p. 28).

Prediabetes refers to a fasting blood glucose of more than or equal to $5.6 \text{ mmol}\cdot\text{L}^{-1}$ confirmed by measurements on at least two separate occasions (ACSM, 2013, p. 28).

Obesity refers to a body mass index of more than or equal to $30 \text{ kg}\cdot\text{m}^{-2}$ or a waist girth of more than 102 cm in men (ACSM, 2013, p. 28).

Risk factors are those characteristics, variables or hazards that, if present for a given individual, make it more likely that the individual will develop a disorder. In order to qualify as a risk, the factor must antedate the onset of the disorder. Also, risk factors are not static. They can change in relation to age or a new stressor in one's life, and can reside within the individual, family or community (ACSM, 2013, p. 22).

A sedentary lifestyle refers to persons not participating in a regular exercise programme or meeting the minimal physical activity recommendations from the US Surgeon General's report, i.e., accumulating 30 minutes or more of moderate physical activity on most days of the week (ACSM, 2013, p. 28).



CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This literature review will cover the direct and indirect impact of CAD on the general population and the fire service personnel in particular. It will examine the risk factors associated with fire organizations and research identifying programmes to reduce the risk of CAD among fire-fighters.

CVD has reached epidemic proportions globally, as well as within South Africa, so much so that many people are at risk of premature disability and/or death (Mark et al., 2007). The signs and symptoms of CHD have a prolonged latent period, before the condition becomes evident and is clinically diagnosed (Barker, 1995). CAD is a preventable condition, with a wealth of information available to empower and educate people (Waldron et al., 2011). The main causes of CHD include risk factors such as, a sedentary lifestyle, high blood pressure, cigarette smoking and hypercholesterolemia (Navas-Nacher et al., 2001). The World Health Organization (WHO) reports that hypercholesterolemia causes more than five million premature deaths a year, with smoking about five million and hypertension almost 7 million (Go et al., 2014).

Some of the disconcerting conditions in developing countries are the rapidly declining levels of physical activity and the poor levels of physical fitness (Bloom et al., 2012) combined with the rapid increase in health risk behaviours and widespread CAD (Soler et al., 2010). The indigent and the poor are especially vulnerable (Soler et al., 2010). Due to a prolonged gestation period, the condition of CAD is compounded and remains insidious for many years

(McGill et al., 2000). Consequently, the extent of the problem only becomes evident in later years, at a time when treatment becomes challenging and expensive (Ashen, 2010).

Whilst fire-fighters are included in CVD statistics of the general population, there are work-related factors specific to the occupation of fire-fighting (Kales et al., 2007). Fire-fighters are literally exerted to the extremes of physical activity in performing their duties, so that if various CVD conditions are undiagnosed, they face an increased risk of injury and death (Kales et al., 2007). Many of the fire-fighters' tasks are strenuous, requiring them to wear protective clothing and, sometimes, with a self-contained breathing apparatus (SCBA) adding an additional carrying load of up to approximately 35 kg, whilst performing various tasks (Schmidt, 2012). For every 1000 fires tackled, approximately 23 to 25 fire-fighters are injured (Smith, 2011). Occupational stress and the sudden change from rest to high-intensity work, literally within seconds, are major contributing factors to increased mortality from CAD in fire-fighters (Mier and Gibson 2004). This lead to the recommendations by the International Association of Fire-Fighters (IAFF) that fire-fighters should engage in regular fitness training in order to meet the physical demands of fire-fighting (Findley et al. 2002). Understanding the risk factors from CAD-related issues is the first step in mitigating the potential line-on-duty-deaths (LODDs).

2.2 Understanding Coronary Artery Disease

Risk factors are a “measurable element or characteristic that is causally associated with an increased rate of a disease, and is an independent and significant predictor of risk of a presenting disease” (O’ Donnell & Elousa, 2008, p. 300). The term “risk factor originates from the Framingham Heart Study (FHS) that began in 1948 with a study of 5209 adult participants, which included women and men between the ages of 30 and 62 years in Framingham, Massachusetts. Participants of the FHS were volunteers subjected to physical and lifestyle interviews to collect data on factors in the development of cardiovascular disease. In 1972, the programme expanded with an offspring study to include a second generation, and in 2002 a third generation was added titled the history of the Framingham Heart Study. Over the past 60 years, data collected by the FHS allowed the research and medical community to understand predictive risk factors for the onset of CAD (O’ Donnell & Elousa, 2008). The milestones in the FHS on the identification of major independent risk factors were as follows: high blood pressure and cholesterol in 1957, with the term “risk factor” coined in 1961, smoking in 1962, obesity and physical inactivity in 1967 and diabetes in 1974 (O’ Donnell & Elousa, 2008). The risk factors identified in the FHS are accepted and used by most experts as major independent risk factors. The International Association of Fire-Fighters (IAFF) recognizes the FHS risk factors in the manual, “A guide to recognition and Prevention of Occupational Heart Disease for the Fire and Emergency Medical Services” which addresses CAD risk factors for the fire service (Poston et al., 2011).

2.2.1 Classification of Risk Factors for Coronary Artery Disease

There are many risk factors associated with CAD that are divided into two categories. Modifiable risk factors, such as physical inactivity, obesity, diabetes, high cholesterol, high blood pressure and cigarette smoking, can be changed by lifestyle modification and can decrease the prevalence of CAD, while non-modifiable risk factors are characteristics that cannot be altered, which include age and family history (ACSM, 2013, p. 28). CAD may develop if a risk factor is present, and it has been shown that the presence of multiple risk factors exponentially increases the risk of developing CVD (Ingelsson, Sundström, & Lind, 2010).



2.2.1.1 Modifiable Risk Factors

Modifiable risk factors account for approximately 80% of strokes and CAD (Sharma, and Ganguly, 2014). According to the Center for Disease Control and Prevention (CDC) the contribution of these factors by percentage to CAD include, physical inactivity 53%, obesity 34%, hypertension 32%, smoking 21%, cholesterol 15% and diabetes 11% (Center for Disease Control, 2008).

2.2.1.1.1 Obesity

Obesity develops from a positive energy balance, increasing the risk of CAD in direct proportion to the accumulation of visceral (central or abdominal) adiposity (The Emerging

Risk Factor Collaboration, 2011). Obesity is thought to be partly inherited and partly due to lifestyle and environmental factors creating a positive energy balance for fat storage (Day & Bailey, 2011).

Research findings show obesity to be a major risk factor for CAD and an important long-term predictor of CAD incidence. The prevalence of obesity in adults is a noticeable CAD risk, with 65% of adults stratified as overweight ($BMI \geq 25-29.9 \text{ kg}\cdot\text{m}^{-2}$) and 31% stratified as obese ($BMI \geq 30 \text{ kg}\cdot\text{m}^{-2}$), thus placing adults at further risk of prediabetes (Hedley et al., 2004).

Obese individuals are more likely to have high blood pressure, dyslipidemia and be diabetic, because of coronary microvascular dysfunction and visceral adiposity (Onat et al., 2004). Due to the close proximity of the heart and visceral fat, an adverse metabolic environment develops leading to the development of microvascular dysfunction. A study conducted by Hubert et al. (1983) indicated that congestive heart failure (CHF) increased by 2.5- to 3-fold from the leanest to the heaviest participants, signifying that those who are overweight have a higher risk when compared to leaner individuals. In addition to weight, waist-to-hip ratio was strongly correlated with cardiovascular risk (Gruson et al., 2009). Individuals who have weight centred around the midsection, known as android fat distribution, are more at risk of CAD than those who carry weight around the hips (gynoid fat distribution) (Mahan & Escott-Stump, 2008).

The distribution of fat between subcutaneous and visceral compartments varies extensively, with subcutaneous fat accounting for over 80% of overall body fat (McArdle et al., 2010, p 760). Men have less subcutaneous fat than women, but women appear to be less susceptible

to the accumulation of visceral fat (McAardle et al., 2010, p 768). Most studies indicate that excess visceral fat carries a much higher risk of CAD, as opposed to excess subcutaneous fat (Day and Bailey 2011; Mokdad et al., 2003; Onat et al., 2004). An increase in plasma lipids, raises hepatic gluconeogenesis, impairs glucose tolerance and stimulates food intake, which serves to increase visceral adiposity and adipocyte hypertrophy (Day and Bailey, 2011). Thus, several mechanisms exist through which increased adiposity causes CAD. Additionally, adipose tissue proliferation has been associated with glucose intolerance, endothelial cell dysfunction, dyslipidemia and hypertension all of which effect heart function (Hertz, Unger, McDonald, Lustik & Biddulph-Krentar, 2004).

Weight loss is important, because it decreases the risk of CAD (Day and Bailey, 2011). In a study conducted by Pascual et al. (2009), participants with metabolic syndrome who lost weight during the trial also decreased systolic and diastolic blood pressures, as well as LDL cholesterol. In addition, the impact of weight loss is important, as it reduces the risk of other cardiovascular risk factors, thus, reinforcing the necessity to be proactive in achieving weight reduction and, ultimately, lower CAD risk.

2.2.1.1.2 Elevated resting blood pressure

Hypertension is known to affect one in four adults, and is a major risk factor for CAD (Escobar, 2002). High blood pressure or hypertension (HTN) can be is defined as the pressure or force exerted on the walls of the arteries as the heart pumps blood, and is recorded as two numbers, namely, systolic and diastolic pressures. The systolic pressure is created as the heart beats, and the diastolic pressure as the heart relaxes between beats (Haider, Larson, Franklin, and Levy, 2003). Blood pressure is categorized into five stages, namely, normal is a systolic

pressure less than 120 mm Hg and a diastolic pressure < 80 mm Hg, prehypertension is a systolic pressure between 120 – 139 mm Hg and a diastolic pressure between 80 – 89 mm Hg, stage 1 hypertension is a systolic pressure between 140 – 159 mm Hg and or a diastolic pressure between 90 – 99 mm Hg, and stage 2 hypertension is systolic pressure greater than or equal to 160 mm Hg and a diastolic pressure greater than or equal to 100 mm Hg (Hader et al., 2003). For every 20 mm Hg increase in systolic blood pressure above 115 mm Hg, there is an increase in cardiovascular mortality by 50% (Escobar, 2002).

Both systolic and diastolic pressures have a positive relationship with CAD risk, as it is a precursor to cardiovascular diseases, including peripheral artery disease, coronary heart disease and cardiac failure, due to an increase in stress on the arteries (Nghiem, 2007). The pathophysiology linking hypertension with CAD starts with endothelial dysfunction or injury caused by rapid increases in blood flow that exacerbates the atherosclerotic process by making plaque more unstable. Over a period of time, persistent hypertension leads to plaque formation in the arteries, eventually leading to atherosclerosis. In response to high blood pressure and an increased workload secondary to obesity, the left ventricle of the heart grows in size (Escobar, 2002). This results in left ventricular hypertrophy that decreases cardiac reserve and leads to an increase in myocardial oxygen demand. Both conditions are contributing factors to myocardial ischemia. Furthermore, left ventricular hypertrophy is found to be a strong risk factor for heart failure (HF), and sudden death (Mahan & Escott-Stump, 2008).

Hypertension is a major risk factor for fire-fighters and a public health problem in both developed and developing countries (Seedat et al., 2006). High arterial blood pressure is often

referred to as the “silent killer”, because individuals with HTN can be asymptomatic for years and then have a heart attack or fatal stroke. Hypertension is largely influenced by factors such as body weight, exercise, alcohol consumption and diet. With lifestyle modifications, it can be managed properly through regular physical activity, diet and medication (Mahan & Escott-Stump, 2008).

2.2.1.1.3 Elevated fasting blood glucose

The fasting blood glucose (FBG) concentration is an indicator of steady-state glucose metabolism in the body (ACSM, 2013, p. 101). One of the main routes through which excess adiposity impedes glucose metabolism is via an increased supply of fatty acids into the circulation. Under normal conditions of insulin sensitivity, insulin suppresses the activity of hormone-sensitive lipase, which reduces lipolysis. Fatty acids, together with glucose, are absorbed by the liver and muscle and stored as energy. This, in turn, limits the supply of fatty acids into the bloodstream. However, when adipocytes become enlarged they also become less sensitive to the antilipolytic action of insulin, causing an increased release and turnover of fatty acids into the bloodstream. Thus, an imbalance in the glucose-fatty acid cycle develops that increases the availability of fatty acids, and reduces the utilization of glucose. Consequently, fatty acid metabolites are produced that impair insulin sensitivity and further decrease glucose transport into muscle and promote chronic hyperglycemia. Recent evidence shows that locally acting adipokines can modify insulin sensitivity and contribute to the development and maintenance of insulin resistance (Day and Bailey, 2011).

According to the American Diabetes Association (ADA), diabetes mellitus (DM) is a group of diseases characterized by high blood glucose levels resulting from defects in the body's

ability to produce insulin, which is needed to convert starches, sugar and other food into energy needed for daily life (Alberti et al., 2009).

The Framingham Heart Study indicated that diabetes mellitus is associated with a two-to-five-fold increase in CAD related death (O'Donnell, 2008). Diabetic individuals lack the ability to make insulin, therefore, leaving an abundance of glucose in the blood. Consequently, excess blood glucose results from defects in insulin secretion in the β -cells or from insulin resistance (O'Donnell, 2008). With an abundance of glucose in the blood, arteries become damaged propagating CAD (Sivapalaratnam et al., 2010). Some of the increased risk for CAD seen in diabetic individuals is attributable to the concurrent presence of other risk factors (Sivapalaratnam et al., 2010). Hypertension and dyslipidemia are associated with insulin resistance and is commonly found in obese individuals (Lloyd-Jones, Adams, Carnethon, De Simone, Ferguson, Flegal, & Haase, 2009). This results in the formation of an atheromatous plaque and, when unstable, precipitates thrombus formation causing the typical diabetic macrovascular scenario (Lloyd-Jones et al., 2009). Further complications include the microvascular disease of CAD that interacts with the macrovascular disease of diabetes, and vice versa. An example of this complication is the increased risk for myocardial infarction and the development of the diabetic foot, both reflecting a failure of small and large blood vessel function (Day and Bailey, 2011).

Management of risk factors, such as hypertension, obesity and dyslipidemia has been shown to effectively reduce the incidence of major coronary events in diabetic individuals (Lloyd-Jones et al., 2009). Additionally, due to dyslipidemia also being a major risk factor, LDL cholesterol in a diabetic individual needs to be maintained at less than $3.8 \text{ mmol}\cdot\text{L}^{-1}$ (Pearson et al., 2003).

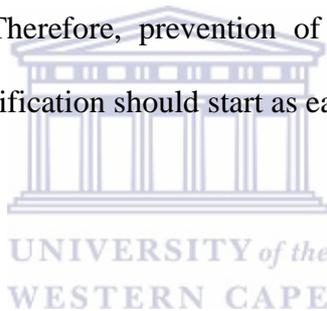
2.2.1.1.4 Elevated total cholesterol

Lipids are transported in blood plasma in combination with a carrier to form lipoproteins that are produced in the liver and composed of apolipoprotein (Apo), a phospholipid, and cholesterol (McGill et al., 2000). Lipoproteins are essential for cell development and assist in the production of vitamin D and hormones. Four types of lipoproteins act as carriers of cholesterol, namely, high-density lipoproteins (HDLs), low-density lipoproteins (LDLs), very low-density lipoproteins (VLDLs), and chylomicrons. Total cholesterol (TC) is the composite of each of the different lipoproteins, that is, HDL, LDL, and VLDL. However, the cholesterol distribution among the various lipoproteins is a more powerful predictor of heart disease than is total cholesterol (ACSM, 2013, p. 101).

Cholesterol can either be consumed through food intake or made in the body. The main purposes are structural and physiological. Dyslipidemia is determined by elevated levels of total serum cholesterol, that is, $TC > 5.2 \text{ mmol}\cdot\text{L}^{-1}$ (ACSM, 2013, p. 28). Elevated fat or triglyceride in the blood is directly linked with raised blood LDL cholesterol levels and, when combined with low HDL cholesterol concentration, constitutes a lethal triad termed atherogenic dyslipidemia (Artinian et al., 2010). This condition is commonly prevalent in individuals with premature CAD (ACSM, 2013, p. 101). Astrup et al., (2011) provides convincing evidence that dietary cholesterol elevates both total cholesterol and LDL

cholesterol, and contributes to atherosclerotic plaque formation and abnormal endothelial control of vasomotor tone.

Based on cholesterol screening of 1650 fire-fighters, 5.8% of fire-fighters were at high risk of CAD and 21.4% were at moderate risk. In a survey conducted by the National Volunteer Fire Council (NVFC) on 2167 fire-fighters, 13.1% reported cholesterol levels above the norms and 3.3% reported high cholesterol levels and receiving medication compared to 33.7% with normal cholesterol levels, whilst 44.2% were unaware of their cholesterol reading. Elevated fatty streaks that affect the endothelial surface area, increase with age, and are associated with reduced HDL cholesterol concentrations, obesity, impaired fasting glucose, as well as hypertension (Johnson, 2013). Therefore, prevention of CAD through weight reduction, regular exercise and lifestyle modification should start as early as possible.



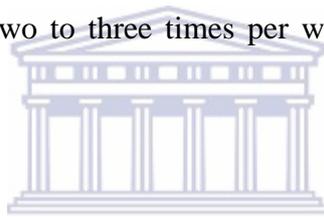
2.2.1.1.5 Sedentary Lifestyle

Not participating in physical activity for at least 30 minutes at a moderate intensity (40%–60% $\dot{V}O_2R$) at least three days of the week for a minimum of three months is considered a positive risk factor (ACSM, 2013, p. 28).

Research suggests a lack of physical activity to be an independent risk factor for CAD (Sebregts et al., 2000; Franklin and Cushman, 2011). Less than 60% of the global population achieves the minimum amount of physical activity as recommended by the American College of Sports Medicine (ACSM) and the United States Centre for Disease Control and Prevention (Kohl et al., 2012). With an increasing age, physical activity tends to decrease, and becomes even less prevalent with chronic disease and disability (Haskell et al., 2007).

Furthermore, a low level of physical fitness (i.e., physical inactivity) has shown to be an independent risk factor for CAD and shown to lead to an increased risk of stroke and angina (Ärnlöv et al., 2010). Without exercise, atherogenesis can occur promptly, thereby, forming a plaque in the arterial walls and reducing the vascularity of the myocardium. Physical inactivity also has an impact on other risk factors, including high density lipoproteins (HDLs), HTN, diabetes and obesity that increase the risk of CVD (Ärnlöv et al., 2010).

An effective and beneficial training programme should include an aerobic component, such as walking or cycling, rowing, swimming or hiking at least three to five days per week for 30-60 minutes per day at a low to moderate intensity. In addition, a resistance training programme should be included two to three times per week to increase muscular strength (Abel, Palmer and Trubee, 2015).



Occupational stress, coupled with the weighted protective gear worn by fire-fighters and the rapid unexpected change in physical demands from rest to high-intensity work are massive contributors to the rise in mortality from CVD in fire-fighters (Schmidt, 2012). In a study conducted by Michaelides et al. (2011), it showed that the tasks of fire-fighting had an energy expenditure corresponding to 50-85% of a fire-fighter's maximal oxygen consumption ($\dot{V}O_2\text{max}$). This indicates that fire-fighters sometimes work at near maximum heart rate capacity and require a high level of cardiorespiratory fitness. Even though there is a need for fire fighters to have a high level of fitness for optimum work performance, it is has been estimated that up to 80% of fire departments neglect the maintenance of basic health and fitness programmes of their fire-fighters (Peterson et al., 2008).

It is reported that without a high level of physical fitness, fire-fighters cannot do their job effectively and safely (Soteriades et al., 2011). In a study on 2164 fire-fighters by Baur (2012), it is reported that 1352 (62.4%) exercised 20 to 30 minutes a day, 3 to 4 times a week, whilst 352 (34.7%) reported having no exercise programme for maintaining fitness levels. Fire-fighters in good physical condition are better prepared to deal with line of duty conditions, such as aerobically challenging labour, hazardous exposures and difficult work hours.

2.2.1.1.6 Cigarette Smoking

Cigarette smoking or tobacco use, whether done actively or passively, has been identified for more than 40 years as a major risk for CVD (Mahan & Escott-Stump, 2008). The cardiovascular risk imposed by tobacco and smoking, interacts with the coexistence of several other coronary risk factors. When additional risk factors are present in a smoker (i.e., high cholesterol and HTN) the risk of CVD is further increased (Prasad, Kabir, Dash & Dab, 2009). Tobacco use promotes fibrinogen, atherosclerosis and a blood clotting agent (Lloyd-Jones et al., 2009). Acute coronary events, including plaque instability, thrombus formation and arrhythmias are influenced by tobacco (Mahan & Escott-Stump, 2008). There is an association between cigarette smoking and increased levels of inflammatory markers (Armson, Shoenfeld, & Amital, 2010). Inflammatory markers, such as C-reactive protein, have been shown to be a predictor of future cardiovascular events in several populations (Bakrhu & Erlinger 2005). Second-hand smoke exposure may also increase the risk of CVD in those who are non-smokers (Armson, Shoenfeld, & Amital, 2010).

Given the diverse health benefits and cost-saving from smoking cessation, preventative efforts undertaken in this area should be encouraged and expanded, especially in developing countries where the threat is the greatest and where tobacco companies have targeted their marketing for future growth (Shroufi et al, 2013).

2.2.1.2 Non-Modifiable Risk Factors

2.2.1.2.1 Family History and Age

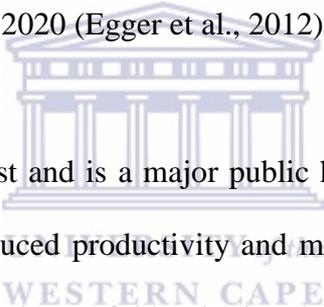
Non-modifiable risk factors include increasing age and family history. Age is associated with an increased risk for CAD in men 45 years or older and in women 55 years or older (ACSM, 2013, p.28). A family history of heart disease is established at a younger age in men than women. A family history is considered to be present when significant clinical history or sudden death occurs in male first-degree relatives younger than 55 years or in female first-degree relatives younger than 65 years (ACSM, 2013, p.28).

With an increase in age, in both men and women, there is an increase in CAD mortality rates (Perk, De Backer, Gohlke, Graham, Reiner, Verschuren, & Deaton, 2012). According to Mahan et al. (2008), men between the ages of 35 and 44 years were three times more at risk of premature CAD than women of the same age. Therefore, the increase in absolute risk with aging becomes clinically significant for men in their mid-40's and in women at about the time of menopause (Perk et al., 2012).

2.3 Prevalence of CAD

2.3.1 Global Prevalence of CAD

Compelling evidence shows a combination of modifiable and non-modifiable CAD risks as one of the leading preventable causes of death in developed countries, as well as in developing countries (Sharma & Ganguly, 2014). Developed nations show that 30 to 50% of all deaths are due to CAD (Barreto et al., 2012). One in three women and one in two men in their fifties are reported to develop CAD during their lifetime, with the risk increasing with a western lifestyle and with age (Barreto et al., 2012). With the exception of sub-Saharan Africa, where HIV/AIDS is the most prevalent, CAD is expected to be the leading cause of global mortality and morbidity by 2020 (Egger et al., 2012).



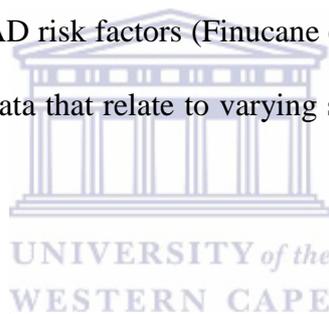
CAD has a direct and indirect cost and is a major public health burden in terms of reduced quality of life, life-years lost, reduced productivity and medical costs (Baruth et al., 2011). The direct cost of heart disease is twofold. Firstly, there is a direct cost of increased healthcare attributable to the costs for screening, medication, laboratory visits and tests, as well as for clinic and doctor's visits (Baruth et al., 2011). Secondly, there is an indirect cost due to absence from work, lower job productivity and lifestyle costs to support disease-related incapacitation (Baruth et al., 2011). Low cost interventions that can be implemented successfully on a population-wide basis and result in significant reductions in CAD risk should be a public health priority, especially in this region.

2.3.2 Regional Prevalence of CAD

In Africa, the prevalence of CAD is relatively low in most regions compared to developed countries (Finucane et al., 2011). In most rural and urban regions of sub-Saharan Africa

(SSA), the prevalence of CAD risk factors, particularly amongst blacks, has traditionally been low (Agyemang et al., 2009). HIV/AIDS has been the major cause of the rise in mortality in SSA, and is attributable to unsafe sex (Finucane et al., 2011). The situation, however, is rapidly changing due to swift urbanization and adopting a western lifestyle and the rapid influence of technology (Agyemang et al., 2009).

African reports suggest that the burden from CAD in 1990 was considerably lower for blacks than whites, and lower than the rates reported in most western countries (Venters & Gany, 2011). Recent epidemiological data shows mortality rates from CVD accounts for 10% of all deaths, and CAD accounts for 3% of all deaths (Finucane et al., 2011). However, less data is available on the prevalence of CAD risk factors (Finucane et al., 2011). Limitations still exist around the reporting of reliable data that relate to varying survey methods used in the region (Finucane et al., 2011).



2.3.3 National Prevalence of CAD

In general, South Africans health status is poor and most likely to become a major public health problem in the future (Ladarios, Steyn & Nel, 2011). Since gaining democracy in 1994, SA's public health has been left unprecedentedly burdened and incapacitated (Kahn, 2011). The populations' mortality and morbidity has worsened in virtually all age groups, driven largely by the HIV/AIDS pandemic (Mayosi et al., 2012). Life expectancy has shortened by 14 years for males and 12 years for females (Samji, 2014).

The public health of the South African population has regressed from a double burden of disease in the 1990s (SADHS, 1998), a triple burden at the turn of the century (Vorster, 2002) to where it's currently at a quadrupled burden of disease (Mayosi et al., 2012). These diseases

are classified into (1) poverty-related conditions, (2) emerging chronic diseases, (3) injuries and (4) HIV/AIDS. The HIV/AIDS prevalence is reported to be at 30%, with CVD mortality second at 17% (Govender, Matzopolous, Makanga & Corrigan, 2012).

In SA, the CAD population demographic profile puts the Indian community at highest risk, followed by people of mixed ethnicity, with whites and blacks least affected (Krakoff et al., 2014). The rate of heart attacks, however, is steadily increasing for people of African origin, especially with increasing urbanization and adoption of a western lifestyle, including those in rural areas as well (Olafiranye et al., 2013).

Several lifestyle and behavioural factors are endemic to South Africans placing them at risk of heart disease (Di Cesare et al., 2013). For women, 30 years and older, the highest tobacco-related death rate identified was in the mixed ethnic population, followed by whites, then blacks and, lastly, Indians (Sitas et al., 2013). In men, 30 years and older, the highest tobacco-related death rates were also found in the population of mixed ancestry, followed by Africans and Indians, with whites being the lowest (Sitas et al., 2013).

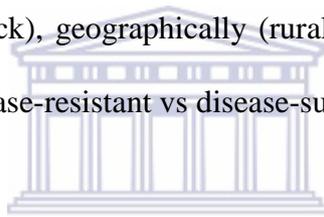
In South Africa, all population groups have an elevated prevalence of hypertension (Schutte et al., 2012). Approximately 5 to 6 million South Africans, aged 15 years and older, are diagnosed with hypertension (Griffiths et al., 2012), millions of whom are not sufficiently diagnosed i.e.-only 26% of men and 51% of women know they have hypertension, with fewer being properly treated (Schutte et al., 2012).

Cholesterol levels vary among the different population groups, with whites having the highest levels, followed by persons of mixed ethnicity, then Indians, with blacks having the lowest.

In blacks, ideal lipid levels characterized by low total cholesterol and high HDL cholesterol may provide them with a cardio-protective effect (Peer et al., 2012).

Obesity is a major problem among South Africans, with the highest prevalence found among white males, followed by Indians, then persons of mixed ancestry, with blacks being the lowest (Peer et al., 2012). However, in females, blacks had the highest rates, followed by persons of mixed ancestry, then whites, with Indians having the lowest (Peer et al., 2012).

In most developing countries, including SA, patterns of CAD appear to be passing through a transition phase, in which the differences in heart disease risk are based upon the various population groups (white vs. black), geographically (rural vs. urban), socioeconomic status (poor vs. rich), and genetics (disease-resistant vs disease-susceptible) (Dalal et al., 2011).



Therefore, the challenge for South Africans lies in identifying the risks most relevant to each community, and for action to be taken in order to defeat the rise in future CAD risk. During the past 20 years in South Africa, CAD risk factors have predominantly showed an unfavourable trend in the entire adult population, as well as in the younger population (Kahn et al., 2011). This shows the importance of assessing the disease burden, so that the issues identified can be detected early and addressed. This will allow for cost-effective health interventions in order to decrease the disease burden (Mayosi et al., 2012).

2.3.4 CAD Prevention

Due to the long latency period, altering risk factors is particularly suited to the prevention of CAD. This can easily be achieved by modifying human lifestyle and behaviour, with massive cost-saving potential and benefits to the public (Thompson, Arena & Pescatello, 2013).

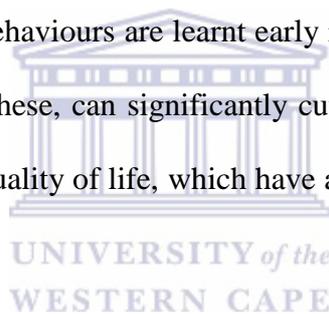
Historically, prevention is described as being of two types, namely, primary prevention that occurs before evidence of disease appears, and secondary prevention, when disease is already present (Gaziano, 1998). Prevention has been expanded to three basic types of intervention, namely, primordial, that is, the prevention of risk factors; primary, that is, the treatment of risk factors; and secondary, the prevention of recurring cardiovascular events (Franklin & Cushman, 2011).

As the rise in CAD continues, strong views support that primary prevention should be the cornerstone of public health intervention programmes (Estruch et al., 2013). In the primary prevention approach, two common strategies are used, that is, the high-risk approach and the population approach (Yusuf et al., 2005). The population approach utilizes community-based interventions to health in order to reduce the number of risks by modifying behaviours (Yusuf et al., 2005). In the high-risk approach, a few high-risk individuals are targeted for intervention. Ultimately, the population approach yields substantial benefits due to the large numbers involved, whereas in the high-risk approach, the benefits are more individualized with minimal benefit for the larger community (Yusuf et al., 2005).

A construct of ideal cardiovascular health has been defined by the American Heart Association (AHA), namely: (1) the simultaneous presence of four favourable health behaviours (nonexistence of smoking within the last year, ideal BMI, physically activity and consumption of a dietary pattern that promotes cardiovascular health); (2) the simultaneous

presence of four favourable health factors [absence from smoking within the last year, untreated total cholesterol ($<5.18 \text{ mmol}\cdot\text{L}^{-1}$), untreated blood pressure ($< 120/80 \text{ mm Hg}$) and the absence of diabetes mellitus]; and (3) the absence of clinical CVD (including CHD, stroke and heart failure) (Goff et al., 2014).

Lifestyle programmes utilized in prevention strategies for CAD include education with diet, weight management, exercise, and smoking cessation (Ebrahim et al., 2011). The importance shown in abstaining from smoking plays a vital role in promoting a healthy lifestyle (Goff et al., 2014). Instilling self-control and self-efficacy in participants is achieved by targeting knowledge, skills and attitudes (Ebrahim et al., 2011). Individuals then have a better understanding of how negative behaviours are learnt early in life, and how to change them in future. Valuable life skills, like these, can significantly cut costs and decrease CAD risk, as well as improve healthcare and quality of life, which have also proven to be cardio-protective (Ashen, 2010).



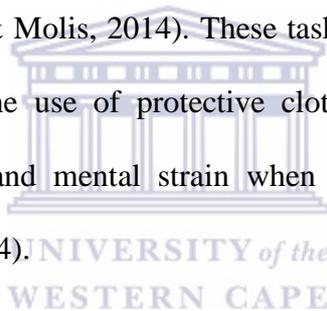
South Africa has shown enthusiasm for heart healthy programmes that utilize educational methods and counselling to encourage people to decrease the risk of developing heart disease. Counselling, when tailored to the individuals' stages of readiness to change, coupled with strategies for improving individuals' attitudes and knowledge, is reported to be more effective than conventional approaches to health education (Norcross, Krebs & Prochaska, 2011).

Most of the literature on CAD prevention and treatment is derived from studies completed among select populations and developed countries. Therefore, there is an urgent need to contribute studies and relevant knowledge pertaining to CAD prevention, particularly that are

population-based, evidence-based and culturally informative. These studies, if well-constructed, have the potential to translate into efficient and effective strategies of best practice (Prabhakaran & Yusuf, 2010).

2.3.5 Fire-Fighters Employment Requirements

Fire-fighting is considered one of the most dangerous professions, as the tasks place a large demand on many men and women who put their lives on the line in order to protect their community and minimize property destruction. Tasks performed in fire-fighting could result in near-to-maximal heart rates, and a need for recruiting both the aerobic and anaerobic energy systems (Fahy, Leblanc & Molis, 2014). These tasks coupled with external stressors, such as the environment and the use of protective clothing in fighting fires, provide a strenuous increase in physical and mental strain when completing such duties (Siddall, Standage, Stokes and Blizon, 2014).



Many fire-fighters are on duty 24-hours a day and are required to respond to emergencies during this period. Several alarms sound at different times of the day or night having fire-fighters respond rapidly to assist (Kitchen, 2012). The sudden change from rest leads to an increase in heart rate and stress, irregular sleeping patterns and unhealthy dietary habits (Solana, Navarrete, Murillo, & Horrillo, 2013). This leads to a greater energy expenditure, as fire-fighters carry heavy equipment, as well as their own body mass (e.g., climbing stairs), while wearing full fire-fighting protective clothing, as well as the SCBA (Schmidt, 2012).

A study conducted by Holmer and Gahved (2007) measured the metabolic cost of fire-fighters simulated work tasks. Tasks included walking/running on flat ground, climbing three

flights of stairs and descending four flights of stairs, with each task being performed twice. The average completion time for the entire simulated work task was 22 min, with an average $\dot{V}O_{2peak}$ of $2.75 \text{ L}\cdot\text{min}^{-1}$ ($33.9 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$). The highest $\dot{V}O_{2peak}$ was observed while completing the stair climb with a $\dot{V}O_2$ of $3.55 \text{ L}\cdot\text{min}^{-1}$ ($43.8 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$). The study demonstrated that fire-fighters who had a high aerobic fitness were able to complete the simulated tasks in the shortest time (Holmer & Gavhed 2007). In support of this finding, Taylor, Lewis Notley and Peoples (2012) reported a minimum $\dot{V}O_{2peak}$ of $3.70 \text{ L}\cdot\text{min}^{-1}$ ($39 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) in fire-fighters who were required to complete a five minute stair climbing treadmill test at a rate of 60 steps/min in full protective clothing.

Von Heimburg et al. (2006) reported the energy cost of a simulated victim rescue as high. It's reported that each fire-fighter had to climb six floors (vertical ascent of 20.5 m) carrying a 10 m hose, an axe and a flashlight. Once at the top of the stairs, they had to then successfully complete the tasks. Fire-fighters had to rescue six victims by dragging them to a rescue mat (covering a total of 162 m). Mean $\dot{V}O_{2peak}$, heart rate and blood lactate were measured once at the top of the stairs and again on completion of the victim rescue. Mean $\dot{V}O_{2peak}$, heart rate and blood lactate levels at the top of the stairs were $44 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, (88% maximum), $167\pm 13 \text{ bpm}$ (83% maximum) and $6.8 \text{ mmol}\cdot\text{L}^{-1}$, respectively. The mean completion heart rate and blood lactate were 182 bpm and $13 \text{ mmol}\cdot\text{L}^{-1}$, respectively, with the highest $\dot{V}O_{2peak}$ value being after the victim rescue of $3.70 \text{ L}\cdot\text{min}^{-1}$ (Von Heimburg et al. 2006).

The above data indicates that on-duty fire-fighters must perform specific duties that are both physically and mentally demanding. This requires a great amount of agility, speed, stamina, anaerobic capacity, aerobic power and muscular endurance to be able to successfully complete the tasks. The allocation of screening for CAD risk factors, individualized exercise

programme prescription and time for training should be made available for fire-fighters in order to maintain and improve fitness (Barr et al., 2011).

2.3.6 Fire-Fighters Work Environment

In order for on-duty fire-fighters to perform specific duties without incurring LODD risk, fire-fighters need to meet the requirements of the job and must possess a high level of aerobic power, anaerobic power, muscular strength and endurance, as well as a lean body composition (Schmidt, 2012).

As with most fire-fighters' duties, they do not only fight fires but also administer medical care to victims of accidents, such as in car crashes or accidents at home. Rescue operations may also be necessary in the event of a natural disaster, as it falls within the scope of practice for fire-fighters. The variety of duties change with the given situation and these changes occur rapidly (Poston et al., 2011).

Work environments also vary, as fire-fighters can potentially be exposed to flammable, poisonous or explosive chemicals or gasses, radioactive material, bodily fluids, blood, and foreign matter (Kitchen, 2012). During an emergency call, fire-fighters must protect themselves by wearing protective fireproof clothing along with a helmet and steel-toe boots. The protective equipment weighs up to approximately 23 kg and retains a great deal of heat (Durand et al., 2011).

Fire-fighters are required to work under maximal amounts of stress to a near maximum heart rate combining medical and fire duties, uniform, exposure, rescue efforts of others as well as

their own (Kitchen, 2012). To date, few studies have examined fire-fighters responses to live fires, as it's considered impractical and could place a fire-fighter in danger. With minimal studies having monitored heart rate during fire rescue work, there is a scarcity of information provided on the environmental conditions (Kitchen, 2012). In an actual emergency call out, it was found that fire-fighters heart rates ranged between 84-100% of the individuals maximum and this corresponded to a 63-97% of estimated $\dot{V}O_2\text{max}$ (Bos et al. 2004). In contrast, Time spent at the fire station involves rest, maintenance and cleaning of equipment, honing skills and developing new ones, as well as exercise and eating (Kitchen, 2012).

2.4 CAD and Fire-Fighters

2.4.1 Prevalence of CAD in Fire-Fighters



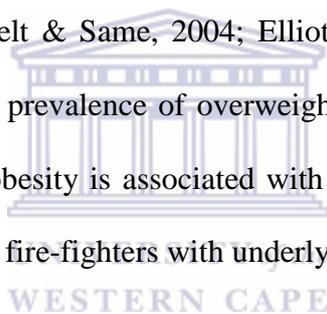
Largely due to CAD, cardiovascular events account for nearly 45% of deaths among on-duty fire-fighters (Fahy, Leblanc & Molis, 2014). Between January 1, 1994 and December 31, 2004 the NFPA reported 1144 fire-fighter deaths, with 449 of the 1144 or 39% due to CAD. Kales et al. (2007) reported that CAD deaths were classified into LODDs, during which 32% of deaths from CAD occurred during fire suppression, 31% during alarm response and 37% during other duties. Fire suppression accounted for 32% of deaths from CAD, even though it only consumed one-to-five percent of fire-fighters time each year. The risk of death was up to approximately 10 to 100 times as high as the risk compared with non-emergency duties.

In 2009, the NFPA reported a total of 90 fire-fighter fatalities (NFPA, 2014). The highest among all of the categories was 56% with the leading cause being stress and exertion (Soteriades et al., 2011). This category included all cardiac or cerebrovascular deaths, such as

stroke, heart attack and other events relating to extreme climatic thermal exposure. A total of 50 stress and exertion deaths occurred, with 39 being the result of a heart attack, eight due to stroke, and one death each from heat exhaustion, a pulmonary embolism and damage to a heart valve from extreme physical exertion (NFPA, 2014).

2.5 Cause of Increased Risk of CAD in Fire-Fighters

The risk of CAD in relation to fire-fighting could increase due to job-related stressors, such as working under extreme conditions, a poor diet and the lack of adequate physical fitness (Byczek, Walton, Conrad, Reichelt & Same, 2004; Elliot et al., 2004; Kales et al., 2007). Smith et al. (2012) found a high prevalence of overweight and obesity in male career fire-fighters. This is noteworthy, as obesity is associated with increased risk of CAD, and most duty-related CAD events occur in fire-fighters with underlying CAD.



2.5.1 Physical Activity

Due to the physical demands of fire-fighting, an insufficient amount of physical fitness to maintain health places fire-fighters at an increased risk for CAD (Scanlon & Ablah, 2008). There is no national mandatory fitness battery for South African fire-fighters to measure standards for fire-fighters fitness levels or job-performance tasks (Schmidt, 2012). A study by Schmidt (2012), suggested that the eThekweni Fire Department in Kwazulu Natal, SA, use normative data from American and Australian fire-fighters. This normative data is not culturally specific nor does it take into account different fire suppression methods used in different countries (Schmidt, 2012). Furthermore, Kales (2009) reported that the policy in fire departments does not require fire-fighters to exercise regularly. However, fire-fighters

undergo annual medical examinations, as well as fitness assessments conducted at least once a year (Lewis, 2014).

Fire-fighters need a great level of cardiorespiratory health and fitness to be able to respond to the job's demanding emergency situations. With a low level of physical fitness, fire-fighters are at an increased risk for CAD (Kitchen, 2012).

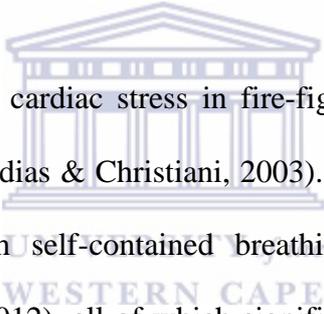
Current exercise programmes for fire-fighters focus primarily on cardiovascular fitness (Schmidt, 2012). It has been recommended these programmes should include physical conditioning programmes that simulate the demands of fire-fighting and that address all components of health-related physical fitness. Cardiovascular fitness testing should include the performance of job-related tasks to improve test validity (Schmidt, 2012).



2.5.2 Work Stressors and the Environment

Fire-fighters are exposed to various factors in the work environment, encompassing extreme temperatures, heavy physical exertion, smoke, chemical and noise exposure and emergency alarms creating a stressful working environment (Guidotti, 2002). These work and environmental stressors cause fire-fighters to be at an increased risk for CAD (Guidotti, 2002). During fire suppression, heat stress can occur (Rossi, 2003). As a result of the extreme heat given off from the fire, coupled with the fire retardant uniform worn by the fire-fighter, these can lead to an increase in body temperature (Guidotti, 2002). With an increase in temperature, the body adapts by increasing perspiration and fluid loss, resulting in electrolyte imbalance. If electrolytes are not replaced timeously, a decrease in stroke volume and cardiac output occurs (Rossi, 2003).

Cardiac stress can lead to complications when coupled with stressful daily activities and heavy physical exertion (Yang et al., 2013). On the job fire-fighting duties require immediate physical activity, interspersed with long bouts of rest or light duty work. During periods of extreme physical activity, fire-fighters' heart rates increase due to a surge of adrenaline in the sympathetic nervous system (Yang et al., 2013). In a comparative study of heart rates, including varying weights of self-contained breathing apparatuses, there was a 70 to 80% increase in maximum heart rate within the first minute of exercise, regardless of the weight of the breathing apparatus. Until the fire was extinguished, heart rate continued to increase to 90-to-100% of age-predicted maximum (Smith, Barr & Kales, 2013).



Another factor found to increase cardiac stress in fire-fighters was the fireproof uniforms worn (Kales, Soteriades, Christoudias & Christiani, 2003). Fire-fighters are required to wear fireproof uniforms coupled with self-contained breathing apparatus (SCBA) weighing approximately 25 kg (Schmidt, 2012), all of which significantly increase heart rate, oxygen consumption and water loss (Kales, Soteriades, Christoudias & Christiani, 2003).

In addition, chemical and smoke inhalation also directly affect CAD risk (Satran et al., 2005). Fire smoke contains a mixture of vapour, heated gases and particulate matter with the mainstream comprising hydrogen cyanide and carbon monoxide that, if inhaled, can cause disruption in blood transport and cellular use of oxygen, resulting in hypoxia and, eventually, myocardial injury (Satran et al., 2005). Repeated long-term exposure to significant particulate matter has been linked to CAD and the initiation and/or progression of atherosclerosis associated with cardiovascular mortality (Dockery et al., 1993). Alternatively, short-term

exposure has resulted in heart attacks among fire-fighters, especially those with pre-existing heart disease (Peters, Dockery, Muller & Mittleman, 2001).

Regular exposure to cardiac stressors can increase CAD risk leading to cardiovascular disease (Kales et al., 2003). Drew-Nord et al. (2009) reported that, whereas the general population frequently dies of cardiovascular events between six a.m. and midnight, fire-fighters most often have cardiac death between noon and midnight. During this time of fire-fighter death, there was a significant correlation with a period of high intensity emergency dispatches at most fire departments, linking the increased risk of premature cardiovascular mortality with fire suppression (Drew-Nord et al., 2009)

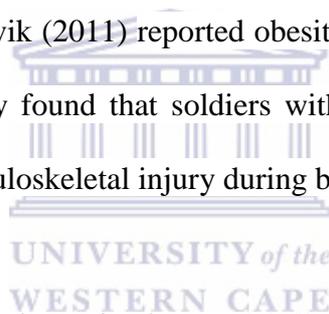


2.5.3 Diet

Diet has a direct effect on CAD risk in fire-fighters, and is a major link between obesity, hypertension and diabetes (Nagaya 2006). A study was done by Kuehl (2013) in promoting healthy lifestyles through alternative models' effects (PHLAME) to determine the efficacy of onsite health promotion in fire stations. The study was done by randomly assigning three fire stations to (a) a team-based curriculum, (b) individual counsellor meetings, and (c) a control. The intervention resulted in significant reductions in LDL cholesterol. The team approach significantly increased co-worker cohesion, personal exercise habits and co-workers' healthy behaviours. The one-on-one strategy significantly increased dietary self-monitoring, thus decreasing fat intake, and reduced depressed feelings.

2.5.4 Obesity

The prevalence of obesity may hinder and endanger fire-fighters' work performance and lead to serious clinical conditions relating to diabetes and HTN. Obesity is associated with HTN, low HDLC, high triglycerides and LDLC, and high plasma glucose levels. Soteriades et al. (2008) reported that fire-fighters with obesity are more likely to have HTN compared to overweight or normal weight fire-fighters. The association between obesity and risk of job disability among fire-fighters was examined by Soteriades et al. (2008). The average BMI of fire-fighters was $29.0 \pm 4 \text{ kg m}^{-2}$. Twenty-seven percent of fire-fighters had class I obesity, 7% class II and 6% class III or extreme obesity. These results by Soteriades et al. (2008) showed that a one kg m^{-2} increase in BMI was associated with a 5% increase in the risk of job disability. Heir, Erikson and Sanvik (2011) reported obesity to be associated with injury risk in comparable occupations. They found that soldiers with higher BMIs were significantly more likely to experience a musculoskeletal injury during basic training.



A study by Byczek et al. (2004) determined mean BMI of suburban US fire-fighters to be 29 kg m^{-2} categorizing them as overweight. BMI values ranged from 19.5 to 54.3 kg m^{-2} with 44% of fire-fighters classified as overweight, and 30% classified as obese. Within the study, it was determined that male fire-fighters had a higher prevalence of obesity ($> 30 \text{ kg m}^{-2}$) and a high total cholesterol ($> 13.4 \text{ mmol L}^{-1}$) when compared to US adult men. HTN ($> 140/90 \text{ mm Hg}$) and diabetes (fasting plasma glucose $> 7 \text{ mmol L}^{-1}$) of fire-fighters was lower compared to U.S. adult men. Similarly, a study by Nagaya et al. (2006) determined that a BMI of 30 kg m^{-2} or more is a strong predictor of diabetes and CAD.

2.6 Prevention of CAD in Fire-Fighters

2.6.1 Medical Examinations

During fire suppression, the risk of adverse cardiovascular events may be increased (Kales et al., 2009). Many fire-fighters have underlying cardiovascular risk factors, such as a lack of adequate physical fitness or subclinical or clinical CAD disease or pathology. Many studies maintain the initiation of an onsite diet programme, as well as an exercise programme coupled with routine medical examinations (Kales et al., 2009). With annual and routine medical examinations, up to 75% of US fire-fighters with CAD were detected. These fire-fighters who have not had a recent medical examination are at risk for mortality from on-duty cardiovascular-related deaths. (Kales et al., 2009).



2.6.2 Diet Education

Since diet is a modifiable risk factor, it may be significant to educate fire-fighters regarding diet. Similarly, to the general public, fire-fighters consider proper nutrition an intimidating task (Kitchen, 2012). Kay et al. (2001) suggests appropriate nutrition education, addressing barriers to change and convincing fire-fighters that healthful dietary changes could be made, without sacrificing enjoyment of the eating experience and, thereby, reducing the risk of CAD.

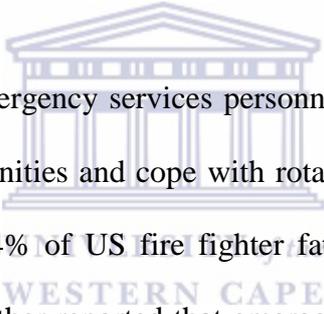
Many fire-fighters are willing to modify their diet and physical activity habits (Mabry et al., 2013). At least 90% of respondents in the Scanlon and Ablah (2008) study preferred fire departments taking a more direct and hands-on role in educating its members about the medical risk associated with their jobs. This suggests that they would attend a department-organized lecture concerning advice on proper diet and exercise, and reduction of their risk of

heart attack. Many were interested in participating in a department sponsored health and fitness programme.

2.6.3 Sleep and stress

Fire-fighters experience many life-threatening challenges, e.g., prolonged stress which may have negative effects on both job performance and personal adjustment (Carey et al., 2011).

Burnout and stress may result from an imbalance between personal resources and situational needs, that may affect the personality change in behaviour, as well as the psychological and physiological well-being (McGrath, 1970).



Fire fighters, like many other emergency services personnel, make life-and-death decisions, experience limited career opportunities and cope with rotating shift work (Anson & Bloom, 1988). In 1982 approximately 44% of US fire fighter fatalities were attributable to stress (Anson & Bloom, 1988). It is further reported that emergency fire-fighters are vulnerable to an increased incidence of diseases of adaptation (Anson & Bloom, 1988). Fiedler, Frost and Swartout (1981) found a lack in the quality of interaction between supervisors and lower-ranking fire fighters as an important single-related stressor reported by their sample.

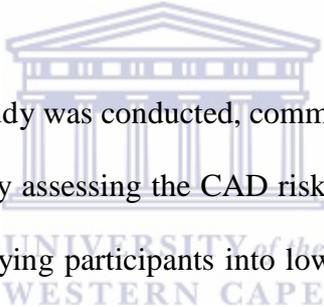
Carey (2011) conducted a study measuring sleep deprivation, depression, substance use, social bonding, and quality of life in 112 US fire-fighters. It was discovered that many fire-fighters reported sleep deprivation (59%), binge drinking behaviour (58%), poor mental well-being (21%), current nicotine use (20%), hazardous drinking behaviour (14%), depression (11%), poor physical well-being (8%), caffeine overuse (5%), or poor social bonding (4%). Correlations were identified between sleep deprivation, depression, physical/mental well-

being, and drinking behaviours. The high-risk behaviours that impact psychosomatic well-being were prevalent in professional fire-fighters, which require environmental and individual-based health promotion interventions.

Oosthuizen (2009) evaluated job and family stress amongst fire-fighters in the South African context. He found that task characteristics, organisational functioning, physical working conditions and job equipment, career and social matters, remuneration, fringe benefits and personnel policy were identified as causes of job stress originating within the work situation. Moreover, interviews discovered that marital dysfunction and divorce, limited time with the family, problems with children, alcohol and drug abuse, lack of exercise, suicide, anger aimed at family members, physical and emotional exhaustion, lonely marital partners, unavailability to help the family when needed and depression were identified as causes of family stress arising outside the work situation. The primary recommendation was to implement a counselling job and family stress programme to enhance the wellness and psychological health of fire-fighters and their families, or for counselling of fire-fighters and their families who were experiencing job and/or family stress.

CHAPTER THREE: RESEARCH METHODS

3.1 Introduction



This chapter discusses how the study was conducted, commencing with the recruitment of the fire-fighters. This was followed by assessing the CAD risk factors in municipal fire-fighters. Next, the study focused on stratifying participants into low, moderate or high risk, followed by determining the relationship between the various CAD risk factors in fire-fighters. The methodology followed in the study is based upon standardized testing procedures as advocated by the American College of Sports Medicine (ACSM) and the International Society for the Advancement of Kinanthropometry (ISAK).

3.2 Study Population and Sample

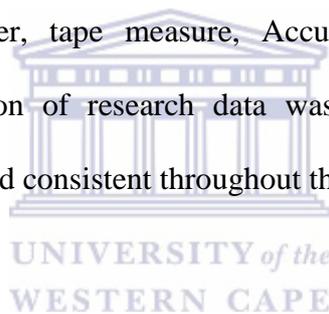
A sample of 219 full-time employed male fire-fighters were drawn from the Western Cape Fire and Rescue Department. This study was conducted in the Western Cape area between July 2014 and August 2015. The participants were recruited through convenience sampling.

Male fire-fighters from three fire-fighting platoons from the City of Cape Town Fire and Rescue Services were included.

A sample size of 180 participants was determined in consultation with the Department of Statistics at UWC to ensure the statistical power of the study.

3.3 Clinical Equipment

The following clinical equipment was used, namely, a stethoscope, sphygmomanometer, beam balance scale, stadiometer, tape measure, Accutrend plus and Accucheck. All equipment used in the collection of research data was accurately calibrated following approved guidelines, and remained consistent throughout the study.



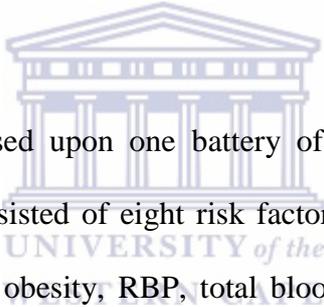
3.4 Participant Recruitment

Approval for the study was obtained from the Chief Fire Officer of the WCFRD. The researcher verbally informed the fire-fighters of three selected platoons about the nature and scope of the study a week before testing commenced. Each fire-fighter received an information letter (Appendix A) and a consent form (Appendix B), describing the purpose of the research, the benefits of participating in the study, the procedures that would take place, possible risks and discomforts that might occur, and how the participant's information would be kept confidential and secure.

3.4.1 Participant Selection, Preparation and Screening

The participants selected for the study were only those who granted their written consent. The divisional commanders received an email with pretest instructions (Appendix C), at least 48 hours prior to testing, informing them about the mandatory preparatory requirements for the various clinical tests and a demographic questionnaire. Testing was scheduled for approximately 10 - 15 minutes per participant. Fire-fighters were excused in the event of a public emergency call, and retested the following shift.

3.4.2 Test Measurements



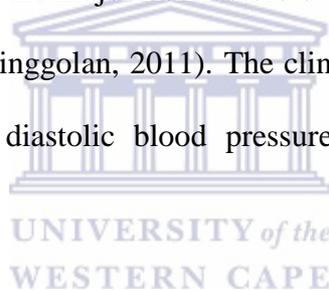
The test measurements were based upon one battery of assessments, namely, CAD risk factors. These measurements consisted of eight risk factors, namely, age, family history of heart disease, cigarette smoking, obesity, RBP, total blood cholesterol level, fasting blood glucose level, and a sedentary lifestyle.

Each participant performed a CAD risk assessment that entailed measuring rbp, fasting total blood cholesterol, fasting blood glucose, and body composition evaluation. This was conducted at various fire stations throughout the Western Cape. A pre-test questionnaire was administered to the fire-fighters comprising demographic and descriptive risk factor information, namely, cigarette smoking, family history of heart disease, age and lifestyle (sedentary/not). The instrument consisted of a CAD risk stratification form, anthropometric measurements, a questionnaire pertaining to family history of heart disease, cigarette smoking and a sedentary lifestyle. All measurements adhered to ACSM (American College

of Sports Medicine, 2013a, pp.39-92) and ISAK guidelines (Marfell-Jones et al., 2006, pp 5-88).

3.5 CAD Risk Assessment

The present study measured only the major risk factors of CAD that are reported to account for almost 90% of CAD risk (Nainggolan, 2011). The clinical measurements taken were the following: resting systolic and diastolic blood pressures, total cholesterol, obesity and prediabetes.



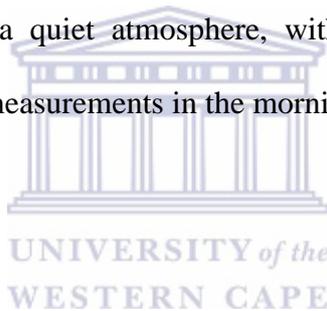
3.5.1 Family History, Cigarette Smoking and a Sedentary Lifestyle

A CAD risk assessment questionnaire (Appendix D) was used to record the descriptive data such as age, gender, family history of premature CAD, cigarette smoking, physical activity habits, and prescribed medication, if any. Sedentary lifestyle was reported as not participating in at least 30 minutes of moderate-intensity physical activity on at least three days per week for at least three months (ACSM, 2013. p.28)

3.5.2 Obesity

Obesity as a CAD risk factor was defined as a BMI $\geq 30 \text{ kg}\cdot\text{m}^{-2}$ or a waist-to-hip-ratio ≥ 0.95 or a waist circumference $> 102 \text{ cm}$. All measurements were recorded on the CAD risk assessment questionnaire (ACSM, 2013, p.28).

The anthropometric measurements taken consisted of the following, namely, body mass (weight), stature (height) and waist and hip circumferences according to ISAK guidelines (Marfell-Jones, Olds, Stewart & Carter, 2006, p. 57). Participants were informed in the pre-test instructions about how to prepare for testing, what garments to wear and the duration of testing. The lecture rooms at the fire stations were used for taking the anthropometric measurements, which provided a quiet atmosphere, with privacy observed at all times. Preference was given for taking measurements in the mornings after roll-call at 10 am.



3.5.2.1 Body Mass (Weight)

Participants were weighed wearing minimal clothing. Body weight was measured to the nearest 100 g using a beam balance scale (Seca model 700, Gmbh & Co., Germany) with a measurement range from 0 to 220 kg calibrated against standard low and high weights. The scale was first checked and zeroed. Each subject stood on the centre of the scale, facing away from the balance beam, without support and with their weight evenly distributed across both feet. The tester determined the appropriate weight of the participant using the sliding weights on the beam-balance, and reported it to the recorder to enter onto the data sheet. The average of two measurements was used as the final measurement, provided that the measurements were within 0.1 kg of each other. If not, additional measurements were taken until the appropriate limits were obtained.

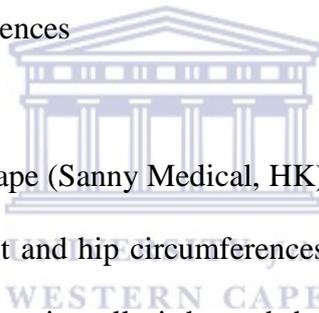
3.5.2.2 Stature (Height)

Stature (height) was measured without shoes to the nearest 5 mm using a stadiometer (Seca model 700, Gmbh & Co., Germany) with a measurement range from 60 to 200 cm and calibrated against an anthropometer (Holtain, UK). The stretch stature was measured with participants standing barefoot on a level rubber plate with the heels together and the heels, buttocks and upper back touching the stadiometer stand. The participants head was placed in the Frankfort plane, in other words, the tester placed the tips of the thumbs on each orbitale (lower edge of the eye socket) and the tips of the index fingers on each tragion (the notch superior to the tragus of the ear), then horizontally aligned the two. The tester then relocated the thumbs posteriorly towards the subject's ears, and far enough along the line of the jaw to ensure that upward pressure, when applied, is transferred through the mastoid process. The participant was then instructed to inhale deeply and, while keeping the head in the Frankfort plane, the tester applied gentle upward lift through the mastoid process. Next, the recorder placed the sliding head-board firmly down on the vertex (highest point of the skull), compressing the hair as much as possible, but not affecting the stretch height. The recorder finally checked that the participant's heels to see that they did not leave the rubber floor of the stadiometer, before taking the measurement and before the subject exhaled. The average of two measures was used as the final measurement provided that the measures were within 5 mm of each other.

3.5.2.3 Body Mass Index

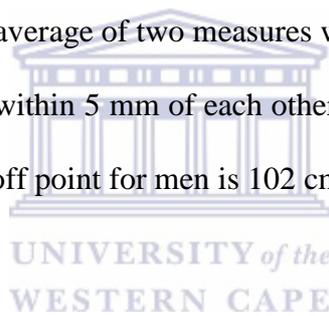
Body mass index (BMI) or Quetelet index is used to assess weight relative to height, and was calculated from body mass in kilograms (kg) divided by stature in metres squared (m^2) and was expressed as $kg\cdot m^{-2}$. This value is considered a good indicator of general body composition in population-based studies, and is related to health outcomes (The Emerging Risk Factor Collaboration, 2011). Significant CHD risk begins at a BMI of $30.0\ kg\cdot m^{-2}$ in both males and females (ACSM, 2013, p. 28) and is associated with excess body fat.

3.5.2.4 Waist and Hip Circumferences



A non-extensible, flexible metal tape (Sanny Medical, HK) with a measurement range from 0 to 2 m was used to measure waist and hip circumferences to the nearest 0.3 cm. The cross-hand technique was used for measuring all girths and the reading was taken from the steel tape measure held at right angles to the body segment where the zero was located more lateral than medial on the participant's body. In order to position the tape measure correctly, the case was held in the right hand and the stub in the left hand. The stub was passed around and to the back of the body segment and grasped in the right hand, while facing the body segment, thereby freeing the left hand. The left hand was used to manipulate the tape to the correct level and then passed underneath the casing to grasp the stub again. The middle fingers of both hands were used to locate the tape at the precise landmark for measurement and to orientate the tape so that the zero was easily read. The objective was to minimize gaps between the tape and the skin, as well as indentations to the skin, wherever possible. When taking the reading, the tester's eyes were positioned at the same level as the tape to avoid the

error of parallax. The waist was measured at the narrowest part of the abdomen between the lower costal (10th rib) border and top of the iliac crest, perpendicular to the long axis of the trunk. The hip measurement was taken at the level of the greatest posterior protuberance of the buttocks that usually corresponds anteriorly to about the level of the symphysis pubis, that is, at the widest part of the hips. When measuring the waist, the tester stood in front of the participant who abducted the arms slightly to allow the tape to pass freely around the abdomen. The measurement was taken at the end of a normal expiration (end-tidal measurement). Similarly, when measuring the hips, the tester stood in front of the participant who folded the arms across the chest and stood feet together with gluteal muscles relaxed. The tape was passed around the hips and held in a horizontal plane at the target level before the measurement was taken. The average of two measures was used as the final measurement, provided that the measures were within 5 mm of each other (Marfell-Jones et al., 2006, pp 5-88), the waist circumference cut-off point for men is 102 cm (ACSM, 2013, p.28).



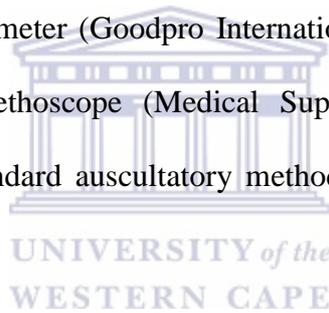
3.5.2.5 Waist-to-Hip Ratio

Waist-hip ratio is a simple measure calculated by dividing the waist circumference (cm) by the hip circumference (cm) and is considered an indicator of body fat distribution (central or android versus peripheral or gynoid fat patterning). Ratios above 0.95 are considered indicative of obesity and significantly increased CAD risk in men (ACSM, 2013, p28).

Because of its association with abdominal obesity, waist circumference alone is also used as an indicator of significant CAD risk when recorded above 102 cm in men (ACSM, 2013, p.28).

3.5.2.6 Resting blood pressure

Hypertension, as a CAD risk factor, was defined as a participant on anti-hypertensive medication or a systolic blood pressure equal to or above 140 mm Hg and/or a diastolic blood pressure equal to or above 90 mm Hg, confirmed by three measurements on two separate occasions (ACSM, 2013, p.28). Participants presented themselves at the fire station and were taken to one of the lecture rooms for BP measurement. Before being tested, the participants had to confirm that the pre-test instructions were observed. Blood pressure (SBP and DBP) was measured indirectly. Three measurements were taken (minimum of one minute apart) with a pressure cuff of appropriate size placed around the left upper arm, while using a standard mercury sphygmomanometer (Goodpro International Co., Limited, China), and an acoustic Sprague Rappaport stethoscope (Medical Supplies and Equipment Company, Houston, Texas, USA). The standard auscultatory method of blood pressure measurement was observed.

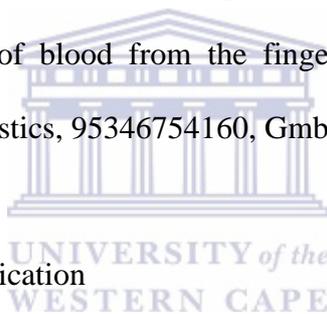


In preparation for testing, each participant sat quietly for at least 5 minutes, breathing spontaneously and without talking. With the cuff fully deflated, the mercury meniscus was checked for a zero rating. The cuff was quickly inflated to 20-30 mm Hg above the first Korotkoff sound and then the pressure was slowly released at a rate of 2-3 mm Hg per second. Systolic blood pressure (SBP) was noted at the first appearance of the Korotkoff sounds (phase 1) and diastolic blood pressure (DBP) at the disappearance of the sounds (phase 5).

3.5.2.7 Fasting blood cholesterol and blood glucose

Dyslipidemia, as a CAD risk factor, was defined as low-density lipoprotein (LDL) cholesterol concentration $> 3.4 \text{ mmol}\cdot\text{L}^{-1}$ or high-density lipoprotein (HDL) cholesterol concentration $< 1.03 \text{ mmol}\cdot\text{L}^{-1}$ or total cholesterol (TC) concentration $> 5.2 \text{ mmol}\cdot\text{L}^{-1}$ or participants currently using cholesterol-lowering medication. Invasive procedures were used for total cholesterol determination, whereby a drop of blood from the finger was taken and sampled in the Accutrend Plus meter (Roche Diagnostics, 04235643059, GmbH, Germany).

Prediabetes as a CAD risk factor, was defined as (fasting) blood glucose concentration level $\geq 5.6 \text{ mmol}\cdot\text{L}^{-1}$. (ACSM, 2013, p. 21) Invasive procedures were also used for glucose determination, whereby a drop of blood from the finger was taken and sampled in the AccuCheck meter (Roche Diagnostics, 95346754160, GmbH, Germany).



3.4 Participant CAD Risk Stratification

Risk stratification was determined according to the guidelines of the American College of Sports Medicine (ACSM, 2013, p23) as follows:

- *Low risk stratification:* asymptomatic participants presenting with zero or only one CAD risk factor.
- *Moderate risk stratification:* asymptomatic participants presenting with two or more CAD risk factors, but without clinical signs or symptoms of cardiovascular, respiratory, and/or metabolic disease.

- *High risk stratification*: participants presenting with clinical (overt) signs and symptoms indicative of cardiovascular, respiratory, and/or metabolic disease or with diagnosed disease.

3.6.1 Inter-Rater (Tester) Reliability

All testing personnel used in the study were appropriately trained. Blood pressure measurements were standardized against an experienced clinician, using a double-headed stethoscope with measurements recorded to the nearest 2 mm Hg. Testers measuring height, weight, and waist and hip circumferences were also trained by criterion testers according to the ISAK guidelines (Marfell-Jones et al., 2006, pp 5-88), and the technical error of measurement (TEM) for testers was established within acceptable limits for research. In this regard, the requirements of tester accuracy (minimal error per test) and consistency (producing repeatable results from test to test) were standardized across all measurements, and testers not meeting acceptable criteria underwent further training. The accepted anthropometric technical error of measurement (measurement tolerance) for testers was as follows (Pederson and Gore, 1996,-pp. 77-95):

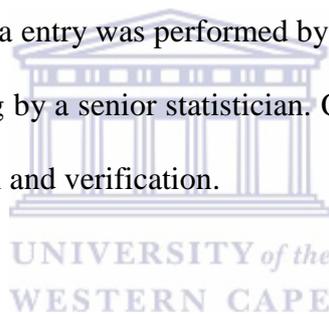
- Body mass. 0.1 kg
- Height (stretch), 5 mm
- Girths (waist and hip), 3 mm

With regard to subject integrity, the testers were instructed when taking measurements not to compromise the physical and emotional well-being of participants. Similarly, the testers were also sensitized to the cultural practices and traditions of the participants, and encouraged to

be mindful of these throughout the study, in addition to observing basic practices of hygiene, i.e., keeping their fingernails trimmed and hands washed at all times.

3.7 Data Management

During testing, a recorder accompanied each tester, who entered and verified the accuracy of the data. The quality of testing was standardized by carefully preparing both the participants and the tester. To safeguard the privacy of all participant information, all testers participating in the study were required to sign a confidentiality declaration (Appendix A). All participants' data was captured electronically on computer into Microsoft Excel and stored against a private access code. Data entry was performed by an experienced data-capturer with duplicate entry and crosschecking by a senior statistician. Queries were sent in batches to the principle researcher for resolution and verification.



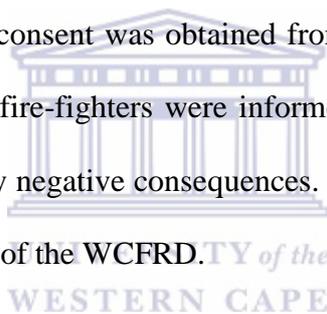
3.8 Ethical Considerations

The following additional ethical considerations were addressed:

- Confidentiality: Provision was made for the confidential safekeeping of participants' information at all times.
- Privacy: Throughout the study, participants were consulted individually and tested privately at their respective fire stations. Fire stations surrounding the University were tested at the biokinetics clinic, Department of SRES at UWC, following standard protocol.

- Safety: Every effort was made to ensure that no harm came to any participant. Universal precautions of safety and standardized emergency procedures were observed when testing participants. Also, reasonable precautions were taken to ensure that the participants did not endure unnecessary discomfort, while simultaneously adhering to standards of best practice. Equally important was the disposal of biohazardous material, such as the disposable lancets, gloves, cholesterol and glucose test strips and sterilizing materials. Such equipment was disposed of with due regard for the guidelines stipulated by the SAMRC (2002).

The Senate Research and Ethics Committee at the University of the Western Cape approved this study, and informed written consent was obtained from all participants. Participation in the study was voluntary and the fire-fighters were informed that they could withdraw from the study at any stage without any negative consequences. Permission for this study was also gained from the Chief fire officer of the WCFRD.



3.9 Statistical Analyses

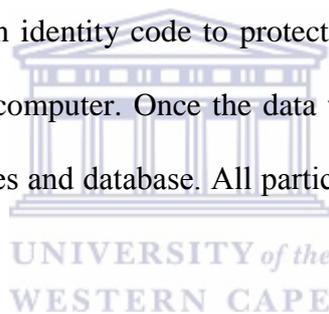
All participant data was transferred, in duplicate, into an MS Office Excel 2013 spreadsheet by double entry to ensure accuracy. It was then exported to the Statistical Package for the Social Sciences (SPSS) version 22 for data analysis.

Confidentiality and privacy were assured at all times. All electronic back-up copies of the data were stored on computer against password access restrictions that were controlled by the

researcher. Descriptive statistics (mean, standard deviation (\pm SD)) was obtained for all the selected variables. A significance level $p < 0.05$ was used.

The study utilised the- Kruskal-Wallis test for non-parametric data as the situation where the ANOVA normality assumptions may not have been applied. The post-hoc Mann–Whitney test was then used to follow up. A Bonferroni correction was applied to the post hoc analysis to minimise type I error, so that all effects were reported at a 0.0167 level of significance. Furthermore, a correlation matrix was used to show the relationship between the various CAD risk factors.

Each participant was allocated an identity code to protect their identity when capturing the data either on data sheets or on computer. Once the data was collected, only the researcher had access to the participant's files and database. All participant files were stored in a locked cabinet.



CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter presents the results of the study investigating the CAD risk factors of fire-fighters in the Western Cape. There were several objectives, namely, to:

- Assess the prevalence of CAD risk factors in municipal fire-fighters;
- Stratify the fire-fighters into low, moderate or high CAD risk; and

- Determine the relationship between the various CAD risk factors in fire-fighters.

4.2 Prevalence of CAD Risk Factors

Figure 4.1 shows the table of CAD risk factors from least prevalent to most prevalent.

4.2.1 Sedentary Lifestyle

Of the 219 fire-fighters, 51.14% (n = 112) reported a sedentary lifestyle (i.e., did not participate in a regular exercise programme or did not meet the physical activity recommendations from the US General's Report (ACSM, 2013, p28). Various fire stations implemented their own fitness initiatives, but only 21.46% (n = 47) of fire-fighters in this study reported participating in regular physical activity.



4.2.2 Obesity

Based upon BMI analysis, 45.90% (n = 101) of the fire-fighters were classified as obese (i.e., $BMI \geq 30 \text{ kg}\cdot\text{m}^{-2}$). Waist circumference was also used in this study with 45.20% (n = 99) indicative of android obesity (waist circumference > 102 cm). The mean and standard deviation for BMI was reported at $27.38 \pm 5.09 \text{ kg}\cdot\text{m}^{-2}$. The mean and standard deviation for WC was $87.00 \pm 11.86 \text{ cm}$.

4.2.3 Cigarette Smoking

Overall in this study, smoking cigarettes was reported by 38.30% (n = 84) of fire-fighters, who indicated that 1 or more cigarettes were smoked per day for a minimum period of 6 months.

4.2.4 Family History of CAD

A positive family history of CAD was recorded in 32.80% (n = 72) of the fire-fighters (i.e., myocardial infarction, coronary revascularization or sudden cardiac death before 55 years of age in father or other male first-degree relative, or before 65 years of age in mother or other female first-degree relative).



4.2.5 Elevated total cholesterol

From the 219 male fire-fighters who participated in the study, 31.00% (n = 68) had elevated total cholesterol (i.e., total cholesterol $> 5.18 \text{ mmol}\cdot\text{L}^{-1}$ or were on prescribed lipid-lowering medication). The mean and standard deviation for total cholesterol was $5.27 \pm 0.93 \text{ mmol}\cdot\text{L}^{-1}$.

4.2.6 Elevated resting blood pressure

An elevated blood pressure was prevalent in 27.30% (n = 60) of fire-fighters (i.e., systolic BP $\geq 140 \text{ mm Hg}$ and/or diastolic BP $\geq 90 \text{ mm Hg}$ or on prescribed antihypertensive medication). The mean and standard deviation for resting blood pressure was reported at $121.05 \pm 17.35 \text{ mm Hg}$.

4.2.7 Age

In this study, 20.51% of fire-fighters were equal to or above the age of 45 years, which placed them at moderate CAD risk. The mean and standard deviation for age was reported at 37.85 ± 9.80 years.

4.2.8 Elevated blood glucose levels

A total of 17.30% ($n = 38$) of fire-fighters recorded a fasting blood glucose value ≥ 5.6 $\text{mmol}\cdot\text{L}^{-1}$. The mean and standard deviation was reported at 6.77 ± 2.19 $\text{mmol}\cdot\text{L}^{-1}$.



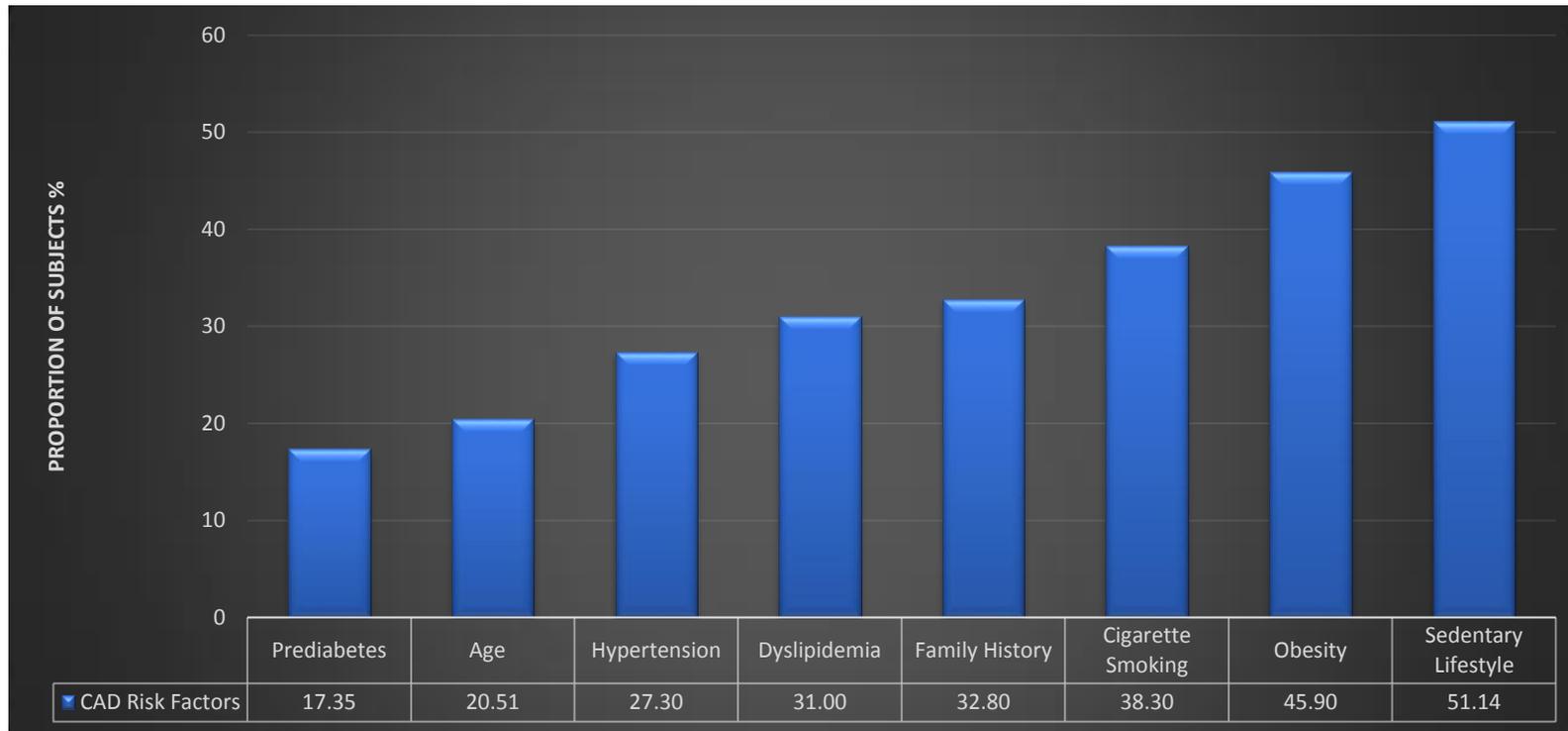


Figure 4.1. Prevalence of CAD risk factors in the participants.

Figure 4.2 presents data on the 219 male fire-fighters tested, whose age ranged between 18 – 65 years, with an average of 37.85 ± 9.80 years. On average, fire-fighters had between two and three CAD risk factors. From all the participants, 65.2% were stratified as being at moderate risk with

two or more CAD risk factors. Furthermore, 14.1% fire-fighters were stratified as high risk (i.e., diagnosed with diabetes and/ or CVD). The remaining 21.0% of fire-fighters were classified as low risk (≤ 1 risk factor).

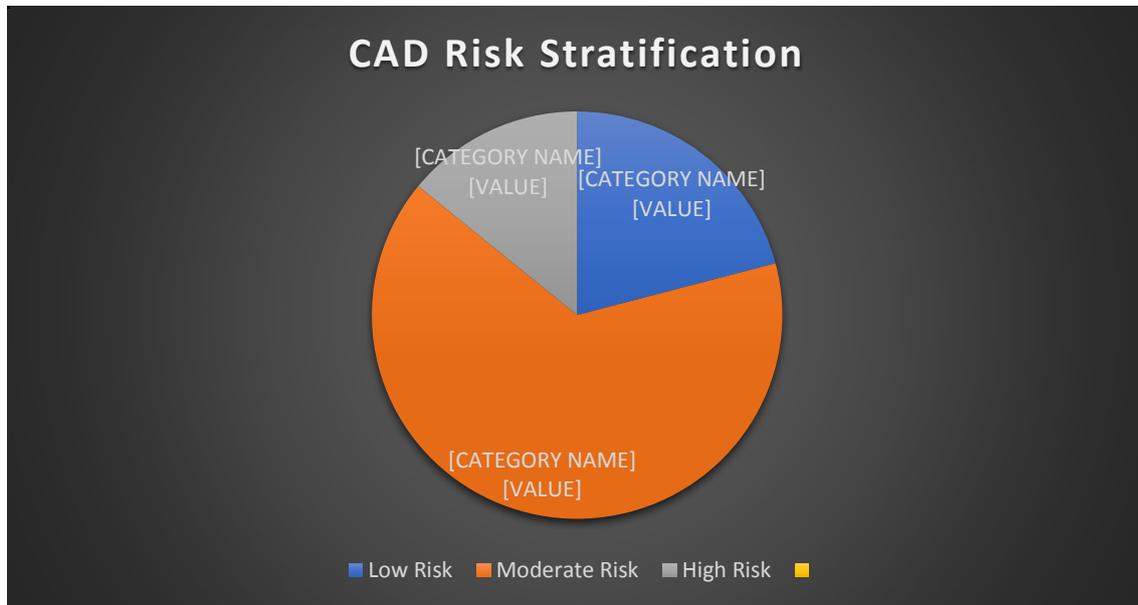
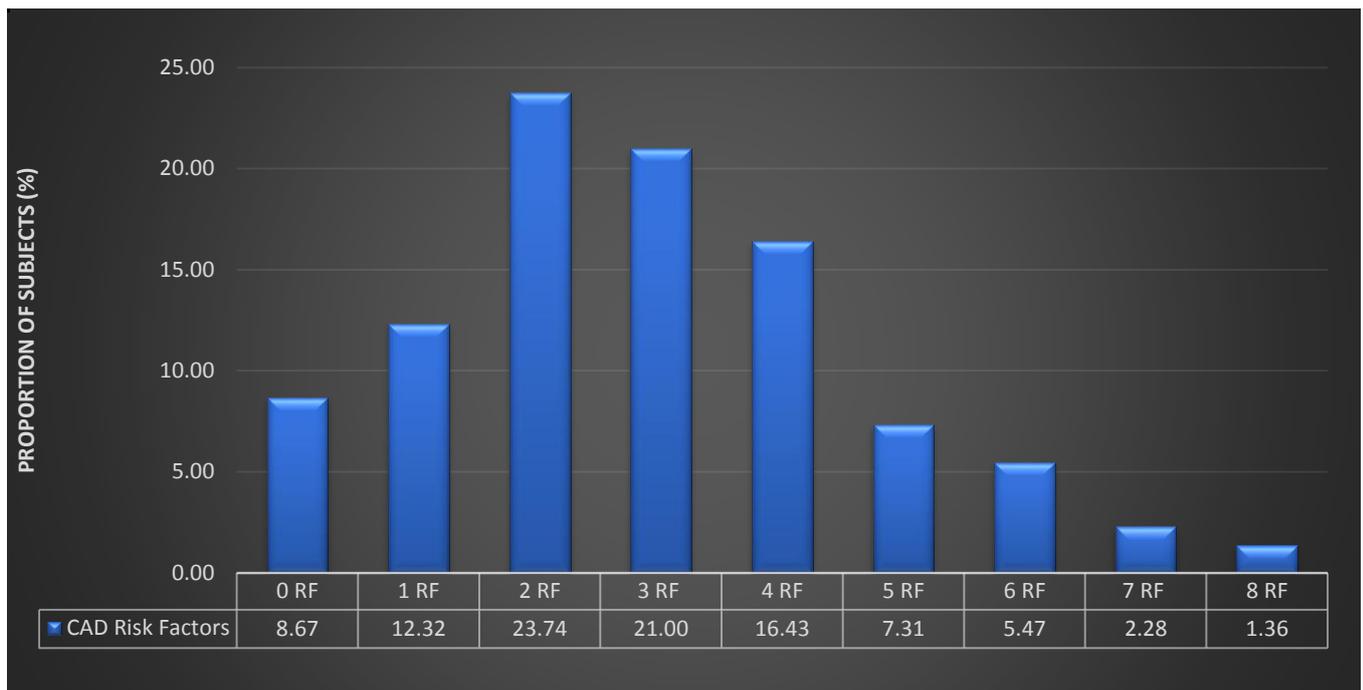


Figure 4.2. Percentage of fire-fighters with low, moderate and high risk stratification.

Figure 4.3 presents results on the frequencies of the CAD risk factors occurring simultaneously in the participants, ranging from one to eight risk factors. Among the 219 fire-fighters, 1.36% ($n = 3$) presented with a frequency of all eight CAD risk factors. The percentage of participants with zero, one, two, three, four, five, six and seven risk factors were 8.67% ($n = 19$), 12.32% ($n = 27$), 23.74% ($n = 52$), 21.00% ($n = 46$), 16.43% ($n = 36$), 7.31% ($n = 16$), 5.47% ($n = 12$) and 2.28% ($n = 5$), respectively.



RF = risk factor

Figure 4.3. Distribution of the frequencies of occurrence of CAD risk in the participants.

Figure 4.4 shows the CAD risk stratification in fire-fighters. Based on the results, 21.00% (n = 46) of fire-fighters were stratified as low risk (≤ 1 risk factor). There were 51.59% (n = 143) fire-fighters with two or more CAD risk factors, who were stratified at moderate risk. The remaining 7.76% (n = 30) of fire-fighters were stratified as high risk with reported diagnoses of diabetes mellitus and/or cardiovascular disease.

More than half (53.33%) of fire-fighters over the age of 45 years (n = 45) were stratified as high risk (i.e., diagnosed with diabetes, cardiovascular and/or respiratory disease), whilst the remaining 46.66% had two or more CAD risk factors, inclusive of age, and were, therefore, classified as being at moderate risk.

In Table 1, the mean BMI's of the participants with normal body mass, overweight and obesity were 22.06 ± 1.83 , 27.55 ± 1.27 , and $32.34 \pm 2.38 \text{ kg}\cdot\text{m}^{-2}$, respectively. There was a significant difference for BMI between the three groups [$H(3) = 187.28$, $p = 0.00$]. Post hoc analysis using Mann–Whitney test for BMI showed significant differences between groups, i.e., normal body mass and overweight groups ($U = 0.00$, $r = -0.79$), normal body mass and obese groups ($U = 0.00$, $r = -0.87$), and overweight and obese groups ($U = 0.00$, $r = -0.79$). A Bonferroni correction was applied to the post hoc analysis to minimise the type I error, so that all effects are reported at a 0.0167 ($.05/3=0.0167$) level of significance.

Table 1 further shows that amongst fire-fighters, waist circumference was the most frequent health condition related to overweight ($86.26 \pm 7.76 \text{ cm}$) and obesity ($94.98 \pm 11.03 \text{ cm}$). The prevalence of prediabetes ($5.96 \text{ mmol}\cdot\text{L}^{-1} \pm 0.96$) and waist circumference ($86.26 \pm 7.76 \text{ cm}$) among overweight men, increased Further in prediabetic, obese men ($6.65 \text{ mmol}\cdot\text{L}^{-1} \pm 2.42$). Waist circumference ($94.98 \text{ cm} \pm 11.03$) also related to an increase in body weight. Elevated cholesterol levels were prevalent among overweight fire-fighters ($5.42 \text{ mmol}\cdot\text{L}^{-1} \pm 0.90$), and remained relatively similar even with an increase in body weight in obese firemen ($5.39 \text{ mmol}\cdot\text{L}^{-1} \pm 0.85$). Significant P values were also frequent for SBP among the four BMI groups from the total participants ($121.05 \pm 17.35 \text{ mmHg}$) to the obese population ($127.80 \pm 15.01 \text{ mmHg}$). DBP also showed a significance among the groups with total participants mean and standard deviation reported at $79.19 \pm 9.82 \text{ mmHg}$ with an increase in DBP as the body weight increased $82.68 \pm 8.75 \text{ mmHg}$. Similarly, fasting blood glucose also showed a significance with $p < 0.01$ among normal $5.75 \pm 2.19 \text{ mmol}\cdot\text{L}^{-1}$ and obese reported at $6.65 \pm 2.42 \text{ mmol}\cdot\text{L}^{-1}$. Waist circumference increased from $78.90 \pm 7.97 \text{ cm}$ to $94.98 \pm 11.03 \text{ cm}$ thus also showing a significance amongst the groups. Hip circumference also showed a significant value increasing from 92.32 ± 6.38 to $105.51 \pm 10.93 \text{ cm}$. WHR increased in circumference

from 0.85 ± 0.068 to 0.90 ± 0.080 . An increase in body weight also lead to a significant p value <0.00 from 70.34 ± 10.52 kg to 85.62 ± 14.13 kg.



Table 1: CAD risk factors among BMI categories.



Variables	Total (n = 219)	Normal Weight (n = 88)	Overweight (n = 38)	Obese (n = 93)	P Value
Systolic (BP) (mm Hg)	121.05±17.35	115.86±17.63	116.58±16.85	127.80±15.01	0.00
Diastolic (BP) (mm Hg)	79.19±9.82	76.47±9.65	76.97±10.17	82.68±8.75	0.00
Fasting- Cholesterol (mmol·L ⁻¹)	5.27±0.93	5.07±1.01	5.42±0.90	5.39±0.85	0.23
Fasting blood glucose (mmol·L ⁻¹)	6.77±2.19	5.75±2.24	5.96±0.96	6.65±2.42	0.01
Waist Circumference (cm)	87.00±11.86	78.90±7.97	86.26±7.76	94.98±11.03	0.00
Hip Circumference (cm)	98.82±10.49	92.32±6.38	97.50±6.38	105.51±10.93	0.00
WHR	0.88±0.75	0.85±0.68	0.88±0.60	0.90±0.80	0.00
Age (yr)	37.85±9.80	38.46±9.80	38.71±10.40	36.93±9.60	0.53
Height (m)	1.71±0.10	1.70±0.09	1.72±0.08	1.72±0.11	0.39
Weight (kg)	77.51±13.89	70.34±10.52	74.26±9.06	85.62±14.13	0.00
BMI (kg·m⁻²)	27.38±5.09	22.06±1.83	27.55±1.27	32.34±2.38	0.00

Variables	SBP	DBP	Fasting Chol	Fasting BG	WC	HC	WHR	BMI	Age	Height	Weight
SBP											
DBP	0.799**										
Fasting Chol	0.099	0.138*									
Fasting BG	0.220**	0.195*	0.170*								
WC	0.414**	0.396*	0.160*	0.274**							
Hip Circumference	0.199**	0.206*	0.035	0.147*	0.756*						
WHR	0.414**	0.377*	0.205**	0.242**	0.665*	0.023					
BMI	0.330**	0.313**	0.149*	0.217**	0.711**	0.675**	0.313**				
Age	-0.011	0.051	-0.045	0.048	-0.027	-0.067	0.015	-0.060			
Height	0.096	0.012	0.020	0.105	0.075	0.014	0.090	0.070	-0.91		
Weight	0.149*	0.134*	0.072	0.181**	0.389**	0.385**	0.151*	0.512**	-0.122	0.441**	

Table 2: Correlation matrix of the relationship between the various CAD risk factors

WHR, waist-hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index, WC, waist circumference; BG, blood glucose; Chol, cholesterol

**Significant at $p < 0.01$; *Significant at $p < 0.05$.



The bivariate correlation shows that there was a significant correlation between DBP and SBP ($r = 0.799, p < 0.01$). There was also a significant relationship between HC and WC ($r = 0.756, p < 0.01$), with WC and WHR ($r = 0.665, p < 0.01$). Waist circumference also showed a significant value with BMI ($r = 0.711, p < 0.01$) and Hip circumference with BMI ($r = 0.673, p < 0.01$).

Waist circumference was found to have a significant relationship with SBP ($r = 0.414, p < 0.01$), with DBP ($r = 0.396, p < 0.01$), with prediabetes ($r = 0.274, p < 0.01$) and with dyslipidemia ($r = 0.160, p < 0.05$). Hip circumference also had a significant relationship with SBP ($r = 0.199, p < 0.01$), with DBP ($r = 0.206, p < 0.01$) and with WC ($r = 0.756, p < 0.01$). Hip circumference also had a relationship with prediabetes ($r = 0.147, p < 0.05$).

WHR had a significant relationship with SBP ($r = 0.414, p < 0.01$), with DBP ($r = 0.377, p < 0.01$), with dyslipidemia ($r = 0.205, p < 0.01$), with WC ($r = 0.242, p < 0.01$) and with hip circumference at ($r = 0.665, p < 0.01$). BMI showed a statistically significant relationship with SBP ($r = 0.330, p < 0.01$), with DBP ($r = 0.313, p < 0.01$), with prediabetes ($r = 0.217, p < 0.01$), with WC ($r = 0.711, p < 0.01$), with hip circumference ($r = 0.673, p < 0.01$) and with WHR ($r = 0.313, p < 0.01$). Finally, weight showed a significant correlation with prediabetes ($r = 0.181, p < 0.01$), with WC ($r = 0.389, p < 0.01$), with hip circumference ($r = 0.385, p < 0.01$), with BMI ($r = 0.512, p < 0.01$), and height ($r = 0.441, p < 0.01$). Also weight showed a significant correlation with SBP ($r = 0.149, p < 0.05$), with DBP ($r = 0.134, p < 0.05$) and with WHR ($r = 0.151, p < 0.05$).

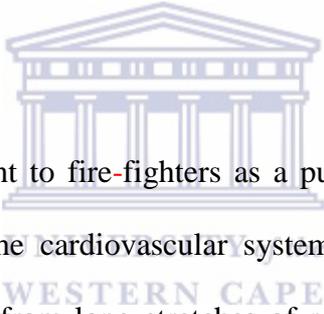
CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study sought to investigate the prevalence of CAD risk factors of municipal fire-fighters, to assess the frequency distribution of CAD risk factors among municipal fire-fighters in the Western Cape Province, to stratify fire-fighters into low, moderate and high risk for CAD and to determine the relationship between the various CAD risk factors.

5.2 Prevalence of CAD Risk Factors

5.2.1 Sedentary Lifestyle

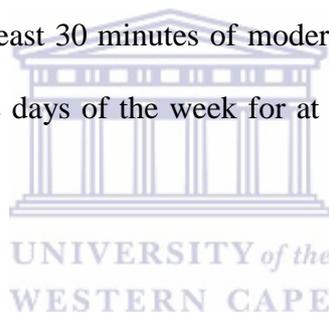


Physical activity is very important to fire-fighters as a public service, with work demands placing a significant stress on the cardiovascular system (Soteriades et al., 2011). This, coupled with the sudden change from long stretches of relative inactivity to high-intensity work, wearing relatively weighted protective fireproof clothing, increases the risk of mortality in fire-fighters (Mier and Gibson, 2004).

Efforts by fire-fighters, during an emergency, require extreme physical exertions that test their physiological capacities to the extreme. Sudden cardiac failure, overheating and gas inhalation experienced during extreme physical exertion have been identified as life-threatening (Lim et al., 2014). Consequently, this leads to an inability to continue with the task at hand and could lead to extreme fatigue, psychological imbalance, panic, uncoordinated movements, and an inability to see, hear, or breathe (Prezant, 2011). As a

result, fire-fighters are required to have a certain level of fitness when responding to alarms and fighting fires.

In the present study, a sedentary lifestyle was the most frequent CAD risk factor, occurring in 50.90% of the participants. This finding was further supported by Soteriades et al. (2002) in which inadequate physical activity was present in the fire service. Fire-fighters often experienced long sedentary periods, with many departments not making exercise mandatory or having regular physical activity regiments, even though most fire stations have the training facilities to accommodate these needs. Fire-fighters are at risk, as they do not meet the minimum physical activity requirements for health benefits, as stipulated by the ACSM guidelines of participating in at least 30 minutes of moderate-intensity (40% -60% $\dot{V}O_2\text{max}$) physical activity on at least three days of the week for at least three months (ACSM, 2013, pp. 105).



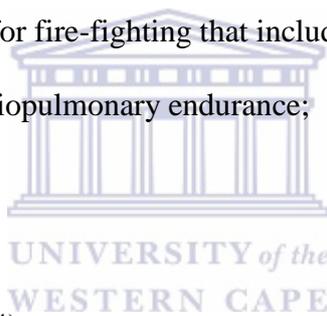
Bauer (2012) reported that high levels of physical inactivity and low levels of cardiorespiratory fitness are predictors for the development of CAD. Irregular bouts of vigorous and strenuous activity required by fire-fighters are a precursor to acute coronary heart events, should fire-fighters have low fitness levels (Soteriades, 2011). A lack of physical activity predisposes fire-fighters to an increased fat mass (Soteriades, 2011). Moreover, obese fire-fighters are more susceptible to further weight gain placing them at an increased risk of cardiovascular events (Soteriades, 2011).

In the present study, 45 males were over the age of 45 years with 53.3% of these individuals at high risk of CAD. Many engaged in sedentary behaviour which promotes atherosclerosis over a period of time, and also increases the risk of acute cardiovascular events (Soteriades,

2011). Laaksonen (2002) reported that high-risk men engaging in low levels of physical activity were less likely to develop CAD than sedentary men.

In the present study, fire-fighters were required by health policy to undergo a full medical examination annually by a medical examiner in the City of Cape Town (Schmidt, 2014). They were also required to complete a battery of physical fitness assessments conducted by a trained physical instructor (Schmidt, 2014). At the moment, South Africa has various testing batteries to examine fire-fighting performance and job tasks, with a scarcity of normative data available (Schmidt, 2014). The City of Cape Town Fire and Rescue Services identified the need for physical fitness tests and fitness training, specifically for South African fire-fighters. The Physical Ability Test (PAT) is designed to use job-related tasks to test the major areas of physical fitness that are required for fire-fighting that include the following areas:

- Aerobic capacity and cardiopulmonary endurance;
- Muscular strength;
- Muscular endurance; and
- Flexibility. (Schmidt, 2014)

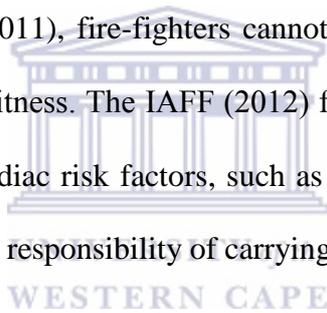


5.2.2 Obesity

Obesity invariably develops from a positive energy balance, with the risk of CAD directly related to the accumulation of central or abdominal adiposity (The Emerging Risk Factor Collaboration, 2011). Being obese is a national epidemic in South Africa and a major risk factor for CAD (Peer et al., 2012). Partly because obese individuals are more likely to have high blood pressure, be diabetic and have dyslipidemia (Peer, 2009). This is noteworthy, as this current study shows 45.90% of fire-fighters were obese. Similarly, Soteriades et al. (2005) demonstrated that overweight and obese fire-fighters were at a greater risk of injury,

and were associated with a higher prevalence of CAD risk factors, such as prediabetes, hypertension, and hypercholesterolemia. Research further suggested that fire-fighters with a high BMI will develop an increased risk of job disabilities, coupled with impaired vascular function, leading to an increased risk of (CVD) (Soteriades et al., 2011).

The risk of diabetes, dyslipidemia, hypertension and heart disease among men increases proportionally with BMI (Gray, 2004). Various studies have found a prevalence of overweight and obesity, according to BMI, in career fire-fighters with a mean BMI of $29.0 \pm 4 \text{ kg}\cdot\text{m}^{-2}$ (Kitchen, 2012). In this study, an area of concern was the elevated BMI correlating with modifiable risk factors, such as a sedentary lifestyle and cigarette smoking (Gray, 2004). According to Soteriades et al. (2011), fire-fighters cannot do their job safely or effectively without a high level of physical fitness. The IAFF (2012) further stated that “physical fitness also has a positive impact on cardiac risk factors, such as obesity and diabetes, and enables fire-fighters to meet the strenuous responsibility of carrying out their duties.”



Waist circumference is a significant predictor of CAD risk (Ashwell et al., 2012). Waist circumference is an indirect estimate of visceral fat, the dangerous internal fat which coats the organs (Lanigan, 2009). It is a more accurate predictor of cardiovascular risk and metabolic syndrome (ACSM, 2013, p. 28). The current consensus is that abdominal adipocytes are apparently more reactive to regular exercise training than femoral adipocytes (Lanigan, 2009). This suggests that exercise training and a hypocaloric diet are the most effective treatments of abdominal obesity (Lanigan, 2009).

An area of concern in the current study was waist circumference with high measurements correlating to an increase in cardiovascular events (Kitchen, 2009). An increase in abdominal

male obesity (>108cm), has shown to be an independent risk factor for CAD, diabetes, dyslipidemia and hypertension (Hu, Jousilahti, Antikainen, Katzmarzyk, & Toomilehto, 2010).

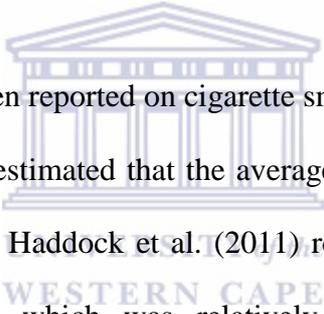
Pischon et al. (2008), showed that the distribution of adiposity could be more significant than body weight itself. Peer (2013) found that when BMI was replaced with waist circumference in men, the risk for diabetes increased 4.0% for every centimetre gained around the waist.

Fire-fighters experience high rates of obesity (ranging from 30%-40%) similar to that found among the general adult population (Flegal, 2008). In addition, Elliot et al. (2007) demonstrated that fire-fighters experience weight gains of approximately 0.5 to 1.6 kg per year throughout their career. Weight and body fat adversely affect fire-fighters' performance on the ground (Bray, 2004, p.89). Fire-fighters with an elevated BMI have difficulty breathing, because of a decrease "in residual lung volume associated with an increase in abdominal pressure" (Bray, 2004, p.89). This results in a rapid breathing rate. Similarly, as a fire-fighter's body mass increases, their efficiency decreases, resulting in fatigue setting in quicker (Williford & Scharff-Olsen, 1998).

5.2.3 Cigarette Smoking

Cigarette smoking has been associated with a number of negative physiological changes, however, it is one of the most avoidable CAD risk factors (Mozaffarian, 2014). Smokers are more likely to have a clustering of risk factors that include hypertension, physical inactivity and dyslipidemia (Mozaffarian, 2014).

In the present study, tobacco usage was prevalent in 38.30% of the fire-fighters. There is evidence from the IAFF (2012) identifying the relationship between tobacco usage, the physical demands of fire-fighting and exposure to carbon monoxide as contributing increased risk for heart disease, including heart attack and stroke (Haddock, 2011). Smoking among fire-fighters is associated with other significant health and safety risks (Haddock, 2011). Smokers were more likely to have been diagnosed with an anxiety disorder, have an alcohol problem and found driving under the influence compared to non-smokers (Haddock (2011). Cigarette smoking appears to decrease as physical activity increases. So, the adoption of an exercise intervention is likely to result in an attenuated smoking pattern (Wood & Stefanick, 1990, p.419).



To date, only two studies have been reported on cigarette smoking among fire-fighters. Lee et al. (2004) between 1987 – 1994 estimated that the average prevalence of cigarette smoking amongst fire-fighters was 26.9%. Haddock et al. (2011) reported a prevalence of 13.6% of fire-fighters smoking cigarettes, which was relatively low compared to the general population. Over the decades, there has been a decrease in cigarette smoking among fire-fighters and a rise in the usage of smokeless tobacco (Haddock et al., 2011). Policy changes such as “no tobacco use” has been introduced as a condition of employment for fire-fighters (Haddock et al., 2011). Laws against smoking indoors have also been implemented, facilitating the reduction in cigarette smoking (Haddock et al., 2011).

Fire-fighters are encouraged to quit smoking or, alternatively, to change to using smokeless tobacco (Haddock et al., 2011). Furthermore, the need to maintain high levels of health and fitness and relatively low smoking rates will be beneficial to fire-fighters (Haddock et al., 2011). This serves as a mechanism to reduce the impact of CAD among fire-fighters

(Haddock et al., 2011). More research is needed to explore cigarette smoking among fire-fighters and the effects thereof.

5.2.4 Family History of CAD

A Family history of heart disease is a non-modifiable risk factor. In this study, a family history of CAD occurred relatively frequently, with 32.80% of fire-fighters reflecting a positive family history of CAD. The risk of CAD is exponentially increased when family history is combined with poor dietary habits, physical inactivity and smoking (Sivapalaratnam et al., 2010). Smith (2012) reported that 1.7% of fire-fighters had obesity and a family history of CAD. The IAFF (2012) found factors such as insulin resistance, abdominal obesity, a sedentary lifestyle, hormonal imbalances, and a poor diet are likely the prime factors in the development of metabolic syndrome. Family history also plays a major role in the development of prediabetes and type 2 diabetes (Kitchen, 2012). The heart disease manual in the fire service (Yang, 2013) further emphasizes the importance of a family history of CAD in fire-fighters, thereby contributing to high blood pressure. Furthermore, the impact of family lifestyle choices, such as sedentary lifestyles and unhealthy nutrition cannot be overemphasized (Kales et al, 2009).

5.2.5 Elevated total cholesterol

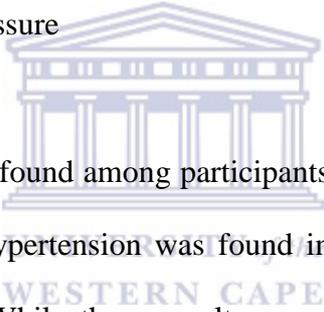
Dyslipidemia is a prevalent risk factor among fire-fighters, and has been associated with excess adipose tissue, glucose intolerance, hypertension and endothelial dysfunction, all of which affect the hearts function (Hertz et al., 2004). In the present study, 31.00% of fire-fighters had dyslipidemia. Due to the demands of having to respond to emergencies, fire-fighters may not always have the opportunity to eat healthy, balanced meals at a regular time (Hertz et al., 2004). Like other shift workers, fire-fighters are more likely to eat fast-foods or 'quick' meals with high proportions of fat that adversely affect blood lipid levels (Capewell et al., 2008). A diet rich in fat and protein accelerates the atherosclerotic process (Capewell et al., 2008). Furthermore, Capewell et al. (2008) reported on the relationship between cholesterol and atherosclerosis in the aorta. They found that lifestyle changes, such as diet, exercise, weight loss and not smoking, decreased lipid deposits in the aorta.

Yang (2013) reported fire-fighters to have dyslipidemia, i.e., total cholesterol level of 11.1 mmol·L⁻¹, low-density lipoprotein cholesterol of 8.9 mmol·L and/or requiring lipid-lowering medications. In the present study, 66.7% (n = 16) of the participants with dyslipidemia and were treated for high cholesterol through medication and/or diet. Similiarly, Soteriades et al. (2002) investigating the lipid profile of fire-fighters found dyslipidemia to be a prevalent risk factor among fire-fighters. Over time, the fire-fighters mean total cholesterol levels decreased from 12.2 mmol·L⁻¹ to 11.1 mmol·L⁻¹, suggesting the benefits of the frequent use of lipid-lowering medication (Soteriades, 2011).

Soteriades (2011) reported dyslipidemia is inadequately managed among fire-fighters. As a large proportion of fire-fighters lipid measurements that fall outside the target ranges of evidence-based healthy adults (Soteriades, 2011).

In a study on cholesterol screening done between 2004 – 2007, it was found that 37.0% of the 7904 fire-fighters had an elevated total cholesterol ($\geq 11.1 \text{ mmol}\cdot\text{L}^{-1}$) (Fahy et al., 2014). To reduce dyslipidemia, recommendations would be to have well-nourished pre-packed meals made available for fire-fighters, i.e., one at the fire station and another in the on-duty kit (Fahy et al., 2014).

5.2.6 Elevated resting blood pressure

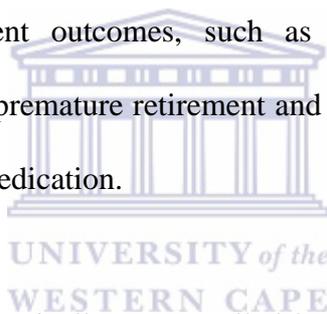


Elevated blood pressure was also found among participants in this study. The average blood pressure was 121/79 mm Hg. Hypertension was found in 27.30% of the participants, and 9.41% were pre-hypertensive. While these results are concerning, they are considerably lower than what has been reported in other studies on fire-fighters and among American adults (Carey et al., 2011; Donovan et al., 2009; Go et al., 2014).

An elevated blood pressure is a major risk factor not only for CAD, but also for heart failure and, particularly, for stroke (Mozaffarian, 2012). A study by Lewington (2008) reported that for every diastolic blood pressure increase of 10 mm Hg or systolic blood pressure increase of 20 mm Hg, the risk of CVD increased twofold. Research investigating fire-fighters during intense work reported that heart rates reached between 70 and 90% of their maximal age-predicted heart rates (Phillips, 2012).

Kales (2007) also reported that noise increases blood pressure. Alarms, sirens, vehicle engines, and mechanized rescue equipment typically produce average noise exposures in the 63 to 85 decibel (dBA) range that has a negative effect on the cardiovascular system (Kales, 2007). This report by Kales (2007) suggests that siren noises potentially elevate systolic blood pressure by 5.9 to 11.8 mm Hg.

An elevated blood pressure has been associated with a clustering of CAD risk factors. This includes men over the age of 45 years, dyslipidemia, insulin resistance, and glucose intolerance (Unal et al., (2004). Capewell (2000) identified that CAD is greater among hypertensive fire-fighters. Bjorck (2008) indicated that hypertension is an independent predictor of adverse employment outcomes, such as on-duty death, injury on duty, termination of duty, resignation, premature retirement and cardiovascular events precipitated by not taking anti-hypertensive medication.



In a study by Holder (2006), chronically uncontrolled hypertension and hypertensive heart disease were responsible for nearly 8% of cardiovascular disability retirements. The general population has high levels of CAD such as hypertension, obesity and diabetes (Kales, 2009). Of the fire-fighters in the current study who were diagnosed with hypertension, 71.7% had their diagnosis treated with medication, exercise and/or diet, and 28.3% remained untreated.

Hypertension is common in the South African population (Peer, 2013). A high intake of salt independently increases the risk of hypertension in overweight persons (Mozaffarian, 2012). Bjorck et al. (2015) suggests that in addition to lifestyle changes, health promotion that focused on implementing improved dietary habit, facilitates a decrease in blood pressure. The dietary approaches to stop hypertension (DASH) physical activity and improvement in

detection and effective medication treatment are all important in controlling high blood pressure (Bjorck et al., 2015).

5.2.7 Age

In this study, participants were aged between 20 and 60 years. Age is associated with an increased risk for CAD in men from 45 years and older (ACSM, 2013, p. 28). In this study, 20.51% of fire-fighters were above the age of 45 years, which placed them at an increased CAD risk. In men, lifestyle factors and family history can cause plaque build-up in the arteries as they age. McGill et al. (2000) showed that an increase in an individual's age leads to a higher prevalence of CAD. Physical activity tends to decrease with age and is less prevalent amongst those with chronic diseases (Sebregts et al., 2000).



5.2.8 Elevated fasting blood glucose

Findings in the present study showed that 17.27% of fire-fighters were at risk of CAD, due to prediabetes. a study by O'keefe (2013) reported that prediabetes and obesity can affect municipal work performance. Fire-fighters' work performance can be affected by having difficulty climbing ladders with equipment (O'keefe, 2013). Similarly, the findings from the current study show a statistically significant relationship between prediabetes and obesity. The association between prediabetes and obesity is well established (Thorpe, 2011) such that evidence-based weight loss programmes are recommended for obese individuals at risk of developing diabetes (Thorpe, 2011). Obesity coupled with physical inactivity is independently related to the risk of developing diabetes (Aldana et al., 2006).

In 2006 and 2007, 5065 fire-fighters were screened for glucose (Fahy et al., 2011). The study revealed 5.9% to be prediabetic and 2.7% as diabetic. However, in 2010, 216 fire-fighters were medically screened, and 14.8% were found to be diabetic, whilst 32.9% were prediabetic (Fahy et al., 2011).

In a cohort study of 957 career fire-fighters, approximately 26% displayed high blood glucose levels ($\geq 5.54 \text{ mmol}\cdot\text{L}^{-1}$) (Baur et al., 2012). Donovan et al. (2009) reported 1% of fire-fighters had a fasting glucose $\geq 6.1 \text{ mmol}\cdot\text{L}^{-1}$, whilst Yoo and Franke (2009) reported a 3 to 4% prevalence of diabetes in fire-fighters. The prevalence of type II diabetes among fire-fighters is linked with a 21% risk of experiencing an on-duty CAD event (Soteriades et al., 2011). Furthermore, medical conditions such as diabetes and obesity predispose fire-fighters to heat illness. Kitchen (2012) reported that diet had a direct effect on CAD, linking obesity, prediabetes and hypertension in fire-fighters. Therefore, promoting a daily intake of fruits, vegetables and an exercise regime, to counteract and reduce the risk of prediabetes in fire-fighters is important (Kitchen 2012). Findings from Dorsey (2012) demonstrated that lifestyle modifications, such as physical activity, can reduce the transition from prediabetes to type 2 diabetes in fire-fighters.

5.3 CAD Risk Stratification

This study reported on the risk stratification of municipal fire-fighters in the Western Cape. Overall, in the 219 participants, 21.0% were at low risk of CAD. This was followed by 64.4% at moderate risk of CAD and 14.6% at high risk.

The study identified that, of the 45 male fire-fighters over the age of 45 years, 53.33% were at high risk (i.e., diagnosed with diabetes and/or CVD by a medical doctor), whilst the remaining 31.11% had two or more CAD risk factors and, therefore, were stratified as being at moderate CAD risk. Only, 15.55% of male fire-fighters were classified as low risk (≤ 1 risk factor).

In the study, 9.19% of male fire-fighters under the age of 45 were classified as high risk. Also, 64.94% of fire-fighters under the age of 45 years had two or more CAD risk factors and were classified as being at moderate CAD risk. Only, 25.86% of male fire-fighters under the age of 45 years were stratified as low risk (≤ 1 risk factor). Soteriades et al. (2011) reported that an increase in age is an independent predictor of CAD in fire-fighters, and an adjustment to the types of duties performed by fire-fighters should be made.

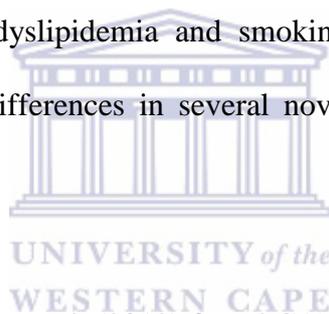
Mittleman (2007) suggested that predictive risk stratification of all asymptomatic fire-fighters, without a history of atherosclerotic disease, should include maximal exercise tolerance testing (ETT) starting at the age of 45 or earlier. Furthermore, Mittleman (2007) reported that the stress test results of fire-fighters should be examined for electrocardiogram changes suggestive of ischemia, for abnormal blood pressure response, for abnormal heart rate recovery, and for impaired exercise capacity.

Including age, eight CAD risk factors were assessed in this study. For the purposes of this study, the CAD risk factors were grouped as frequencies ranging from zero to eight risk factors. When considering the number of participants with various frequencies of CAD risk factors, it was apparent that there was a substantial prevalence of participants with two or more risk factors. The most frequent risk factors being a sedentary lifestyle and obesity. The

presence of participants with zero (8.67%) and one risk factor (12.34%) is clear evidence of the benefits of physical activity, good dietary habits and health promotion (Bassuk and Manson, 2005).

Wolkow (2012) determined cardiovascular risk screening of volunteer fire-fighters. The findings of the study displayed 68.2% of male fire-fighters stratified as moderate risk. Furthermore, 5.2% of male fire-fighters were stratified as high risk, while the remaining 26.6% of fire-fighters were classified as low risk.

Smith et al. (2012) found no differences in the prevalence of traditional CAD risk factors such as obesity, hypertension, dyslipidemia and smoking between obese and non-obese firemen. However, there were differences in several novel risk factors warranting further investigation.



A systematic review by Soteriades et al. (2012) found CAD to be the major cause of on-duty death among fire-fighters and a leading cause of morbidity. CAD in the fire service had an adverse effect with safety implications and cost impacts on government (Soteriades et al., 2012).

CAD among fire-fighters has significantly improved over the last decade providing insight into potential preventive strategies. However, despite the strenuous demands on fire-fighters, the prevalence of low fitness, obesity, and other CAD risk factors is high (Soteriades et al., 2012).

Statistical approaches have documented that on-duty CAD events occur among fire-fighters with underlying CAD. These CAD events occur during certain times of day, during certain periods of the year, and are more frequent during strenuous duties compared with non-emergency situations (Soteriades et al., 2012).

There is evidence that associates a higher risk of on-duty death and disability among fire-fighters with a history of CAD. Therefore, most fire-fighters with known CHD or other clinically significant atherosclerotic endpoints should be restricted from participating in strenuous emergency duties (Soteriades et al., 2012)

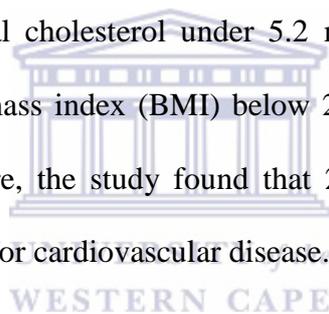
When considering that much research has been conducted on CAD risk factors in fire-fighters involving blood pressure, exercise, diabetes and weight, few studies have investigated dietary lifestyles related to the prevalence of CAD. Therefore, due to the relationship between poor diet and cardiovascular health, it is important to consider dietary intake with regard to CAD risk in fire-fighters (Kitchen, 2012).

Yang et al. (2013) found that on-duty sudden cardiac death (SCD) usually occurs in fire-fighters more than 45 years due to CAD. Yang further investigated cases of SCD in fire-fighters aged less than 45 years. Of the SCD cases, 63% were obese and 67% had a coronary artery disease -related cause of death. Furthermore, hypertension, including cases with left ventricular hypertrophy, increased SCD risk by 12-fold. A history of CVD and smoking were also independently associated with SCD (Soteriades et al., 2012). SCD in young fire-fighters is primarily related to preventable lifestyle factors (Yang et al., 2013). Obesity norms, smoking bans, improved screening and/or wellness programmes are potential strategies to reduce SCD in younger fire-fighters (Yang et al., 2013). Improved CAD risk identification

among fire-fighters has important implications for both individual health and public safety (Soteriades et al., 2012).

5.4 Relationship Between various CAD risk factors

Overall, 19 participants out of the 219 evaluated, displayed all of the characteristics of optimal cardiovascular health (systolic blood pressure below 120 mm Hg, diastolic blood pressure below 80 mm Hg, total cholesterol under $5.2 \text{ mmol}\cdot\text{L}^{-1}$, fasting plasma glucose under $5.6 \text{ mmol}\cdot\text{L}^{-1}$, and body mass index (BMI) below $25 \text{ kg}\cdot\text{m}^{-2}$) as described by Lloyd-Jones et al. (2010). Furthermore, the study found that 21.00% of the fire-fighters tested displayed at least one risk factor for cardiovascular disease.



Understanding the major independent CAD risk factors is critical for the fire service, due to the impact of CAD on LODDs. O'Donnell and Elousa (2008) reported that risk factors are the result of interactions between genetic and environmental factors over an extended period of time. A reduction in cardiovascular risk factors among fire-fighters will lead to a reduction in LODDs (Johnson, 2013). Implementation of interventions will be needed to reduce the risk of CAD among fire-fighters and improve overall fitness.

A study by Geibe et al. (2008) showed that fire-fighters who had pre-existing CAD diagnoses had a 15-fold increase in the risk for an on-duty fatal cardiovascular event. More than 80% of CAD events among fire-fighters were due to pre-existing heart disease (Baur et al., 2012).

Cardiovascular events occur among fire-fighters with underlying CAD, where some are diagnosed and others go unrecognized (Soteriades et al., 2011). The Development of contributing risk factors for CAD occurs gradually over years and eventually triggers an on-duty cardiovascular event in fire-fighters (Dussinger, 2014). Optimal CAD risk status has shown a reduction in the risk of CAD deaths or risk of CAD events (Lloyd-Jones et al., 2010). The Framingham Heart Study found optimal levels of risk factors correlated with a 69% reduction in CAD risk (Lloyd-Jones et al., 2010).

A cohort of 957 fire-fighters with an average age of 39.6 years and BMI of 29.3 kg·m⁻² showed a 28.3% prevalence of increased waist circumference, prediabetes, elevated blood pressure and dyslipidemia (Donovan et al., 2009). Although these risk factors are controlled with medication, they are still considered risks (Mozumdar & Liguori, 2010). It is understood that these factors work synergistically when an individual has metabolic syndrome, thus increasing the risk of CAD in fire-fighters (Go et al., 2014). Furthermore, precaution is advised in prohibiting fire-fighters from participating in training or emergency environments, due to the safety and health risks to him/herself and others (NFPA, 2013).

A Sedentary lifestyle is considered a major risk factor for CAD (Durand et al., 2011). About 12% of the global burden of myocardial infarction is due to sedentary lifestyle, after accounting for other CAD risk factors (Go et al., 2014). The AHA recommends 150 or more minutes of moderate-intensity activity or 75 or more minutes of vigorous-intensity activity to improve cardiovascular health (Durand et al., 2011). Sedentary lifestyles and low levels of physical activity among fire-fighters have been reported (Durand et al., 2011).

The National Fire Protection Association notes that for the safe performance of US fire-fighting, the individual requires a maximal rate of oxygen consumption ($\dot{V}O_{2\max}$) of at least $42 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ or 12 metabolic equivalents (METs) (NFPA, 2013). The recommendations are that fire-fighters testing below 12 METS should be counselled to improve their fitness levels. If fire-fighters have an aerobic capacity below 8 METs, the NFPA recommends that the individual is prescribed a required aerobic fitness programme, and that there are restrictions placed on job tasks that would expose him/her to excessive physical exertion (NFPA, 2013). Among 214 career male fire-fighters, a quarter (25%) did not meet the NFPA fitness standard (Donovan et al., 2009).



Dussinger (2014) conducted a study on health behaviours and CAD risk among 42 fire-fighters. The screening evaluations displayed risk factors of CAD that included high obesity rates, increased waist circumference, elevated body mass, blood pressure and lipid levels. Sodium intake was positively correlated with systolic blood pressure (SBP) and physical activity was negatively correlated with SBP.

The frequency and intensity of physical activity is strongly associated with CAD risk factors (Dussinger (2014). Physical activity and cardiorespiratory fitness have been shown to improve body composition and lower risk factors for CAD (Durand et al., 2011). Fitness also protects against the development of atherosclerosis and acute, exertion-triggering cardiovascular events (Baur et al., 2012).

One metabolic equivalent (MET) improvement in aerobic capacity results with a 15% decrease in cardiovascular disease and a 12% decrease in mortality risk (Go et al., 2013). An increase in aerobic fitness above 12 METS could lower BMI by 1.6 units according to the NFPA guideline, as well as increase HDLC by about $0.27 \text{ mmol}\cdot\text{L}^{-1}$, lower triglycerides by more than $1.66 \text{ mmol}\cdot\text{L}^{-1}$, and lower blood glucose levels by about $0.49 \text{ mmol}\cdot\text{L}^{-1}$ (Baur et al., 2012).

Despite a large prevalence of sedentary lifestyles among fire-fighters, more than 70% of fire departments still lack programmes to promote health and fitness, and most departments do not require exercise or regular medical examinations (Kales et al., 2007). This suggests that sedentary lifestyles may continue to be a serious issue in the fire service.



5.5 Conclusion

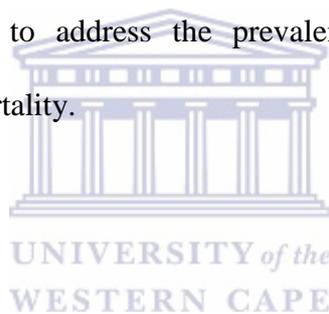
From the results of this study a sedentary lifestyle and obesity are the most prevalent risk factors of CAD among fire-fighters. Fire-fighters showed a large prevalence of moderate CAD risk factors, most of which are modifiable. This was followed by low risk with the least prevalent being high risk. Significant relationships were also found between the various CAD risk factors such as DBP and SBP, WC and HC, WC and WHR, WC and BMI with HC and BMI also showing statistical significance.

5.6 Recommendations

A medically supervised, graded exercise training programme should be undertaken to decrease the CAD risk in municipal fire-fighters in the Western Cape. Kales et al. (2007) reported that the major cardiovascular risks factors are detectable at routine examinations and

mostly modifiable. Yet, 75% of fire-fighters who die from on-duty cardiovascular-related deaths have not had a recent medical examination (Kales et al., 2007). Furthermore, high risk participants must be encouraged to make the necessary lifestyle changes in order to reduce their risk and be stratified in the moderate-to-low risk category. This can be done through education on cardiovascular health promotion and by regular screening of personnel considered to be at high CAD risk.

In addition, the limited data on CAD risk factors and the scarcity of data of South African fire-fighters, signifies that there is a need for basic research to address these shortcomings. More investigations are needed in this area that will aid municipal fire-fighters in the Western Cape to enhance their health, to address the prevalence of CAD risk and decrease cardiovascular morbidity and mortality.



5.7 Summary

Some of the CAD risk factors commonly found in fire-fighters include a sedentary lifestyle, obesity, prediabetes, dyslipidemia and an increased waist circumference. In addition, high blood pressure was inversely related to level of physical activity.

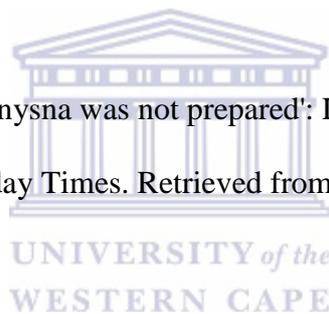
Numerous fire-fighters were obese, based on BMI and WHR, cigarette smokers and took blood pressure and cholesterol lowering medication. By adding modifiable risks to the job stressors, such as increased heart rate, smoke inhalation, heat stress, and intense physical activity, fire-fighters lives are greatly in danger of cardiovascular events.

Overall, both past findings and this current study indicate that fire-fighters are at an increased risk of CAD. Therefore, it is imperative for health professionals to educate the fire-fighting population on their cardiovascular risk, and on the benefits of adopting a healthy lifestyle. With a lack of public policy concerning cardiovascular risk and fire-fighting, CAD education could be a major means to decreasing cardiovascular risk.

5.8 References

Abel, M. G., Palmer, T. G., & Trubee, N. (2015). Exercise Program Design for Structural Firefighters. *Strength & Conditioning Journal*, 37(4), 8-19.

Alexander, E. (2017, June 12). 'Knysna was not prepared': Local fire-fighters not equipped for a blaze of this scale. *The Sunday Times*. Retrieved from <http://www.timeslive.co.za>



American College of Sports Medicine (Ed.). (2013). *ACSM's health-related physical fitness assessment manual*. Lippincott Williams & Wilkins.

American College of Sports Medicine (2013). *ACSM's guidelines for exercise testing and prescription*. Seventh edition. Lippincott, Williams and Wilkins, Philadelphia.

Ärnlöv, J., Ingelsson, E., Sundström, J., & Lind, L. (2010). Impact of body mass index and the metabolic syndrome on the risk of cardiovascular disease and death in middle-aged men. *Circulation*, 121(2), 230-236.

Adedoyin, R. A., Mbada, C. E., Balogun, M. O., Martins, T., Adebayo, R. A., Akintomide, A., & Akinwusi, P. O. (2008). Prevalence and pattern of hypertension in a semiurban community in Nigeria. *European Journal of Cardiovascular Prevention and Rehabilitation*, 15(6), 683-687.

Agyemang, C., Addo, J., Bhopal, R., De Graaf Aikins, A., & Stronks, K. (2009). Cardiovascular disease, diabetes and established risk factors among populations of sub-Saharan African descent in Europe: a literature review. *Globalization and Health*, 5(1), 7. 10.1186/1744-8603-5-7

Alberti, K. G. M. M., Eckel, R. H., Grundy, S. M., Zimmet, P. Z., Cleeman, J. I., Donato, K. A., & Smith, S. C. (2009). Harmonizing the metabolic syndrome. *Circulation*, 120(16), 1640-1645.

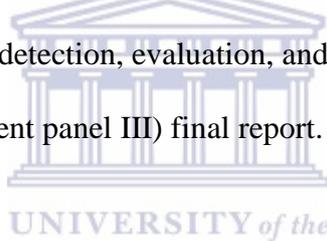
Alberts, M., Urdal, P., Steyn, K., Stensvold, I., Tverdal, A., Nel, J. H. and Steyn, N. P. (2005). Prevalence of cardiovascular diseases and associated risk factors in a rural black population of South Africa. *European Journal of Cardiovascular Prevention and Rehabilitation*, 12(4), 347-354.

Aldana, S., Barlow, M., Smith, R., Yanowitz, F., Adams, T., Loveday, L., & Merrill, R. M. (2006). A worksite diabetes prevention program. Two-year impact on employee health. *American Association of Occupational Health Nurses Journal*, 54(9), 389-395

Almahmeed, W., Arnaout, M. S., Chettaoui, R., Ibrahim, M., Kurdi, M. I., Taher, M. A., & Mancina, G. (2012). Coronary artery disease in Africa and the Middle East. *Therapeutics and Clinical Risk Management*, 8, 65-72.

American Heart Association (2009). Heart disease and stroke statistics 2010 update: A report from the American Heart Association. *Circulation*, 121, e46-e215. doi: 10.1161/CIRCULATIONAHA.109.192667

American Heart Association (2002). Third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III) final report. *Circulation*, 106, 3141- 3421.



Andrews, B.C., Ruhling, R.O., Burrell, E., Basset, S. & Sands, B. (1985). Physical fitness of South African and American young adults. *South African Journal for Research in Sport, Physical Education and Recreation*, 8(2), 23-33.

Arnson, Y., Shoenfeld, Y. & Amital, H. (2010). Effects of tobacco smoke on immunity, inflammation and autoimmunity. *Journal of Autoimmunity*, 34(3), J258-J265.

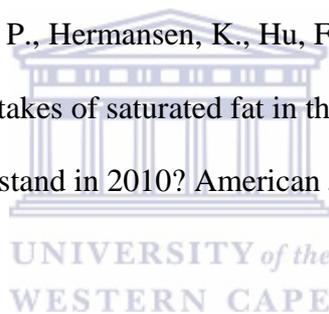
Artinian, N. T., Fletcher, G. F., Mozaffarian, D., Kris-Etherton, P., Van Horn, L., Lichtenstein, A. H., Kumanyika, S., Kraus, W. E., Fleg, J. L., Redeker, N. S., Meininger, J. C., Banks, J., Stuart-Shor, E. M., Fletcher, B. J., Miller, T. D., Hughes, S., Braun, L. T., Kopin, L. A., Berra, K., Hayman, L. L., Ewing, L. J., Ades, P. A., Durstine, J. L., Houston-Miller, N. and Burke, L. E. (2010). Interventions to promote physical activity and dietary

lifestyle changes for cardiovascular risk factor reduction in adults: a scientific statement from the American Heart Association. *Circulation*, 122, 406-441.

Ashen, D. (2010). Cost-effective prevention of coronary heart disease. *Journal for Nurse Practitioners*, 6(10), 754-764.

Ashwell, M., Gunn, P., & Gibson, S. (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: a systematic review and meta-analysis. *Obesity Reviews*, 13(3), 275-286.

Astrup, A., Dyerberg, J., Elwood, P., Hermansen, K., Hu, F. B., Jakobsen, M. U. and Nestel, P. (2011). The role of reducing intakes of saturated fat in the prevention of cardiovascular disease: where does the evidence stand in 2010? *American Journal of Clinical Nutrition*, 93(4), 684-688.



Bakhru, A., & Erlinger, T. P. (2005). Smoking cessation and cardiovascular disease risk factors: results from the Third National Health and Nutrition Examination Survey. *PLoS Med*, 2(6), e160.

Barker, D. J. P. (1995). Fetal origins of coronary heart disease. *British Medical Journal*, 311, 171-74.

Barr, D., Reilly, T., & Gregson, W. (2011). The impact of different cooling modalities on the physiological responses in fire-fighters during strenuous work performed in high environmental temperatures. *European Journal of Applied Physiology*, 111(6), 959-967.

Barreto, S. M., Miranda, J. J., Figueroa, J. P., Schmidt, M. I., Munoz, S., Kuri-Morales, P. P., & Silva, J. B. (2012). Epidemiology in Latin America and the Caribbean: current situation and challenges. *International Journal of Epidemiology*, 41(2), 557-571.

Bassuk, S. S., & Manson, J. E. (2005). Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *Journal of Applied Physiology*, 99(3), 1193-1204.

Bates, J. T. (1987). Coronary artery disease deaths in the Toronto Fire Department. *Journal of Occupational and Environmental Medicine*, 29(2), 132-135.

Baur, D. M., Leiba, A., Christophi, C. A., & Kales, S. N. (2012). Low fitness is associated with exercise abnormalities among asymptomatic fire-fighters. *Occupational Medicine*, 62(7), 566-569.

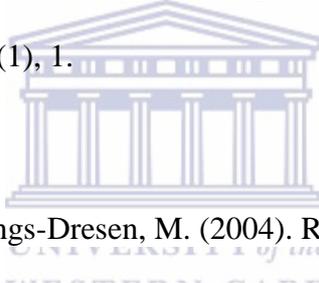
Beaglehole, R., Epping-Jordan, J., Patel, V., Chopra, M., Ebrahim, S., Kidd, M., & Haines, A. (2008). Improving the prevention and management of chronic disease in low-income and middle-income countries: a priority for primary health care. *Lancet*, 372(9642), 940-949.

Bilzon, J. L., Scarpello, E. G., Smith, C. V., Ravenhill, N. A., & Rayson, M. P. (2001). Characterization of the metabolic demands of simulated shipboard Royal Navy fire-fighting tasks. *Ergonomics*, 44(8), 766-780.

Björck, L., Capewell, S., O'Flaherty, M., Lappas, G., Bennett, K., & Rosengren, A. (2015). Decline in coronary mortality in Sweden between 1986 and 2002: comparing contributions from primary and secondary prevention. *PloS one*, 10(5), e0124769.

Bloom, D. E., Cafiero, E., Jané-Llopis, E., Abrahams-Gessel, S., Bloom, L. R., & Fathima, S. & O'Farrell, D. (2012). The global economic burden of noncommunicable diseases, (8712).

Bodin, T., Albin, M., Ardö, J., Stroh, E., Östergren, P. O., & Björk, J. (2009). Road traffic noise and hypertension: results from a cross-sectional public health survey in southern Sweden. *Environmental Health*, 8(1), 1.



Bos, J., Mol, E., Visser, B., & Frings-Dresen, M. (2004). Risk of health complaints and disabilities among Dutch fire fighters. *International Archives of Occupational and Environmental Health*, 77(6), 373-382.

Byczek, L., Walton, S., Conrad, K., Reichelt, P., & Same, D. (2004). Cardiovascular risk in fire-fighters- Implications for occupational health nurse practice. *American Association of Occupational Health Nurses Journal*, 52, 66-76.

Capewell, S., Morrison, C. E., & McMurray, J. J. (1995). Contribution of modern cardiovascular treatment and risk factor changes to the decline in coronary heart disease mortality in Scotland between 1975 and 1994. *Heart*, 81(4), 380-386.

Dalton, M., Cameron, A. J., Zimmet, P. Z., Shaw, J. E., Jolley, D., Dunstan, D. W., & Welborn, T. A. (2003). Waist circumference, waist-hip ratio and body mass index and their correlation with cardiovascular disease risk factors in Australian adults. *Journal of Internal Medicine*, 254(6), 555-563.

Dalal, S., Beunza, J. J., Volmink, J., Adebamowo, C., Bajunirwe, F., Njelekela, M., & Holmes, M. D. (2011). Non-communicable diseases in sub-Saharan Africa: what we know now. *International Journal of Epidemiology*, 40(4), 885-901.

Day, C. and Bailey, C. J. (2011). Obesity in the pathogenesis of type 2 diabetes. *British Journal of Diabetes and Vascular Disease*, 11(2), 55-61.

Di Cesare, M., Khang, Y. H., Asaria, P., Blakely, T., Cowan, M. J., Farzadfar, F., & Oum, S. (2013). Inequalities in non-communicable diseases and effective responses. *Lancet*, 381(9866), 585-597.

Dockery, D., Pope, A., Xu, X., Spengler, J., Ware, J., Fay, M., Ferris, B., & Speizer, F. (1993). An association between air pollution and mortality in six U.S. cities. *New England Journal of Medicine*, 329, 1753-1759.

Donovan, R., Nelson, T., Peel, J., Lipsey, T., Voyles, W., & Israel, R. G. (2009). Cardiorespiratory fitness and the metabolic syndrome in firefighters. *Occupational medicine*, 59(7), 487-492.

Drew-Nord, D., Hong, O., & Froelicher, E. (2009). Cardiovascular risk factors among career fire-fighters. *American Association of Occupational Health Nurses Journal*, 57, 415-422. doi: 10.3928/08910162-20090916-02

Durand, G., Tsismenakis, A. J., Jahnke, S. A., Baur, D. M., Christophi, C. A., & Kales, S. N. (2011). Fire-fighters' physical activity: relation to fitness and cardiovascular disease risk. *Medicine and Science in Sports and Exercise*, 43(9), 1752-1759.

Dussinger, B. (2014). Predictors of health behaviours and cardiovascular disease risk factors for professional fire-fighters. Doctoral dissertation, Colorado State University. Libraries.

Ebrahim, S. and Smith, G. (1997). Systematic review of randomized controlled trials of multiple risk factor interventions for preventing coronary heart disease. *British Medical Journal*, 314, 1666-1691.



Ebrahim, S., Taylor, F., Ward, K., Beswick, A., Burke, M. and Davey-Smith, G. (2011). Multiple risk factor interventions for primary prevention of coronary heart disease (Review). Retrieved on March 28, 2011 from <http://www.thecochranelibrary.com>

Egger, M., Ekouevi, D. K., Williams, C., Lyamuya, R. E., Mukumbi, H., Braitstein, P., & Dabis, F. (2012). Cohort Profile: The international epidemiological databases to evaluate AIDS (IeDEA) in sub-Saharan Africa. *International Journal of Epidemiology*, 41(5), 1256-1264.

Elliot, D., Goldberg, L., Duncan, T., Kuehl, K., Moe, E., Breger, R., DeFrancesco, C., Ernst, D., and Stevens, V. (2004). The PHLAME fire-fighter's study: Feasibility and findings. *American Journal of Health Behavior*, 28, 13-23.

Elliot, D. L., Goldberg, L., Kuehl, K. S., Moe, E. L., Breger, R. K., & Pickering, M. A. (2007). The PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) firefighter study: outcomes of two models of behavior change. *Journal of Occupational and Environmental Medicine*, 49(2), 204-213.

Escobar, H. (2002). Hypertension and coronary heart disease. *Journal of Human Hypertension*, 16(1), S61-S63.



Estruch, R., Ros, E., Salas-Salvadó, J., Covas, M. I., Corella, D., Arós, F., & Lamuela-Raventos, R. M. (2013). Primary prevention of cardiovascular disease with a Mediterranean diet. *New England Journal of Medicine*, 368(14), 1279-1290.

Fahy, R., Leblanc, P., & Molis, J. (2014). Fire-fighter fatalities in the United States, 2013. National Fire Protection Association.

Findley, B. W., Brown, L. E., & Whitehurst, M. (2002). Anaerobic power performance of incumbent female firefighters. *The Journal of Strength & Conditioning Research*, 16(3), 474-476.

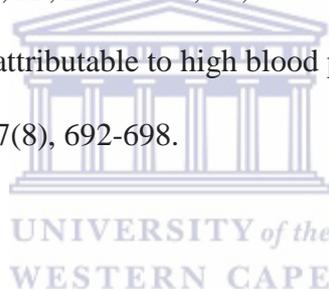
Finucane, M. M., Stevens, G. A., Cowan, M. J., Danaei, G., Lin, J. K., Paciorek, C. J., & Farzadfar, F. (2011). National, regional, and global trends in body-mass index since 1980:

systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9· 1 million participants. *Lancet*, 377(9765), 557-567.

Franklin, B. A. and Cushman, M. (2011). Recent advances in preventive cardiology and lifestyle medicine: A themed series. *Circulation*, 123, 2274-2283.

Flegal, K. M., Carroll, M. D., Ogden, C. L., & Curtin, L. R. (2010). Prevalence and trends in obesity among US adults, 1999-2008. *Jama*, 303(3), 235-241.

Gaziano, T., Laubscher, R., Steyn, K., Bradshaw, D., & Collaboration, S. A. C. R. A. (2007). Estimating the burden of disease attributable to high blood pressure in South Africa in 2000. *South African Medical Journal*, 97(8), 692-698.



Gaziano, J. M. (1998). Primary and secondary prevention of coronary heart disease. *Cardiology Rounds*, 2(8), 1-8.

Gaziano, J. M., Hennekens, C. H., O'Donnell, C. J., Breslow, J. L. and Buring, J. E. (1997). Fasting triglycerides, high-density lipoprotein, and risk of myocardial infarction. *Circulation*, 96, 2520-2525.

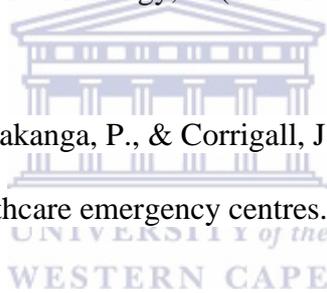
Glueck, C. J., Kelley, W., Wang, P., Gartside, P. S., Black, D., & Tracy, T. (1996). Risk factors for coronary heart disease among fire-fighters in Cincinnati. *American journal of industrial medicine*, 30(3), 331-340.

Go, A. S., Mozaffarian, D., Roger, V. L., Benjamin, E. J., Berry, J. D., Blaha, M. J., & Fullerton, H. J. (2013). AHA statistical update. *Circulation*, 127, e62-e245.

Go, A. S., Mozaffarian, D., Roger, V. L., Benjamin, E. J., Berry, J. D., Blaha, M. J., & Fullerton, H. J. (2014). Heart disease and stroke statistics—2014 update: a report from the American Heart Association. *Circulation*, 129(3), e28.

Goff, D. C., Lloyd-Jones, D. M., Bennett, G., Coady, S., D'Agostino, R. B., Gibbons, R., & Robinson, J. G. (2014). 2013 ACC/AHA guideline on the assessment of cardiovascular risk. *Journal of the American College of Cardiology*, 63(25 Part B), 2935-2959.

Govender, I., Matzopoulos, R., Makanga, P., & Corrigall, J. (2012). Piloting a trauma surveillance tool for primary healthcare emergency centres. *South African Medical Journal*, 102(5), 303-306.



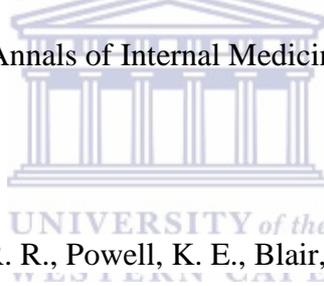
Guidotti, T. (2002). Human factors in fire-fighting: Ergonomic, cardiopulmonary, and psychogenic stress related issues. *International Archives of Occupational and Environmental Health*, 64, 1-12.

Griffiths, M. E., Malan, L., Rooyen, J. M. V., Koekemoer, G., & Vorster, C. B. (2012). Silent ischemia is associated with subclinical atherosclerosis in African males: the sympathetic activity and ambulatory blood pressure in Africans study. *Clinical and Experimental Hypertension*, 34(5), 363-369.

Groenewald, P., Vos, T., Norman, R., Laubscher, R., Van Walbeek, C., Saloojee, Y., Sitas, F. and Bradshaw, D. (2007). Estimating the burden of disease attributable to smoking in South Africa in 2000. *South African Medical Journal*, 97, 674-681.

Haddock, C. K., Jitnarin, N., Poston, W. S., Tuley, B., & Jahnke, S. A. (2011). Tobacco use among fire-fighters in the central United States. *American journal of industrial medicine*, 54(9), 697-706.

Haider, A. W., Larson, M. G., Franklin, S. S., & Levy, D. (2003). Systolic blood pressure, diastolic blood pressure, and pulse pressure as predictors of risk for congestive heart failure in the Framingham Heart Study. *Annals of Internal Medicine*, 138(1), 10-16.



Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., & Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*, 116(9), 1081.

Heir, T., Erikssen, J., & Sandvik, L. (2011). Overweight as predictor of long-term mortality among healthy, middle-aged men: a prospective cohort study. *Preventive medicine*, 52(3), 223-226.

Henderson, N. D., M. W. Berry and T. Matic 2007, "Field measures of strength and fitness predict fire-fighting performance on physically demanding tasks." *Personnel Psychology*, 60, 431-473.

Hertz, R., Unger, A., McDonald, M., Lustik, M., & Biddulph-Krentar, J. (2004). The impact of obesity on work limitations and cardiovascular risk factors in the U.S. workforce. *Journal of Occupational and Environmental Medicine*, 46, 1196-1203. doi: 0.1097/01.jom.0000147222.53729.1e

Holmer, I., and Gavhed, D. (2007). Classification of metabolic and respiratory demands in fire-fighting activity with extreme workloads. *Applied Ergonomics*, 38, 45-52.

Hu, G., Jousilahti, P., Antikainen, R., Katzmarzyk, P., & Toomilehto, J. (2010). Joint effects of physical activity, body mass index, waist circumference, and waist to hip ratio on the risk of heart failure. *Circulation*, 121, 237-244.

Hubert, H., Feinleib, M., & McNamara, P. (1983). Obesity as an independent risk factor for cardiovascular disease: A 26- year follow-up of participants in the Framingham heart study. *Circulation*, 67, 968-976.

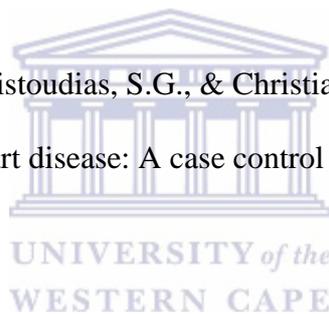
Ingelsson, E., Sullivan, L. M., Murabito, J. M., Fox, C. S., Benjamin, E. J., Polak, J. F., & D'Agostino, R. B. (2007). Prevalence and prognostic impact of subclinical cardiovascular disease in individuals with the metabolic syndrome and diabetes. *Diabetes*, 56(6), 1718-1726.

Jitnarin, N., Poston, W. S. C., Haddock, C. K., Jahnke, S., & Tuley, B. C. (2013). Accuracy of body mass index–defined overweight in fire fighters. *Occupational medicine*, 63(3), 227-230.

Johnson, R.B (2013). Cardiovascular risk factors at St. George Fire Protection District. Doctoral dissertation, The University of Alabama at Birmingham.

Kahn, K. (2011). Population health in South Africa: Dynamics over the past two decades. *Journal of Public Health Policy*, 32(1), S30-S36.

Kales, S.N., Soteriades, E.S., Christoudias, S.G., & Christiani, D. (2003). Fire-fighters and on-duty deaths from coronary heart disease: A case control study. *Environmental Health*, 2, 2-14.



Kales, S.N., Soteriades, E.S., Christophi, C.A., & Christiani, D.C. (2007). Emergency duties and deaths from heart disease among fire-fighters in the United States. *New England Journal of Medicine*, 356, 1207-1214.

Kales, S. N., Tsismenakis, A. J., Zhang, C., & Soteriades, E. S. (2009). Blood pressure in fire-fighters, police officers, and other emergency responders. *American journal of hypertension*, 22(1), 11-20.

Kannel, W., & McGee, D. (1979). Diabetes and cardiovascular disease. The Framingham study. *The Journal of the American Medical Association*, 241, 2035-2038.

Kannel, W. (1996). Blood pressure as a cardiovascular risk factor: Prevention and treatment. *Journal of the American Medical Association*, 275, 1571-1576.

Kay, B., Lund, M., Taylor, P., & Herbold, N. (2001). Assessment of fire-fighters cardiovascular disease- related knowledge and behaviors. *Journal of the American Dietetic Association*, 101, 807-809.



Kelley, G. A., Kelley, K. S., & Franklin, B. (2006). Aerobic exercise and lipids and lipoproteins in patients with cardiovascular disease: a meta-analysis of randomized controlled trials. *Journal of cardiopulmonary rehabilitation*, 26(3), 131.

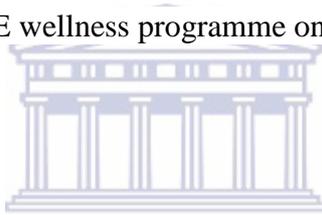
Kitchen, E. A. (2012). An assessment of cardiovascular risk factors and dietary intake in fire-fighters. Doctoral dissertation, Kent State University.

Klein, S., Allison, D. B., Heymsfield, S. B., Kelley, D. E., Leibel, R. L., Nonas, C., & Kahn, R. (2007). Waist circumference and cardiometabolic risk: a consensus statement from shaping America's health: Association for Weight Management and Obesity Prevention; NAASO, the Obesity Society; the American Society for Nutrition; and the American Diabetes Association. *Obesity*, 15(5), 1061-1067.

Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., & Lancet Physical Activity Series Working Group. (2012). The pandemic of physical inactivity: global action for public health. *Lancet*, 380(9838), 294-305.

Krakoff, L. R., Gillespie, R. L., Ferdinand, K. C., Fergus, I. V., Akinboboye, O., Williams, K. A., & Pepine, C. J. (2014). 2014 hypertension recommendations from the eighth joint national committee panel members raise concerns for elderly black and female populations. *Journal of the American College of Cardiology*, 64(4), 394-402.

Kuehl, K. S., Elliot, D. L., Goldberg, L., Moe, E. L., Perrier, E., & Smith, J. (2013). Economic benefit of the PHLAME wellness programme on fire-fighter injury. *Occupational medicine*, 63(3), 203-209.



Kumada, M., Kihara, S., Sumitsuji, S., Kawamoto, T., Matsumoto, S., Ouchi, N., & Nakamura, T. (2003). Association of hypoalbuminemia with coronary artery disease in men. *Arteriosclerosis, thrombosis, and vascular biology*, 23(1), 85-89.

Laaksonen, D. E., Lakka, H. M., Salonen, J. T., Niskanen, L. K., Rauramaa, R., & Lakka, T. A. (2002). Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. *Diabetes care*, 25(9), 1612-1618.

Labadarios, D., Steyn, N. P., & Nel, J. (2011). How diverse is the diet of adult South Africans?. *Nutrition journal*, 10(1), 1.

Lakka, H. M., Salonen, J. T., Tuomilehto, J., Kaplan, G. A., & Lakka, T. A. (2002). Obesity and weight gain are associated with increased incidence of hyperinsulinemia in non-diabetic men. *Hormone and metabolic research*, 34(09), 492-498.

Lanigan, J., Barber, S., & Singhal, A. (2010). Prevention of obesity in preschool children. *Proceedings of the Nutrition Society*, 69(02), 204-210.

Lim, D. K., Baek, K. O., Chung, I. S., & Lee, M. Y. (2014). Factors related to sleep disorders among male fire-fighters. *Annals of occupational and environmental medicine*, 26(1), 11.

Lee, D. J., Fleming, L. E., Gomez-Marín, O., & LeBlanc, W. (2004). Risk of hospitalization among firefighters: The national health interview survey, 1986–1994. *American journal of public health*, 94(11), 1938-1939.



Lee, D. J., LeBlanc, W., Fleming, L. E., Gómez-Marín, O., & Pitman, T. (2004). Trends in US smoking rates in occupational groups: the National Health Interview Survey 1987–1994. *Journal of Occupational and Environmental Medicine*, 46(6), 538-548

Levenson, J. W., Skerrett, P. J., and Gaziano, M. (2002). Reducing the global burden of cardiovascular disease: the role of risk factors. *Preventive Cardiology*, 5, 188-199.

Lewington, S., Whitlock, G., Clarke, R., Sherliker, P., Emberson, J., Halsey, J., & Collins, R. (2008). Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-

analysis of individual data from 61 prospective studies with 55000 vascular deaths (vol 370, pg 1829, 2007). *Lancet*, 372(9635), 292-292.

Lewis, A. (2014). Gripes over fire-fighter fitness test 'not true'. Independent Online. Retrieved from <http://www.iol.co.za/news/south-africa/westerncape-gripes-over-fire-fighter-fitness-test-'not-true'> October 2014.

Lloyd-Jones, D., Adams, R., Carnethon, M., De Simone, G., Ferguson, T. B., Flegal, K., & Haase, N. (2009). Heart disease and stroke statistics—2009 update a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation*, 119(3), e21-e181.



Lopez, A. D., Mathers, C. D., Ezzati, M., Jamison, D. T. and Murray, C. J. L. (2006). Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet*, 367, 1747-57.

Lim, D. K., Baek, K. O., Chung, I. S., & Lee, M. Y. (2014). Factors related to sleep disorders among male fire-fighters. *Annals of occupational and environmental medicine*, 26(1), 11.

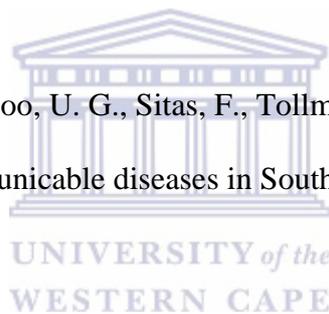
Mabry, L., Elliot, D. L., MacKinnon, D. P., Thoemmes, F., & Kuehl, K. S. (2013). Understanding the durability of a fire department wellness program. *American Journal of Health Behavior*, 37(5), 693-702.

Mahan, K.L., & Escott-Stump, S. (2008). Krause's food and nutrition therapy (12th ed.). Philadelphia: Saunders Elsevier.

Manning, J.E., & Griggs, T.R. (1983). Heart rates in fire-fighters using light and heavy breathing equipment: similar near-maximal exertion in response to multiple workload conditions. *Journal of Occupational Medicine*, 25, 215-218.

Mark, D. B., Van de Werf, F. J., Simes, R. J., White, H. D., Wallentin, L. C., Califf, R. M. and Armstrong, P. W. (2007). Cardiovascular disease on a global scale: defining the path forward for research and practice. *European Heart Journal*, 28, 2678-2684.

Mayosi, B. M., Flisher, A. J., Lalloo, U. G., Sitas, F., Tollman, S. M. and Bradshaw, D. (2009). The burden of non-communicable diseases in South Africa. *Lancet*, 374 (9693), 934-947.



Mayosi, B. M., Lawn, J. E., Van Niekerk, A., Bradshaw, D., Karim, S. S. A., Coovadia, H. M., & Lancet South Africa team. (2012). Health in South Africa: changes and challenges since 2009. *Lancet*, 380(9858), 2029-2043.

McArdle, W. D., Katch, F. I. and Katch, V. L. (2001). *Exercise Physiology: Energy, Nutrition, and Human Performance*. Fifth edition. Lippincott, Williams & Wilkins, Philadelphia.

McDonald, M., Hertz, R. P., Unger, A. N., & Lustik, M. B. (2009). Prevalence, awareness, and management of hypertension, dyslipidemia, and diabetes among United States adults

aged 65 and older. *Journal of Gerontology Series A: Biological Sciences and Medical Sciences*, 64(2), 256-263.

McGill, H. C., McMahan, C. A. and Zieske, A. W. (2000). Associations of coronary heart disease risk factors with the intermediate lesion of atherosclerosis in youth. The pathobiological determinants of atherosclerosis in youth (PDAY) research group. *Arteriosclerosis, Thrombosis and Vascular Biology*, 20(8), 1998-2004.

Mia, L. (2016). SA Fire-fighters In Canada To Face Heat In Disciplinary Hearing.
<http://ewn.co.za/2016/06/10/SA-fire-fighters-in-Canada-to-face-disciplinary-hearing>

Michaelides, M. A., K. M. Parpa, L. J. Henry, G. B. Thompson and B. S. Brown 2011, Assessment of physical fitness aspects and their relationship to fire-fighters' job abilities. *Journal of Strength and Conditioning Research*, 25(4), 956-965.

Mier, C. M., & Gibson, A. L. (2004). Evaluation of a treadmill test for predicting the aerobic capacity of fire-fighters. *Occupational Medicine*, 54(6), 373-378.

Mittleman, M. A. (2007). Air pollution, exercise, and cardiovascular risk. *New England Journal of Medicine*, 357(11), 1147-1149.

Mokdad, A. H., Ford, E. S., Bowman, B. A., Dietz, W. H., Vinicor, F., Bales, V. S. and Marks, J. S. (2003). Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *Journal of the American Medical Association*, 289, 76-9.

Mozumdar, A., & Liguori, G. (2010). Persistent increase of prevalence of metabolic syndrome among U.S adults: NHANES III to NHANES 1999-2006. *Diabetes care*, 31(1), 216 – 219. Doi:10.2337/dc10-0879

Mukamal, K.J., Chen, C.M., Rao, S.R., & Breslow, R.A. (2010). Alcohol consumption and cardiovascular mortality among U.S. adults, 1987 to 2002. *Journal of the American College of Cardiology*, 55, 1328-1335. doi:10/1016/j.jacc.2009.10.056

Murray, C. J. L. and Lopez, A. D. (1997b). Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. *Lancet*, 349, 1436-42

Nagaya, T., Yoshida, H., Takahashi, H., & Kawai, M. (2006). Policemen and fire-fighters have increased risk for type 2 diabetes mellitus probably due to their large body mass index: A follow-up study in Japanese men. *American Journal of Industrial Medicine*, 49, 30-35. Doi: 10.1002/ajim.20238

Nainggolan, L. (2011). CRP, other biomarkers, not clinically useful to predict cardiovascular disease risk. <http://www.medscape.com/viewarticle/705124>

National Fire Protection Association. Fire statistics, U.S. fire service. (Accessed June 15, 2015, at <http://www.nfpa.org/categoryList.asp?categoryID=955&URL=Research%20&%20Reports/Fire%20statistics/Fire%20service>.)

National Fire Protection Association. (2006). NFPA 1582, Standard on comprehensive occupational medical program for fire departments. National Fire Protection Association.

Navas-Nacher, E. L., Colangelo, L., Beam, C., and Greenland, P. (2001). Risk factors for coronary heart disease in men 18 to 39 years of age. *Annals of Internal Medicine*, 134, 433-439.

Nghiem, H.T. (2007). Raised blood pressure and BMI in midlife predicts heart failure in later life. from <http://www.medscape.com/viewarticle/563680?src=mp>

Norcross, J. C., Krebs, P. M., & Prochaska, J. O. (2011). Stages of change. *Journal of clinical psychology*, 67(2), 143-154.



Norman, R., Bradshaw, D., Schneider, M., Pieterse, D. and Groenewald, P. (2006). Revised burden of disease estimate for the comparative risk factor assessment, South Africa 2000. Cape Town: Medical Research Council (MRC).

Norman, R., Bradshaw, D., Steyn, K., Gaziano, T. and the South African Comparative Risk Assessment Collaborating Group. (2007). Estimating the burden of disease attributable to High Cholesterol in South Africa in 2000. *South African Medical Journal*, 97, 708-715.

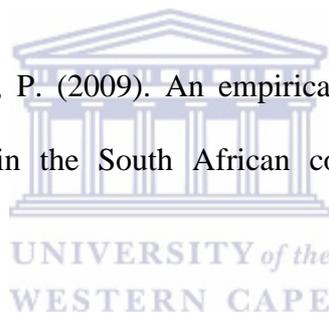
O'Donnell C.J., & Elousa, R. (2008). Cardiovascular risk factors-Insights from Framingham Heart Study. *Revista Espanola De Cardiologia.*, 61(3), 299-310.

O'KEEFE, L. C. (2013). Obesity, Prediabetes, and Perceived Stress in Municipal Workers. Doctoral dissertation, The University of Alabama at Birmingham.

Olafiranye, O., Akinboboye, O., Mitchell, J. E., Ogedegbe, G., & Jean-Louis, G. (2013). Obstructive sleep apnea and cardiovascular disease in blacks: a call to action from the Association of Black Cardiologists. *American heart journal*, 165(4), 468-476.

Onat, A., Avci, G. S., Barlan, M. M., Uyarel, H., Uzunlar, B., and Sansoy, V. (2004). Measures of abdominal obesity assessed for visceral adiposity and relation to coronary risk. *International Journal of Obesity and Related Metabolic Disorders*, 28(8), 1018

Oosthuizen, R. M., & Koortzen, P. (2009). An empirical investigation of job and family stressors amongst fire-fighters in the South African context. *SA Journal of Industrial Psychology*, 33(1), 49-58.



Pascual, J., Rodilla, E., Costa, J., Perez-Lahigüera, F., Gonzalez, C., Lurbe, E., & Redon, J. (2009). Body weight variation and control of cardiovascular risk factors in essential hypertension. *Blood Pressure*, 18, 247-254.

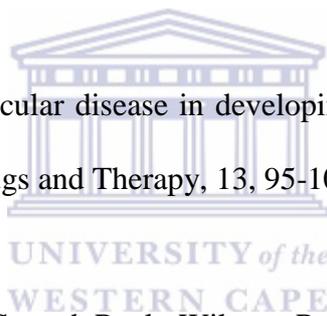
Pasternak, R. C., Abrams, J., Greenland, P., Smaha, L. A., Wilson, P. W. F. and Houston-Miller, N. (2003). Identification of coronary heart disease risk: is there a detection gap? *Journal of the American College of Cardiology*, 41(11), 1863-1874.

Pearson, T., Blair, S., Daniels, S., Eckel, R., Fair, J., Fortmann, S., Franklin, B., Goldstein, L., Greenland, P., Gundy, S., Hong, Y., Miller, N., Lauer, R., Ockene, I., Sacco, R., Sallis, J., Smith, S., Stone, N., & Taubert, K. (2002). AHA guidelines for primary prevention of

cardiovascular disease and stroke: 2002 update: Consensus panel guide to comprehensive risk reduction for adult patients without coronary or other atherosclerotic vascular diseases. *Circulation*, 106, 38-391. doi: 10.1161/01.CIR.0000020190.45892.75

Pearson, T., Mensah, G., Alexander, W., Anderson, J., Cannon, R., Criqui, M., Fadl, Y., Fortmann, S., Hong, Y., Myers, G., Rifai, N., Smith, S., Taubert, K., Tracy, R., & Vinicor, F. (2003). Markers of inflammation and cardiovascular disease: Application to clinical and public health practice: A statement for healthcare professionals from the Centers for Disease Control and Prevention and the American Heart Association. *Circulation*, 107, 499-511. doi: 10.1161.01.CIR.0000052939.59093.45

Pearson, T. A. (1999). Cardiovascular disease in developing countries: myths, realities, and opportunities. *Cardiovascular Drugs and Therapy*, 13, 95-104



Pearson, T. A., Smith, Jr., S. C. and Poole-Wilson, P. (1998). Cardiovascular specialty societies and the emerging global burden of cardiovascular disease: a call to action. *Circulation*, 97, 602-604.

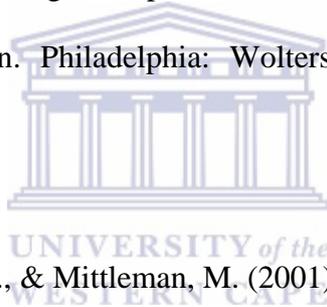
Pederson, D. and Gore, C. (1996). Anthropometry Measurement Error (Chapter 3). In K. Norton and T. Olds (eds.). *Anthropometrica*. University of New South Wales Press, Sydney.

Peer N, Bradshaw D, Laubscher, R, Steyn K. (2009). Trends in adult tobacco use from two South African Demographic and Health Surveys conducted in 1998 and 2003. *South African Medical Journal*. 2009;99(10):744-9.

Peer, N., Steyn, K., Lombard, C., Lambert, E. V., Vythilingum, B., & Levitt, N. S. (2012). Rising diabetes prevalence among urban-dwelling black South Africans. *PloS one*, 7(9), e43336.

Perk, J., De Backer, G., Gohlke, H., Graham, I., Reiner, Ž., Verschuren, M., & Deaton, C. (2012). European Guidelines on cardiovascular disease prevention in clinical practice (version 2012). *European heart journal*, 33(13), 1635-1701.

Pescatello, L. S., & American College of Sports Medicine. (2014). *ACSM's guidelines for exercise testing and prescription*. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins Health.



Peters, A., Dockery, D., Muller, J., & Mittleman, M. (2001). Increased particulate air pollution and the triggering of myocardial infarction. *Circulation*, 103, 2810-2815. doi: 10.1162/01.CIR.103.23.2810

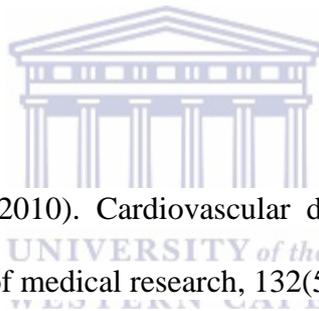
Peterson, M. D., Dodd, D. J., Alvar, B. A., Rhea, M. R., and Favre, M. (2008). Undulation training for development of hierarchial fitness and improved firefighter job performance. *Journal of Strength and Conditioning Research*, 22(5), 1683-1695.

Phillips, M., Payne, W., Lord, C., Netto, K., Nichols, D., & Aisbett, B. (2012). Identification of physically demanding tasks performed during bushfire suppression by Australian rural fire-fighters. *Applied ergonomics*, 43(2), 435-441.

Pischon T, Boeing H, Hoffmann K. (2008). General and abdominal adiposity and risk of death in Europe. *New England Journal Med.* 2008 Nov 13;359(20):2105-20.

Poston, W. S., Haddock, C. K., Jahnke, S. A., Jitnarin, N., Tuley, B. C., & Kales, S. N. (2011). The prevalence of overweight, obesity, and substandard fitness in a population-based firefighter cohort. *Journal of Occupational and Environmental Medicine*, 53(3), 266-273.

Poston, W. S., Haddock, C. K., Jahnke, S. A., Jitnarin, N., & Day, R. S. (2013). An examination of the benefits of health promotion programs for the national fire service. *BMC Public Health*, 13(1), 1.



Prabhakaran, D., & Yusuf, S. (2010). Cardiovascular disease in India: lessons learnt & challenges ahead. *Indian journal of medical research*, 132(5), 529.

Prasad, D.S., Kabir, Z., Dash, A.K., & Dab, B.C. (2009). Smoking and cardiovascular health: A review of the epidemiology, pathogenesis, prevention and control of tobacco. *Indian Journal of Medical Sciences*, 63, 520-533.

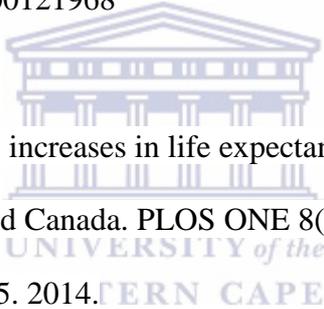
Prezant, D. J., Weiden, M., Banauch, G. I., McGuinness, G., Rom, W. N., Aldrich, T. K., & Kelly, K. J. (2002). Cough and bronchial responsiveness in fire-fighters at the World Trade Center site. *New England Journal of Medicine*, 347 (11), 806-815.

Reddy, S. P., Panday, S., Swart, D., Jinabhai, C. C., Amosun, S. L. and James, S. (2003). Umthenthe Uhlaba Usamila – The South African Youth Risk Behaviour Survey 2002. Cape Town: South African Medical Research Council. from <http://www.mrc.ac.za/healthpromotion/reports.htm>.

Risavi, B. L., & Staszko, J. (2016). Prevalence of Risk Factors for Coronary Artery Disease in Pennsylvania (USA) Fire-fighters. *Prehospital and disaster medicine*, 31(01), 102-107.

Rossi, R. (2003). Fire-fighting and its influence on the body. *Ergonomics*, 46, 1017-1033. doi: 10.1080/0014013031000121968

Samji, H. (2014). Closing the gap: increases in life expectancy among treated HIV-positive individuals in the United States and Canada. *PLOS ONE* 8(12): e81355. Doi:10.1371/journal.pone.0081355. 2014.



Sarwar, N., Gao, P., Seshasai, S. R., Gobin, R., Kaptoge, S., Di Angelantonio, E & Stehouwer, C. D. (2010). Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. *LANCET*, 375(9733), 2215-2222.

Satran, D., Henry, C., Adkinson, C., Nicholson, C., Bracha, Y., & Henry, T. (2005). Cardiovascular manifestations of moderate to severe carbon monoxide poisoning. *Journal of the American College of Cardiology*, 45, 1513-1516.

Scanlon, P., & Ablah, E. (2008). Self-reported cardiac risk and interest in risk modification among volunteer fire-fighters: A survey based studies. *Journal of the American Osteopathic Association*, 108, 694-698.

Schmidt, C. (2012). Association between physical fitness and job performance in South African Fire-fighters Masters dissertation, University of Kwa-Zulu Natal

Schutte, A. E., Schutte, R., Huisman, H. W., Van Rooyen, J. M., Fourie, C. M., Malan, N. T., & Towers, G. W. (2012). Are behavioural risk factors to be blamed for the conversion from optimal blood pressure to hypertensive status in Black South Africans? A 5-year prospective study. *International journal of epidemiology*, 41(4), 1114-1123.

Sebregts, E. H. W. J., Falger, P. R. J. and Bär, F. W. H. M. (2000). A Review. Risk factor modification through nonpharmacological interventions in patients with coronary heart disease. *Journal of Psychosomatic Research*, 48, 425-441.

Seedat, Y. K., Croasdale. M. A., Milne, F. J., Opie, L. H., Pinkney-Atkinson, V. J., Rayner, B. L., Veriava, Y. and Joint National Hypertension Guideline Working Group. (2006). South African Hypertension Guidelines. *South African Medical Journal*, 96, 337-362.

Sharma, M., & Ganguly, N. K. (2014). Burden of cardiovascular diseases in Indians: Estimating trends of coronary artery disease and using low cost risk screening tools. *Apollo Medicine*, 11(3), 148-156.

Shroufi, A., Chowdhury, R., Anchala, R., Stevens, S., Blanco, P., Han, T., & Franco, O. H. (2013). Cost effective interventions for the prevention of cardiovascular disease in low and middle income countries: a systematic review. *BMC Public Health*, 13(1), 1.

Siddall, A. G., Standage, M., Stokes, K. A., & Bilzon, J. L. J. (2014). Development of occupational fitness standards for the UK Fire and Rescue Services (FRS). Department for Health, University of Bath, Bath, UK.

Sitas, F., Egger, S., Bradshaw, D., Groenewald, P., Laubscher, R., Kielkowski, D., & Peto, R. (2013). Differences among the coloured, white, black, and other South African populations in smoking-attributed mortality at ages 35–74 years: a case-control study of 481 640 deaths. *Lancet*, 382(9893), 685-693.



Sivapalaratnam, S., Boekholdt, S. M., Trip, M. D., Sandhu, M. S., Luben, R., Kastelein, J. J. & Khaw, K. T. (2010). Family history of premature coronary heart disease and risk prediction in the EPIC-Norfolk prospective population study. *Heart*, 96(24), 1985-1989.

Smith, D. C., Robinson, C. S. and Myers, E. F. (1997). Incorporating a quality life and well-being instrument as an additional outcome measure of a comprehensive weight management program. *Journal of American Dietetic Association*, 97(9), 108.

Smith, D. L., Fehling, P. C., Frisch, A., Haller, J. M., Winke, M., & Dailey, M. W. (2012). The prevalence of cardiovascular disease risk factors and obesity in fire-fighters. *Journal of obesity*, 2012.

Smith, D. L., Barr, D. A., & Kales, S. N. (2013). Extreme sacrifice: sudden cardiac death in the US Fire Service. *Extreme Physiology & Medicine*, 2(1), 1.

Solana, R. S., Navarrete, J. S. G., Murillo, D. B., & Horrillo, J. M. G. V. (2013). Firefighter performance in a specific task and its relation with fitness tests. *European Journal of Human Movement*, 30, 23-35.



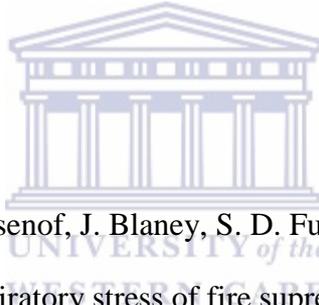
Soler, R. E., Leeks, K. D., Razi, S., Hopkins, D. P., Griffith, M., Aten, A., & Pronk, N. P. (2010). A systematic review of selected interventions for worksite health promotion: the assessment of health risks with feedback. *American journal of preventive medicine*, 38(2), S237-S262.

Soteriades, E. S., Kales, S. N., Liarokapis, D., Christoudias, S. G., Tucker, S. A., & Christiani, D. C. (2002). Lipid profile of fire-fighters over time: opportunities for prevention. *Journal of occupational and environmental medicine*, 44(9), 840-846.

Soteriades ES, Hauser R, Kawachi I, Liarokapis D, Christiani DC, & Kales SN (2005). Obesity and cardiovascular disease risk factors in fire-fighters: a prospective cohort study. *Obes Res*2005;13:1756-1763

Soteriades, E.S., Hauser, R., Kawachi, I., Christiani, D., & Kales, S. (2008). Obesity and risk of job disability in male fire-fighters. *Occupational Medicine*, 58, 245-250. doi: 0.1093/occmed/kqm153

Soteriades, E. S., Smith, D. L., Tsismenakis, A. J., Baur, D. M., & Kales, S. N. (2011). Cardiovascular disease in US fire-fighters: a systematic review. *Cardiology in review*, 19(4), 202-215.



Sothmann, M. S., K. Saupe, D. Jasenof, J. Blaney, S. D. Fuhrman and T. Woulfe (1990), Advancing age and the cardiorespiratory stress of fire suppression: Determining a minimum standard for aerobic fitness. *Human Performance*, 3, 217-236.

The Emerging Risk Factor Collaboration. (2011). Separate and combined associations of body-mass index and abdominal adiposity with cardiovascular disease: collaborative analysis of 58 prospective studies. *Lancet*, 377, 1085-95

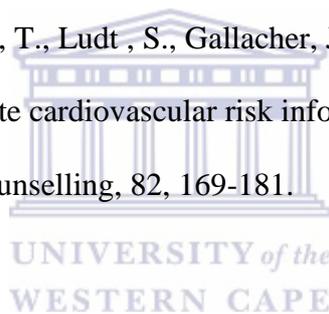
Thompson, P. D., Arena, R., Riebe, D., & Pescatello, L. S. (2013). ACSM's new preparticipation health screening recommendations from ACSM's guidelines for exercise testing and prescription. *Current Sports Medicine Reports*, 12(4), 215-217.

Thorpe, K. E. & Yang, Z. (2011). Enrolling people with prediabetes ages 60-64 in a proven weight loss program could save Medicare \$7 billion or more. *Health Affairs*, 30(9), 1673-1679. doi: 10.1377/hlthaff.2010.0944

Unal B, Critchley JA, Capewell S. (2004). Explaining the decline in coronary heart disease mortality in England and Wales between 1981 and 2000. *Circulation*. Mar9;109(9):1101-7.

Venters, H., & Gany, F. (2011). African immigrant health. *Journal of Immigrant and Minority Health*, 13(2), 333-344.

Waldron, C. A., Van der Weijden, T., Ludt, S., Gallacher, J. and Elwyn, G. (2011). What are effective strategies to communicate cardiovascular risk information to patients? A systematic review. *Patient Education and Counselling*, 82, 169-181.



World Health Organisation. (2002). World health report. Geneva: World Health Organisation, 2002.

Yang, J., Teehan, D., Farioli, A., Baur, D. M., Smith, D., & Kales, S. N. (2013). Sudden cardiac death among fire-fighters under 45 years of age in the United States. *American Journal of Cardiology*, 112(12), 1962-1967.

Yoo, H. L., & Franke, W. D. (2009). Prevalence of cardiovascular disease risk factors in volunteer fire-fighters. *Journal of Occupational and Environmental Medicine*, 51(8), 958-962.

Yusuf, S., Reddy, S., & Ôunpuu, S. (2005). Global burden of cardiovascular diseases: Part I. General considerations, the epidemiologic transition, risk factors, and impact of urbanization. *Circulation*, 104, 2746-2753.

Yusuf, S., Hawken, S., Ôunpuu, S., Bautista, L., Franzosi, M. G., Commerford, P., & Tanomsup, S. (2005). Obesity and the risk of myocardial infarction in 27 000 participants from 52 countries: a case-control study. *Lancet*, 366(9497), 1640-1649.

Yusuf, S., Reddy, S., Ôunpuu, S. and Anand, S. (2001). Global burden of cardiovascular diseases: Part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. *Circulation*, 104, 2855-2864.

Von Heimburg, E. D., Rasmussen, A. K., and Medbo J. I. (2006). Physiological response of fire-fighters and performance predictors during simulated rescue of hospital patients. *Ergonomics*, 49, 111-126.

Wolkow, A., Netto, K., Langridge, P., Green, J., Nichols, D., Sergeant, M., & Aisbett, B. (2012). Cardiovascular risk screening of volunteer fire-fighters. In *Proceedings of Bushfire Cooperative Research Centres & Australian Fire A Council 2012 Conference Research Forum* (Vol. 28).



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CONSENT FORM

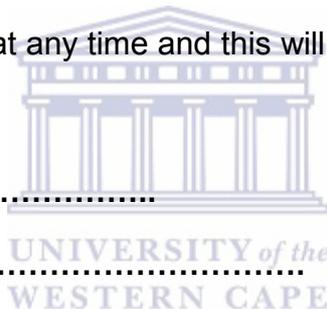
Title of Research Project: Coronary Artery Disease Risk Factors among Firefighters in the Western Cape

The study has been described to me in language that I understand and I freely and voluntarily agree to participate. My questions about the study have been answered. I understand that my identity will not be disclosed and that I may withdraw from the study without giving a reason at any time and this will not negatively affect me in any way.

Participant's name.....

Participant's signature.....

Date.....



Should you have any questions regarding this study or wish to report any problems you have experienced related to the study, please contact the study coordinator:

Study Coordinator's Name: Ghaleelullah Achmat

Cell: 083 670 5832

Email: ghaleel.achmat@gmail.com / 2542036@myuwc.ac.za

Head of Department: Prof. A. Travill

University of the Western Cape

Private Bag X17, Belville 7535

Telephone: 021- 959 2350



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INFORMATION SHEET

Project Title: Coronary Artery Disease Risk Factors among Fire-fighters in the Western Cape

What is this study about?

This is a research project being conducted by Ghaleelullah Achmat from the University of the Western Cape. We are inviting you to participate in this research project in order to establish your current possible Coronary Artery Disease (CAD) risk factors. This will give an indication of areas the individual needs to focus on in order to improve future results, as well as contributing to research which could benefit other fire-fighters in future when looking at common trends amongst fire-fighters when looking at CAD risk factors.

What will I be asked to do if I agree to participate?

You will be asked to complete a consent form before any form of information and data may be recorded. Participation may range from a mere questionnaire to participating in a Health Risk Assessment (HRA) in order to gather the relevant information. This will be done in a private area within the relevant fire houses for the convenience of those on duty. The duration of each assessment may be varied, however this will be established and communicated to the respective individuals. Questions will include information such as cigarette smoking, family history of heart disease, age and gender. Health Risk Assessments will include procedures such as taking resting blood pressure (BP), impaired fasting glucose, total cholesterol, measuring waist, hip, height and weight.

Would my participation in this study be kept confidential?

All your personal information will be kept strictly confidential. To help protect your confidentiality, we will have all assessments done in a secure, private location within the comfort of the firehouse. All recorded data will be kept confidential by replacing individuals' names with numeric codes, and saving the information within a private folder which will be reviewed only by the co-ordinator and supervisor of this research project. If we write a report or article about this research project, your identity will be protected.

What are the risks of this research?

There may be some risks from participating in this research study. Much like any activity or assessment there are risks which can be described as both expected and

unexpected. Possible expected risks of an emotional and psychological nature may include feeling self-conscious, embarrassed, or anxiety due to having fears of predicted negative outcomes. Unexpected risks include physical aspects such as increased heart rate and blood pressure and discomfort during assessments. Risks associated with finger prick blood sampling such as transferring viruses from one person to another will be prevented by using gloves when administering blood samples.

What are the benefits of this research?

The benefits to you include personal enrichment and awareness of your current risk stratification. As a fire-fighter you will be able to establish which areas of your lifestyle needs to be altered in order to maintain health and well-being as well as improve future assessment results.

Do I have to be in this research and may I stop participating at any time?

Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.

Is any assistance available if I am negatively affected by participating in this study?

If negative effects occur of a severe nature medical support will be contacted. Safety precautions will be taken to secure and the individual until medical support arrives.

What if I have questions?

This research is being conducted by Ghaleelullah Achmat from the University of the Western Cape, with the varied locations of relevant fire stations. If you have any questions about the research study itself, please contact Ghaleelullah Achmat at: 083 670 5832 / ghaleel.achmat@gmail.com / 2542036@myuwc.ac.za

Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:

Head of Department: Prof. A Travill
University of the Western Cape
Private Bag X17
Bellville 7535

This research has been approved by the University of the Western Cape's Senate Research Committee and Ethics Committee.



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PRE-TEST INSTRUCTIONS

In order to increase the validity and accuracy of the physical fitness test data, the pre-test instructions should be adhered to strictly.

1. Participant's should refrain from ingesting food, alcohol, or caffeine or using tobacco products within 3 hours of testing.
2. Participant's should be rested for the assessment, avoiding significant exercise or exercise on the day of the assessment.
3. Clothing worn for the assessment should be loose fitting to permit freedom of movement, and include running shoes. Females should bring a loose-fitting, short-sleeved blouse (top), and should avoid restrictive undergarments.
4. If you are currently on medication (for example, asthma pump), please make sure that you have it available when you report for testing, as the tests may affect you adversely. Also report to the biokineticist the last actual dose taken.
5. Candidates with any injuries or illness on the day of testing must report them to the biokineticist immediately and, if possible, schedule another appointment so as not to be unduly penalized before or during testing.
6. Drink plenty of fluids over the 24-hour period preceding the test to ensure normal hydration prior to testing.
7. Get an adequate amount of sleep (6 to 8 hours) the night before the test.

N.B: Please observe the above instructions strictly when preparing for testing, since failing to do so can have a negative impact on the outcome of your evaluations



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CORONARY ARTERY DISEASE (CAD) RISK FACTORS

(Mark with an X in the appropriate space)

Full Name: _____

- Age: ____ years (Date of Birth: _____)

Risk: No _____ Yes _____

- Family history of heart disease: Don't Know ____ No _____ Yes _____

(Myocardial infarction, coronary revascularization, or sudden death before 55 years in father or other male first-degree relative (i.e., brother or son) or before 65 years in mother or other female first-degree relative (i.e., sister or daughter))

- Cigarette smoking: No _____ Yes _____

(current cigarette smoker or those who quit within the previous 6 months)

If yes, number per day/week: _____

- Resting BP: (BP_{SYS} ____ mm Hg and BP_{DIAS} ____ mm Hg)

Risk: No _____ Yes _____

- Fasting Total Cholesterol: (total blood cholesterol ____ mmol·L⁻¹)

Risk: No _____ Yes _____

- Fasting Glucose: (blood glucose ____ mmol·L⁻¹)

Risk: No _____ Yes _____

- **Body Composition: Ht:** _____ **cm** **Wt:** _____ **kg**
 (BMI: _____ **kg·m⁻²**;
 - **Waist circumference:** _____ **cm)**
 - **Waist circumference:** _____ **(cm** **Hip**
circumference: _____ **(cm)**
- Risk: No _____ Yes _____

- **Lifestyle: (physical training/exercise/leisure/...)**

Risk: No _____ Yes _____

If yes; Frequency of training _____ **times/week)**

Intensity of training Low / Moderate / Hard

Type of training _____

Time/ Duration of training _____



Appendix E Tester Reliability Sheet



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Appendix E: Tester Reliability Form

Anthropometric Tester Reliability Form	
Tester Information	Surname
	First name
	Sex (Male=1, female=2)
	Date of Birth
	Ethnicity (B, C, I, W)

Participant Information	Surname
	First Name
	Country
	Ethnicity (B, C, I, W)
	Sex (Male=1, female=2)
	Sport
	Date of Birth

FIRST- TEST	Date of Measurement:				
	Time of Measurement:	Measure	Measure	Measure	Final
	Measurements	1	2	3	Measures
	Body mass (kg)				
	Stretch stature (cm)				
	Waist girth (min.) (cm)				
	Gluteal girth (max.) (cm)				
	Systolic Blood Pressure (mm Hg)				
	Diastolic Blood Pressure (mm Hg)				

RETEST	Date of Measurement:				
	Time of Measurement:	Measure	Measure	Measure	Final
	Measurements	1	2	3	Measures
	Body mass (kg)				
	Stretch stature (cm)				
	Waist girth (min.) (cm)				
	Gluteal girth (max.) (cm)				
	Systolic Blood Pressure (mm Hg)				
	Diastolic Blood Pressure (mm Hg)				

Appendix F Testing Preparation Checklist



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Appendix F: Testing Preparation Checklist*

Participant confirmation

Yes No

The participant has:

- | | | |
|---|--------------------------|--------------------------|
| 1. read and understood the test procedures | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. signed the consent form | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. been familiarized with the test(s) and is comfortable with it (them) | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. understood the starting and stopping procedures | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. understood the expectations before, during and after testing | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. complied with all pre-test instructions concerning: rest, food and drink, smoking, clothing and shoes. | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. confirmed being physically and psychologically ready for testing | <input type="checkbox"/> | <input type="checkbox"/> |

Tester confirmation

The tester has:

- | | | |
|--|--------------------------|--------------------------|
| 1. determined the tests to be administered | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. checked the equipment (and calibration, if required) | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. checked the recording sheets and other supplies, such as stationery, etc. | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. checked the testing area | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. understood the responsibilities clearly | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. confirmed who will be the recorder or assistant | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. understood the testing sequence | <input type="checkbox"/> | <input type="checkbox"/> |
| 8. understood and rehearsed the emergency or safety procedures | <input type="checkbox"/> | <input type="checkbox"/> |
| 9. understood the procedures before during and after testing | <input type="checkbox"/> | <input type="checkbox"/> |
| 10. controlled the testing environment to ensure an atmosphere of privacy, safety and calmness | <input type="checkbox"/> | <input type="checkbox"/> |

Comments:



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