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RESEARCH ARTICLE

Association Between Major Coronary Artery Disease Risk Factors in The City of Cape Town Firefighter and Rescue Service

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Abstract:

Background:

Many CAD risk factors occur concurrently, increasing the odds of the development of other risk factors, which is particularly seen in male and older firefighters.

Objective:

The purpose of this study was to determine the association and odds ratios between the various CAD risk factors in firefighters.

Methods:

This study used a quantitative, cross-sectional and correlational design. A total of 124 full-time firefighters, males and females, were conveniently recruited from the City of Cape Town Fire and Rescue Service. A researcher generated questionnaire was used to collect participant sociodemographic information, and all research procedures were conducted according to the ACSM guidelines. The study took place between September and November 2019.

Results:

There were significant associations between hypertension and age [$\chi^2(1) = 18.0$, $p < 0.001$, OR = 6.3 (95% CI: 2.6, 15.5)], hypertension and obesity [$\chi^2(1) = 7.9$, $p = 0.005$, OR = 3.0 (95% CI: 1.4, 6.6)], hypertension and diabetes [$\chi^2(1) = 5.1$, $p = 0.040$, OR = 4.0 (95% CI: 1.1, 14.8)], and hypertension and dyslipidaemia [$\chi^2(1) = 8.5$, $p = 0.004$, OR = 3.1 (95% CI: 1.4, 6.7)], family history and central obesity [$\chi^2(1) = 3.9$, $p = 0.04$, OR = 2.4 (95% CI: 0.9, 5.8)], and family history and central obesity [$\chi^2(1) = 3.9$, $p = 0.04$, OR = 2.4 (95% CI: 0.9, 5.8)].

Conclusion:

Increased age, central obesity, hypertension and dyslipidaemia increased the odds of developing other major CAD risk factors, which was predominantly apparent in male firefighters of mixed ethnicity. The City of Cape Town Fire and Rescue Service should emphasize the mitigation of these major CAD risk factors through education and behavioural modification, especially as male firefighters aged.

Keywords: Firefighters, Coronary artery disease risk factors, Cardiovascular, Dyslipidaemia, Cigarette smoking, Hypertension, Obesity.

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1. INTRODUCTION

Firefighting is a strenuous occupation, placing enormous workloads on the cardiovascular system. In performing their duties, firefighters are continually placed in life-threatening situations, where they are exposed to severe temperatures, and hazardous chemicals and fumes [1, 2]. Furthermore, a disconcertingly high percentage of firefighters have several CAD risk factors occurring concurrently that exacerbates the risk, not only of developing additional risk factors, but also of premature morbidity and/or mortality, especially while on duty [2 - 5]. Approximately 45% of firefighter fatalities are related to Coronary Artery (CAD) Disease Risk factors, 42% of all firefighter deaths are due to sudden cardiac death, and 39% of all firefighter deaths in the United States are due to myocardial infarctions, with many of these CAD risk factors occurring concurrently [2, 6, 7]. Previous research indicates that these concurrent CAD risk factors occur more often in male compared to female firefighters, with increasing age being a

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significant risk factor influencing the development of these disease clusters [8 - 12]. Furthermore, the literature reported significant associations between certain major CAD risk factors, with an increase in odds of these risk factors occurring concurrently, particularly obesity, hypertension, cigarette smoking and physical inactivity [3, 13 - 18]. The high prevalence of multiple CAD risk factors, and the augmenting effects of specific CAD risk factors on the development of others, in combination with the extreme temperatures, hazardous chemicals and fumes, as well as the heavy cardiovascular workloads experienced by firefighters while on duty, significantly increases the likelihood of a sudden cardiac event in firefighters [5, 6, 11, 19]. Therefore, the current study investigated the association and odds ratios between the various CAD risk factors in firefighters.

2. METHODS

This study used a quantitative, cross-sectional and correlational design. A total of 124 full-time firefighters, males and females, were conveniently recruited from the City of Cape Town Fire and Rescue Service. A researcher-generated questionnaire was used to collect sociodemographic information that included age, gender, marital status, a family history of CAD, cigarette smoking and ethnicity. The International Physical Activity Questionnaire (IPAQ) [20] was used to measure physical activity. The study took place between September and November 2019. All subjects gave their informed consent for inclusion in the study. The study protocol was approved by the Biomedical Research and Ethics Committee (BMREC) at the University of the Western Cape (Ethics reference number: BM19/4/3). The study was also granted permission by the Chief Fire Officer of the City of Cape Town Fire and Rescue Service, as well as the Director of Policy and Strategy of the City of Cape Town. All the information obtained from the participants remained confidential. No personal information of the participants will be disclosed to the Fire Department that could compromise the confidentiality of the participants. All information regarding this research is stored securely in the SRES department, with access available to the researcher and supervisor only.

2.1. Research Measures

Stature was measured using a portable stadiometer, with the participant standing barefoot on a level plastic plate with the heels together, and the heels, buttocks and upper back aligned to the stadiometer rod in the Frankfort plane [21]. Body mass was measured with the participant wearing minimal indoor clothing, and measured to the nearest 50 grams using a precision electronic scale [21]. Blood pressure was measured using a standard blood pressure sphygmomanometer and stethoscope with the appropriate cuff size. The standard auscultatory method of blood pressure measurement was used [21]. Total cholesterol and non-fasting blood glucose were measured using the finger-prick method and analysed with an AcuTrend® Plus GC meter. Waist circumference was measured at the point of the umbilicus [21], between the lower costal border and top of the iliac crest, perpendicular to the long axis of the trunk. Hip circumference was taken at the level of the greatest posterior protuberance of the buttocks. Waist and hip circumferences were measured to the nearest 0.1 cm at the end of normal expiration [22]. The cross-hand technique was used to measure all circumferences using a steel tape measure [21]. The research instruments used for data collection were calibrated, prior to testing. A minimum test-retest reliability coefficient of 0.8 was required prior to the commencement of the study, and only one tester was used in the study [22].

2.2. Analysis

All data was captured by double-entry into a Microsoft Office Excel spreadsheet and then cleaned of errors. Thereafter, it was exported to the Statistical Package for the Social Sciences (version 26) for descriptive and inferential data analysis. Firefighters were then grouped into gender, age and ethnic groups. The Chi-square test was used to determine statistically significant associations and the odds ratios between the various CAD risk factors. A p-value of less than 0.05 was used to indicate statistical significance.

3. RESULTS

The mean age of the firefighters was 37.53±9.05 years, and mean body mass and stature were 87.4±17.9 kg and 172.6±7.3 cm, respectively. The majority of firefighters were male (79.1%), with mean age, body mass and stature of 37.8±9.8 years, 87.8±18.5 kg and 174.7±6.5 cm for males, and 36.4±5.4 years, 85.9±16.2 kg and 164.8±4.5 cm for females. When all participants were arranged into age-group categories, the age-group 20-29 years represented 19.4% of the participants in the study, the age-group 30-39 years had the highest with 44.4%, the age-group 40-49 years had 24.2%, and the age-group 50-65 years had the lowest with 12.1%. The majority of firefighters were of mixed ethnicity (56.5%), followed by Black firefighters (25.8%), and then White firefighters (16.9%). For more information on the CAD risk factor prevalence's or mean values for each risk factor, please refer to the article previously published: https://doi.org/10.4081/jphr.2021.2000 .

In Table **1**, a significant association between family history and age [$\chi^2(1) = 4.17$, $p = 0.041$, OR = 2.6 (95% CI: 1.0, 6.6)], with aged firefighters 2.6 times more likely to have a positive family history of CAD. A family history was significantly associated with central obesity [$\chi^2(1) = 3.9$, $p = 0.040$, OR = 2.4 (95% CI: 0.9, 5.8)], where firefighters with central obesity were 2.4 times more likely to have a family history. There was a significant association between physical inactivity and obesity [$\chi^2(1) = 4.3$, $p = 0.038$, OR = 2.9 (95% CI: 1.0, 8.4)], with obese firefighters 2.9 times more likely to be physically inactive. There was a significant association between hypertension and age [$\chi^2(1) = 18.0$, $p < 0.001$, OR = 6.3 (95% CI: 2.6, 15.5)], hypertension and obesity [$\chi^2(1) = 7.9$, $p = 0.005$, OR = 3.0 (95% CI: 1.4, 6.6)], hypertension and central obesity [$\chi^2(1) = 7.2$, $p = 0.007$, OR = 2.9 (95% CI: 1.4, 6.2)], hypertension and WHR [$\chi^2(1) = 20.9$, $p < 0.001$, OR = 6.3 (95% CI: 2.8, 14.3)], hypertension and diabetes [$\chi^2(1) = 5.1$, $p = 0.040$, OR = 4.0 (95% CI: 1.1, 14.8)], and hypertension and dyslipidaemia [$\chi^2(1) = 8.5$, $p = 0.004$, OR = 3.1 (95% CI: 1.4, 6.7)]. The results also indicated that firefighters with hypertension were 6.3 times more likely to have age as a risk

factor, 3.0 times more likely to be obese, 2.9 times more likely to have central obesity, 6.3 times more likely to have a high WHR, 70.8 times more likely to have systolic hypertension, 5.2 times more likely to have diastolic hypertension, 4.0 times more likely to have diabetes, and 3.1 times more likely to have dyslipidaemia. There was a significant association between age and diabetes [$\chi^2(1) = 23.0$, $p < 0.001$, OR = 20.9 (95% CI: 4.2, 104.3)], age and dyslipidaemia [$\chi^2(1) = 5.3$, $p = 0.022$, OR = 2.7 (95% CI: 1.1, 6.2)], age and obesity [$\chi^2(1) = 3.9$, $p = 0.048$, OR = 2.3 (95% CI: 0.9, 5.4)] and age and WHR [$\chi^2(1) = 14.9$, $p < 0.001$, OR = 5.3 (95% CI: 2.2, 12.9)]. Aged firefighters were 20.9 times more likely to be diabetic, 5.3 times more likely to be dyslipidaemic, 2.3 times more likely to be obese, and 14.9 times more likely to have a high WHR.

Family history had a significant association with age [χ^2 (1) = 4.2, $p = 0.041$, OR = 2.8 (95% CI: 1.1, 7.6)] in male firefighters as shown in Table **2**. This indicated that family history was dependent on age in male firefighters, with aged male firefighters 2.8 times more likely to have a family history of CAD. A family history also had a significant association with obesity [$\chi^2(1) = 5.4$, $p = 0.021$, OR = 3.1 (95% CI: 1.3, 8.5)] and central obesity [$\chi^2(1) = 6.7$, $p = 0.010$, OR = 3.6 (95% CI: 1.3, 9.9)] in male firefighters. Indicating that family history was dependent on obesity, and central obesity specifically, in male firefighters, with obese male firefighters 3.1 times more likely to have family history, and males with central obesity 3.6 times more likely to have a family history of CAD. In male firefighters, there was a significant association between hypertension and age [$\chi^2(1) = 17.3$, $p < 0.001$, OR = 6.8 (95% CI: 2.6, 17.8)], hypertension and obesity[$\chi^2(1) = 10.9$, $p < 0.001$, OR = 4.4 (95% CI: 1.8, 10.9)], hypertension and central obesity [$\chi^2(1) = 7.6$, $p = 0.006$, OR = 3.5 (95% CI: 1.4, 8.9)], hypertension and WHR [$\chi^2(1) = 4.6$, $p < 0.001$, OR = 3.9 (95% CI: 1.1, 14.4)], hypertension and diabetes [$\chi^2(1) = 4.6$, $p = 0.032$, OR = 3.6 (95% CI: 1.1, 14.4)] and hypertension and dyslipidaemia [$\chi^2(1) = 85$, $p = 0.004$, OR = 3.6 (95% CI: 1.5, 8.5)]. Male firefighters who were hypertensive were 6.8 times more likely to be aged, 4.4 times more likely to be obese, 3.5 times more likely to have central obesity, 5.6 times more likely to have a high WHR, 3.9 times more likely to have diabetes, and 3.6 times more likely to have dyslipidaemia. In female firefighters, there was a significant association between hypertension and WHR [$\chi^2(1) = 7.4$, $p = 0.021$, OR = 16.8 (95% CI: 1.6, 176.2)], with females who had a high WHR also 16.8 times more likely to be hypertensive. There was a significant association between WHR and diabetes [$\chi^2(1) = 4.9$, $p = 0.004$, OR = 4.1 (95% CI: 1.1, 15.2)], in male firefighters, with male fire fighters 4.1 times more likely to have diabetes, if they had a high WHR.

Table 1. Association and odds ratio between the various CAD risk factors.

Risk Factor	Family History	Cigarette Smoking	Physical Inactivity	Hypertension	Age *(Males Only)*	Diabetes Mellitus	Dyslipidaemia
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Cigarette Smoking	1.3 (0.5 – 2.8)						
Physical inactivity	0.2 (0.0 – 1.6)	0.4 (0.1 – 1.4)					
Hypertension	1.1 (0.4 – 2.7)	0.7 (0.3 – 1.6)	1.1 (0.4 – 3.3)				
Age	2.6 (1.0 – 6.6)*	0.6 (0.3 – 1.5)	1.9 (0.7 – 5.9)	6.3 (2.6 – 15.5)**			
Diabetes Mellitus	1.5 (0.4 – 5.9)	0.6 (0.1 – 2.2)	1.5 (0.3 – 7.4)	4.0 (1.1 – 14.8)*	20.9 (4.2 – 104.3)**		
Dyslipidaemia	1.1 (0.5 – 2.7)	0.8 (0.4 – 1.9)	1.0 (0.4 – 2.9)	3.1 (1.4 – 6.7)**	2.7 (1.1 – 6.2)*	1.9 (0.5 – 6.6)	
Obesity (BMI)	2.1 (0.9 – 4.9)	0.8 (0.4 – 1.6)	2.9 (1.0 – 8.4)*	3.0 (1.4 – 6.6)**	2.3 (0.9 – 5.4)*	1.5 (0.4 – 5.3)	1.3 (6.2 – 2.7)
Central Obesity	2.4 (0.9 – 5.8)*	0.8 (0.4 – 1.8)	1.6 (0.6 – 4.5)	2.9 (1.3 – 6.2)**	2.2 (0.9 – 5.1)	0.9 (0.3 – 3.5)	1.6 (0.8 – 3.4)
Waist-to-Hip ratio	1.2 (0.5 – 2.9)	0.7 (0.3 – 1.5)	1.8 (0.6 – 4.9)	6.7 (2.8 – 14.3)**	5.3 (2.2 – 12.9)**	3.6 (09 – 13.1)	1.4 (0.7 – 2.9)

Note: * indicates statistically significant association $p < 0.05$; ** indicates statistically significant association $p < 0.01$; OR (95% CI) = odds ratio (95% confidence interval). BMI – body mass index.

Table 2. Association and odds ratios between the various CAD risk factors according to gender.

Risk Factor		Family History	Cigarette Smoking	Physical Inactivity	Hypertension	Diabetes Mellitus	Dyslipidaemia
	Gender	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Cigarette Smoking	Male	1.5 (0.6 – 3.9)					
	Female	1.3 (1.0 – 1.7)					
Physical Inactivity	Male	1.2 (1.1 – 1.3)*	0.5 (0.1 – 1.8)				
	Female	1.5 (0.1 – 18.4)	1.3 (1.0 – 1.6)				
Hypertension	Male	1.2 (0.4 – 3.3)	0.5 (0.2 – 1.1)	0.8 (0.2 – 2.9)			
	female	0.6 (0.1 – 6.8)	6.4 (0.8 – 51.8)	3.4 (0.4 – 30.7)			
Diabetes Mellitus	Male	1.4 (0.4 – 5.98)	0.4 (0.1 – 1.7)	1.5 (0.3 – 8.1)	3.9 (1.1 – 14.4)*		
	Female	0.8 (0.5 – 1.24)	1.1 (0.9 – 1.2)	1.1 (0.9 – 1.2)	-		

(Table 2) contd.....

Risk Factor		Family History	Cigarette Smoking	Physical Inactivity	Hypertension	Diabetes Mellitus	Dyslipidaemia
	Gender	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Dyslipidaemia	Male	1.4 (0.5 – 3.56)	0.8 (0.4 – 1.8)	1.2 (0.4 – 3.9)	3.6 (1.5 – 8.5)**	1.8 (0.5 – 6.3)	
	Female	0.4 (0.0 – 4.31)	1.3 (0.2 – 9.9)	0.6 (0.1 – 6.6)	1.6 (0.0 – 9.7)	-	
Obesity	Male	3.1 (1.3 – 8.5)*	1.0 (0.4 – 2.4)	2.9 (0.9 – 9.7)	4.4 (1.8 – 10.9)**	1.9 (0.5 – 6.9)	1.8 (0.8 – 4.2)
	Female	0.5 (0.1 – 3.7)	0.5 (0.1 – 3.7)	3.0 (0.3 – 33.5)	1.2 (0.2 – 6.9)	-	0.6 (0.1 – 2.9)
Central Obesity	Male	3.6 (1.3 – 9.9)*	1.2 (0.5 – 2.9)	1.6 (0.5 – 5.3)	3.5 (1.4 – 8.7)**	1.4 (0.4 – 5.3)	1.8 (0.7 – 4.3)
	Female	0.8 (0.1 – 5.6)	0.8 (0.1 – 5.6)	1.7 (0.2 – 19.4)	4.4 (0.4 – 43.7)	-	2.5 (0.4 – 15.5)
Waist-to-Hip Ratio	Male	1.7 (0.6 – 4.5)	0.6 (0.3 – 1.4)	1.8 (0.6 – 6.0)	5.6 (2.3 – 13.9)**	4.1 (1.1 – 15.2)*	1.8 (0.8 – 4.2)
	Female	0.3 (0.0 – 2.9)	2.4 (0.3 – 17.9)	1.4 (0.2 – 12.2)	16.8 (1.6 – 176.3)*	-	0.6 (0.1 – 3.0)

Note: *indicates statistically significant association $p < 0.05$; **indicates statistically significant association $p < 0.01$; OR (95% CI) = odds ratio (95% confidence interval)
- indicates no positive risk factors

A significant association was found between cigarette smoking and physical inactivity [χ^2 (1) = 5.3, p = 0.041, OR = 1.6 (95% CI: 1.1, 2.5)] in the age-group 20-29 years (Table **3**). This indicated that cigarette smoking was dependent on physical inactivity, where smokers in the age-group 20-29 years were 1.6 times more likely to be physically inactive compared to non-smokers. Furthermore, in the age-group 20-29 years, there was a significant association between a family history of CAD and central obesity [χ^2 (1) = 9.2, p = 0.032, OR = 40.0 (95% CI: 1.8, 914.8)]. A family history of CAD was dependent on WC, where firefighters in the age-group 20-29 years who had central obesity were 40.0 times more likely to have a family history of CAD.

There were no significant associations between the other age groups and the other CAD risk factors. Based on age-group, hypertension had a significant association with WHR in the age groups 30-39 years [$\chi^2(1) = 12.2$, $p < 0.001$, OR = 9.7 (95% CI: 2.4, 34.8)] and 40-49 years [$\chi^2(1) = 4.8$, p = 0.028, OR = 5.5 (95% CI: 1.2, 26.4)], with the age-group 30-39 years and the age-group 40-49 years being 9.7 times and 5.5 times more likely to be hypertensive, respectively, if they had a high WHR. In the age-group 50-65 years, there was a significant association between hypertension and dyslipidaemia [$\chi^2(1)$ = 5.5, p = 0.041, OR = 18.0 (95% CI: 1.3, 255.7)], where firefighters who had dyslipidaemia were 18.00 times more likely to be hypertensive.

Table 3. Association and odds ratios between the various CAD risk factors according to age group.

Risk Factor	-	Family History	Cigarette Smoking	Physical Inactivity	Hypertension	Diabetes	Dyslipidaemia
	Age Group (years)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	-	-	-
Cigarette Smoking	20-29	0.6 (0.0 – 7.0)					
	30-39	2.9 (0.5 – 17.4)					
	40-49	3.3 (0.63 – 16.8)					
	50-65	1.71 (1.1 – 2.8)					
Physical Inactivity	20-29	2.1 (0.2 – 29.7)	1.6 (1.1 – 2.5)*				
	30-39	1.1 (1.0 – 1.2)	2.1 (0.3 – 13.5)				
	40-49	2.0 (1.4 – 2.9)	1.1 (0.9 – 1.3)				
	50-65	1.4 (0.9 – 2.1)	0.4 (0.0 – 4.7)				
Hypertension	20-29	1.1(0.9 – 1.3)	1.2 (1.0 – 3.3)	4.5 (0.2 – 88.2)			
	30-39	0.5 (0.1 – 4.2)	0.8 (0.2 – 2.7)	0.6 (0.0 – 5.7)			
	40-49	0.6 (0.1 – 2.5)	0.7 (0.2 – 3.5)	2.2 (1.5 – 3.2)			
	50-65	2.0 (0.1 – 28.4)	0.4 (0.1 – 3.9)	0.4 (0.05 – 3.9)			
Diabetes Mellitus	20-29	-	-	-	-		
	30-39	1.0 (0.9 – 1.1)	0.9 (0.9 – 1.0)	1.0 (0.9 – 1.1)	1.0 (0.9 – 1.1)		
	40-49	0.5 (0.8 – 3.3)	0.4 (0.0 - 4.0)	1.3 (1.1 – 1.5)	7.0 (0.7 – 69.5)		
	50-65	1.5 (0.1 – 23.1)	0.6 (0.0 – 7.7)	2.7 (0.3 – 28.4)	0.8 (0.1 – 8.2)		
Dyslipidaemia	20-29	4.8 (0.3 – 78.7)	2.7 (0.2 – 34.2)	1.2 (0.9 – 1.4)	1.2 (0.9 – 1.4)	-	
	30-39	0.3 (0.0 – 2.3)	0.9 (0.3 – 2.9)	0.9 (0.1 – 6.0)	1.6 (0.5 – 5.2)	0.9 (0.9 – 1.0)	
	40-49	0.6 (0.1 – 2.6)	0.9 (0.2 – 4.5)	1.9 (1.3 – 2.6)	2.3 (0.5 – 10.0)	0.7 (0.1 – 4.3)	
	50-65	2.8 (0.2 – 40.1)	0.7 (0.1 – 5.9)	2.3 (0.3 – 20.1)	18.0 (1.3 – 255.7)*	1.2 (0.1 – 11.9)	

(Table 3) contd.....

Risk Factor	-	Family History	Cigarette Smoking	Physical Inactivity	Hypertension	Diabetes	Dyslipidaemia
	Age Group (years)	OR (95% CI)	OR (95% CI)	OR (95% CI)	-	-	-
Obesity	50-65	2.0 (0.1 – 28.4)	0.4 (0.1 – 3.9)	0.4 (0.1 – 3.9)	1.2 (0.9 – 1.4)	-	1.2 (0.9 – 1.4)
	30-39	1.0 (0.2 – 6.2)	1.5 (0.5 – 4.6)	1.4 (0.2 – 9.3)	2.9 (0.9 – 9.8)	1.5 (1.2 – 1.8)	1.2 (0.4 – 3.7)
	40-49	2.3 (0.5 – 10.1)	0.6 (0.1 – 2.9)	2.0 (1.4 – 2.9)	1.7 (0.4 – 7.3)	0.8 (0.1 – 5.1)	0.6 (0.1 – 2.4)
	50-65	0.36 (0.0 – 5.1)	0.4 (0.1 – 3.9)	6.0 (0.5 – 75.3)	2.2 (0.3 – 17.6)	0.8 (0.1 – 8.2)	1.3 (0.2 – 10.3)
Central Obesity	20-29	40.0 (1.8 – 914.8)*	2.7 (0.2 – 34.2)	2.1 (0.2 – 29.7)	4.8 (0.3 – 78.7)	-	4.8 (0.3 – 78.7)
	30-39	0.9 (0.2 – 5.7)	0.9 (0.3 – 2.8)	1.3 (0.2 – 8.5)	2.5 (0.8 – 8.5)	1.5 (1.3 – 1.9)	1.9 (0.6 – 6.1)
	40-49	2.3 (0.5 – 10.2)	0.6 (0.1 – 2.9)	2.0 (1.4 – 2.9)	1.7 (0.4 – 7.3)	0.8 (0.1 – 5.1)	0.6 (0.1 – 2.4)
	50-65	0.34 (0.0 – 5.1)	1.5 (0.2 – 13.2)	1.5 (0.2 – 13.2)	2.2 (0.3 – 17.6)	0.2 (0.0 – 2.5)	0.5 (0.1 – 3.6)
Waist-to-Hip Ratio	20-29	4.8 (0.3 – 78.7)	2.7 (0.2 – 34.2)	2.1 (0.2 – 29.7)	1.2 (0.9 – 1.4)	-	4.8 (0.3 – 78.7)
	30-39	0.5 (0.0 – 4.2)	1.1 (0.3 – 3.3)	1.7 (0.5 – 11.4)	9.2 (2.4 – 34.8)**	1.4 (1.2 – 1.7)	0.8 (0.2 – 2.6)
	40-49	0.8 (0.2 – 3.2)	0.2 (0.0 – 1.3)	2.3 (1.5 – 3.6)	5.5 (1.1 – 26.4)*	2.8 (0.4 – 18.4)	1.8 (0.4 – 7.8)
	50-65	0.7 (0.0 – 10.3)	1.7 (0.1 – 22.5)	0.4 (0.0 – 3.9)	1.2 (0.1 – 11.9)	1.1 (0.1 – 15.5)	0.2 (0.0 – 2.5)

Note: *indicates statistically significant association $p < 0.05$; **indicates statistically significant association $p < 0.01$; OR (95% CI) = odds ratio (95% confidence interval). - indicates no positive risk factors

In firefighters of mixed ethnicity, there was a significant association between a family history of CAD and age [$\chi^2(1) = 6.4$, $p = 0.020$, OR = 4.4 (95% CI: 1.3, 14.6)] (Table **4**). Aged firefighters of mixed ethnicity were 4.4 times more likely to have a family history of CAD. In firefighters of mixed ethnicity, there was also a significant association between physical inactivity and obesity [$\chi^2(1) = 3.9$, $p = 0.048$, OR = 3.7 (95% CI: 0.9, 14.1)], where physical inactivity was dependent on being obese, and obese firefighters of mixed ethnicity were 3.7 times more likely to be physically inactive. In White firefighters, there was a significant association between a family history of CAD and obesity [$\chi^2(1) = 5.5$, $p = 0.032$, OR = 10.0 (95% CI: 1.3, 78.1)] and also between a family history of CAD and central obesity [$\chi^2(1) = 5.5$, $p = 0.032$, OR = 10.0 (95% CI: 1.3, 78.1)]. The results showed that a family history of CAD was dependent on both obesity and central obesity, with White firefighters 10.0 times more likely to have a family history of CAD, if they were obese or had central obesity. There were no significant associations between ethnicity and the other CAD risk factors.

In firefighters of mixed ethnicity, there was a significant association between hypertension and age [$\chi^2(1) = 9.1$, $p = 0.003$, OR = 5.4 (95% CI: 1.7, 17.2)], between hypertension and obesity [$\chi^2(1) = 21.4$, $p = 0.006$, OR = 7.5 (95% CI: 2.6, 15.5)], between hypertension and central obesity [$\chi^2(1) = 21.4$, $p = 0.006$, OR = 4.1 (95% CI: 1.5, 11.5)], between hypertension and WHR [$\chi^2(1) = 14.1$, $p < 0.001$, OR = 7.4 (95% CI: 2.5, 21.9)], and between hypertension and dyslipidaemia [$\chi^2(1) = 7.5$, $p = 0.006$, OR = 7.5 (95% CI: 1.5, 11.3)] (Table **4**). Furthermore, firefighters of mixed ethnicity were older, obese, centrally obese, with a high WHR and dyslipidaemia, and were 5.4, 7.5, 4.1, 7.4 and 7.5 times more likely to be hypertensive, respectively.

Table 4. Association and odds ratios between the various CAD risk factors according to ethnicity.

Risk Factor	-	Family History	Cigarette Smoking	Physical Inactivity	Age	Hypertension	Diabetes	Dyslipidaemia
	Ethnicity	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Cigarette Smoking	Mixed ethnicity	0.8 (0.3 – 2.6)						
	Black	1.4 (1.1 – 1.8)						
	White	2.7 (0.4 – 16.4)						
Physical Inactivity	Mixed ethnicity	0.3 (0.0 – 2.5)	0.5 (0.1 – 1.9)					
	Black	1.2 (1.0 – 1.3)	1.2 (1.0 – 1.5)					
	White	1.2 (0.9 – 1.5)	1.1 (0.1 – 20.5)					
Age	Mixed ethnicity	4.4 (1.3 – 14.6)*	0.5 (0.1- 1.4)	1.8 (0.5 – 7.21)				
	Black	1.2 (1.0 – 1.3)	3.0 (0.4 – 25.5)	1.2 (1.0 – 1.4)				
	White	0.5 (0.1 – 3.8)	0.3 (0.0 – 2.1)	3.8 (1.8 – 8.1)				

(Table 4) contd.....

Risk Factor	-	Family History	Cigarette Smoking	Physical Inactivity	Age	Hypertension	Diabetes	Dyslipidaemia
	Ethnicity	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Hypertension	Mixed ethnicity	1.0 (0.3 – 3.2)	0.6 (0.2 – 1.7)	0.9 (0.3 – 3.7)	5.4 (1.7 – 17.2)*			
	Black	2.8 (0.2 – 49.4)	1.4 (0.3 – 7.5)	3.0 (0.4 – 25.5)	11.0 (0.9 – 125.8)			
	White	0.8 (0.1 – 5.5)	0.4 (0.1 – 3.2)	1.5 (1.1 – 1.9)	8.0 (0.9 – 66.5)			
Diabetes Mellitus	Mixed ethnicity	1.4 (0.3 – 8.0)	0.2 (0.0 – 1.8)	2.4 (0.4 – 14.3)	25.5 (2.8 – 232.1)**	5.0 (0.9 – 27.9)		
	Black	1.1 (0.9 – 1.2)	1.1 (0.9 – 1.2)	1.1 (0.9 – 1.2)	0.5 (0.2 – 1.3)	4.3 (2.2- 8.2)		
	White	1.7 (0.1 – 31.9)	0.8 (0.6 – 1.1)	1.1 (0.9 – 1.3)	2.2 (0.1 – 40.8)	1.2 (0.9 – 1.5)		
Dyslipidaemia	Mixed ethnicity	1.4 (0.4 – 4.1)	1.0 (0.4 – 2.7)	1.0 (0.3 – 3.6)	4.9 (1.5 – 15.9)**	4.1 (1.5 – 11.3)**	3.6 (0.6 – 19.8)	
	Black	1.5 (1.2 – 1.9)	0.9 (0.2 – 4.8)	0.6 (0.1 – 6.6)	0.6 (0.1 – 6.6)	1.8 (0.4 – 8.9)	2.0 (0.1 – 35.4)	
	White	0.9 (0.2 – 5.9)	0.5 (0.1 – 3.1)	1.7 (0.1 – 31.9)	1.4 (0.2 – 8.6)	2.0 (0.3 – 13.7)	1.2 (0.9 – 1.5)	
Obesity	Mixed ethnicity	1.0 (0.3 – 3.2)	1.1 (0.4 – 2.8)	3.7 (0.9 – 14.1)*	2.1 (0.7 – 6.1)	4.1 (1.5 – 11.5)**	2.5 (0.5 – 12.1)	1.4 (0.5 – 3.8)
	Black	2.3 (0.1 – 41.6)	0.5 (0.1 – 3.2)	2.5 (0.3 – 20.9)	0.7 (0.1 – 7.7)	1.1 (0.2 – 5.9)	1.5 (1.2 – 1.9)	1.4 (0.3 – 6.7)
	White	10.0 (1.3 – 78.1)*	0.4 (0.1 – 2.2)	1.4 (0.1 – 25.4)	6.3 (0.8 – 46.6)	4.0 (0.5 – 29.8)	1.4 (0.1 – 25.4)	
Central Obesity	Mixed ethnicity	1.3 (0.4 – 4.1)	1.2 (0.5 – 3.2)	2.2 (0.6 – 7.9)	1.4 (0.4 – 4.1)	4.1 (1.5 – 11.5)**	1.2 (0.2 – 5.9)	2.1 (0.8 – 5.6)
	Black	2.3 (0.1 – 41.6)	0.5 (0.1 – 3.2)	0.7 (0.1 – 7.7)	2.5 (2.9 – 20.9)	1.1 (0.2 – 5.9)	1.5 (1.2 – 1.9)	1.4 (0.3 – 6.7)
	White	10.0 (1.3 – 78.1)*	0.4 (0.1 – 2.2)	1.4 (0.1 – 25.4)	11.0 (0.9 – 125.8)	4.0 (0.5 – 29.8	1.4 (0.1 – 25.4)	
Waist-to-Hip Ratio	Mixed ethnicity	0.7 (0.2 – 2.4)	0.8 (0.3 – 2.2)	2.3 (0.6 – 8.6)	2.8 (0.9 – 8.5)	7.4 (2.5 – 21.9)**	5.0 (0.9 – 27.9)	1.4 (5.4 – 3.8)
	Black	2.8 (0.2 – 49.4)	0.65 (0.1 - 3.9)	0.8 (0.1 – 9.3)	11.0 (0.9 – 125.8)	2.9 (0.6 – 14.9)	2.8 (0.2 – 49.4)	0.9 (0.2 – 4.8)
	White	1.6 (0.3 – 9.5)	0.4 (0.1 – 2.2)	1.4 (0.1 – 25.4)	22.0 (1.9 – 260.6)	13.8 (1.2 – 156.7)*	1.4 (0.1 – 25.4)	

Note: *indicates significant association $p < 0.05$; **indicates significant association $p < 0.01$; OR (95% CI) = odds ratio (95% confidence interval).

In White firefighters, there was a significant association between hypertension and WHR [$\chi^2(1) = 23.8$, $p = 0.046$, OR = 13.8 (95% CI: 1.2, 156.7)], where White firefighters with a high WHR were 13.8 times more likely to be hypertensive. In firefighters of mixed ethnicity, there was a significant association between age and hypertension [$\chi^2(1) = 9.0$, $p = 0.003$, OR = 5.4 (95% CI: 1.7, 17.2)], age and diabetes [$\chi^2(1) = 14.7$, $p = 0.001$, OR = 25.5 (95% CI: 2.8, 232.1)] and age and dyslipidaemia [$\chi^2(1) = 7.7$, $p = 0.012$, OR = 4.9 (95% CI: 1.5, 15.9)]. In firefighters of mixed ethnicity were 9.0, 25.5 and 7.7 times more likely to be hypertensive, diabetic and dyslipidaemia, respectively, if age as a risk factor was present.

4. DISCUSSION

In the present study, there was a significant association between diabetes and hypertension, diabetes and WHR in all males, and diabetes and age in male firefighters of mixed ethnicity. Superko *et al*. [23] reported significant associations between blood glucose, increased BMI and blood pressure in firefighters. Eastlake *et al*. [24] reported elevated blood glucose was significantly associated with increased age in firefighters, where older firefighters were 1.24 times more likely to have elevated blood glucose levels. Damacena *et al*. [25] reported elevated blood glucose was significantly associated with central obesity, with firefighters being 2.94 times more likely to have central obesity if they had elevated blood glucose levels. In contrast, Soteriades *et al*. [17] reported no significant association between diabetes and other CAD risk factors in firefighters. Previous literature reported ambivalent results for diabetes and ethnicity, where some studies reported no statistical significance with regard to ethnicity and diabetes, whereas other studies reported a significant relationship between ethnicity and diabetes [10, 11, 26]. The increased odds of diabetes occurring concurrently with hypertension, older age and a high WHR can be attributed, partially, to the firefighters' variable work schedules which, in most cases, demands a maximal response when dealing with an emergency [10, 11, 26]. This, invariably, leads to increased stress, both physiological and psychological, that adversely impacts blood sugar levels [27 - 30]. In addition, the consumption of fast-

foods, high in simple sugars and saturated fats tended to be the unhealthy first choice of many firefighters that exacerbates their risk of diabetes and obesity, which is further aggravated as firefighters age and glucose homeostasis is further disrupted [7, 8, 11, 23, 29, 31].

The current study reported a significant association between physical inactivity and BMI in firefighters, where physically inactive firefighters were more likely to be obese. Baur *et al*. [32] reported that 56.9% of firefighters exercised for less than 30 minutes per session, and 16.2% exercised once or less per week. The same study also found that obese firefighters exercised less than the recommended 150 minutes per week for healthy adults, and had significantly lower cardiorespiratory fitness. Choi *et al*. [33] reported that firefighters who exercised once or less per week were significantly associated with obesity. Damacena *et al*. [25] reported that physical inactivity was significantly associated with WC in firefighters, with firefighters who had lower physical activity levels being 3.43 times more likely to have central obesity. As expected, physically inactive firefighters were at increased risk of obesity, that could be attributed to the decrease energy expenditure in combination with a diet that was high in simple sugars, saturated fats and sodium.

In the present study age increased the odds of most other modifiable CAD risk factors, especially hypertension, obesity, diabetes and dyslipidaemia. Age was significantly associated and at an increase in odds of developing a family history of CAD, obesity, WHR (central obesity), hypertension, diabetes and dyslipidaemia, especially in male firefighters of mixed ethnicity. Smith *et al*. [12] reported that as male and female firefighters aged, both genders had a significant increase in BMI, but only male firefighters had a significant increase in hypercholesterolemia, hypertension, and hyperglycaemia. Noguiera *et al*. [34] reported a similar result as the present study, and found that older age was significantly associated with BMI in firefighters, with the obese group being 7.0 times more likely to be classified as unfit. Munir *et al*. [35] reported a significant difference between firefighter BMI categories and mean age, where older firefighters had higher mean BMIs than younger firefighters. Similarly, Eastlake *et al*. [24] reported that age in firefighters had a significant association with high blood cholesterol and high blood pressure, with aged firefighters being 1.08 times and 1.06 times more likely to have elevated cholesterol and blood pressure, respectively. In contrast, Smith *et al*. [36] reported no significant association between age and the other risk factors. Perroni *et al*. [37] found significant differences between age and BMI in the age categories 25 years and younger, 26-30 years, 31-35 years, 36-40 years and 41-42 years, where older firefighters were more likely to be obese. Similarly, Damacena *et al*. [25] reported that central obesity was significantly associated with increased age in firefighters, with the age group 40-49 years being 4.9 times more likely to have central obesity, and the age group 50-59 years being 5.41 times more likely to have central obesity. Burgess *et al*. [38] reported the age group 45 years and older was significantly associated with dyslipidaemia, with aged firefighters being 3.3 times more likely to be dyslipidaemic. Poston *et al*. [26] reported that White firefighters had a higher mean age than firefighters of minority firefighters, and the former were more likely to have dyslipidaemia, hypertension and obesity. The age-related association with CAD risk factors may be attributed to a decrease in essential growth factors responsible for angiogenesis and vascular maintenance, increased inflammatory response due to aging, reduced smooth muscle elasticity and increased catabolic metabolic processes caused by a decrease in anabolic hormones, specifically, testosterone, oestrogen, and growth hormone, and reduced insulin sensitivity and cholesterol regulation [38 - 41]. All these age-related changes were associated with the increased incidence of CAD risk factors seen in firefighters, specifically obesity, hypertension and dyslipidaemia [38 - 41].

There were significant associations and increased odds of concurrence between hypertension and age, hypertension and obesity, hypertension and central obesity, hypertension and a high WHR, hypertension and diabetes and hypertension and dyslipidaemia, particularly in male firefighters. Hypertensive firefighters were at increased risk of diabetes, dyslipidaemia and obesity, especially in the older male firefighters. Soteriades *et al*. [18] reported that hypertension was significantly associated with obesity. Soteriades *et al*. [17] also reported that that hypertension was significantly associated with age (45 years and older), obesity, and elevated blood glucose levels. Burgess *et al*. [38] reported that hypertension was significantly associated with elevated LDL-C in firefighters, with hypertensive firefighters being 4.7 times more likely to be dyslipidemic. Choi *et al*. [10] reported that male firefighters were significantly associated with hypertension, and also reported that White firefighters had a higher prevalence of hypertension compared to other ethnic groups. Choi *et al*. [11] also reported that blood pressure was significantly correlated with all ethnicities, especially DBP in Hispanic firefighters and SBP in Asian firefighters. Douglas and Oraeksi [42] reported that in Nigerian firefighters, hypertension was significantly associated with being overweight and cigarette smoking. Previous research established that firefighting specific duties, such as alarm response, performing emergency duties, a disrupted sleep cycle, irregular eating patterns, and high physical and psychological stresses were all significant causes of hypertension in firefighters [27]. These factors triggered an increase in stress hormone release, specifically cortisol, which increased resting heart rate, insulin production and fat storage [27]. Duty-related stress, increased heart rate and adipose tissue accumulation that caused an increase in blood pressure, and may account for the high hypertension prevalence in firefighters [10, 27, 29].

In the current study, an increase in adiposity (obesity, central obesity, WHR) was significantly associated, with an increase in odds of developing a positive family history of CAD, physical inactivity, hypertension and age. With obese firefighters being at an increased risk of presenting as physically inactive, hypertensive and aged. Gendron *et al*. [8] reported a significant association between obesity, age and family history. Eastlake *et al*. [24] reported that BMI was significantly associated with high cholesterol in firefighters, where firefighters with increased BMI were 1.09 times more likely to have high cholesterol. Similarly, Poston *et al*. [43] reported that obesity was significantly associated with SBP,

DBP, high triglycerides and low HDL-C levels, with type I obese firefighters being 2.71 times more likely to have an elevated SBP, being 3.86 times more likely to have an elevated DBP, being 4.20 times more likely to have elevated triglyceride levels, and being 2.64 times more likely to have low HDL-C levels. Ferna *et al*. [44] reported that there was a significant difference between male and female adiposity indices, with both male and female firefighters being at risk. Ide [45] and Walker *et al*. [46] reported that obesity and age were significantly associated. In addition, central obesity was significantly associated with increased age, TC and blood glucose concentration [25]. Rahimi *et al*. [47] reported that BMI was significantly associated with age and WC in firefighters. Regarding ethnicity, Poston *et al*. [26] reported that firefighters of colour in the US had significantly higher BMIs compared to White firefighters. In contrast, studies conducted by Choi *et al*. [11, 33] reported that a higher percentage of White firefighters were obese than other ethnic groups, and that all ethnic groups were associated with obesity. A lack of knowledge in weight management, poor access to low caloric foods, a preference for fast-foods, and increased cortisol levels due to occupational-related stress were principal factors related to the obesity incidence in firefighters [25, 28, 48]. The augmenting effect of increased adiposity on other CAD risk factors can account for the increased association of firefighters being at increased risk for acquiring additional CAD risk factors related to obesity [25, 43, 48].

In the present study cigarette smoking was associated with physical inactivity in the youngest age group of 20-29 years, but was not associated with any other risk factors. Previous literature reported no significant associations between smoking and other CAD risk factors or between smokers and non-smokers and CAD risk factors [49, 50]. However, these studies indicate smokers were less likely to engage in vigorous physical activity, more likely to be drinkers, and present with symptoms of depression [49, 50]. Similar to previous literature, the present study did not find any significance between cigarette smoking, ethnicity and other CAD risk factors [26, 51, 52]. A possible explanation for the association between cigarette smoking and physical inactivity in the 20-29 years age group might be due to younger firefighters being more likely to partake in unhealthy lifestyle behaviours, as reported in previous literature, and being less mindful of their personal health and wellbeing [14, 45, 53].

In the present study dyslipidaemia was significantly associated with hypertension and age in firefighters, particularly in males, especially in the 50-65-year age-category, and those of mixed ethnicity. Cohen *et al*. [54] reported that dyslipidaemia was significantly associated with age. Damacena *et al*. [25] reported a significant association between high cholesterol and central obesity, with dyslipidemic firefighters being 1.71 times more likely to have central obesity. Burgess *et al*. [38] reported that high LDL-C was significantly associated with increased age (45-year and older) and hypertension, with older and hypertensive firefighters being 3.3 and 4.7 times more likely to have high LDL-C levels, respectively. Davis *et al*. [55] also reported that TC concentration increased with firefighter age. Soteriades *et al*. [16] reported significant associations between TC, triglyceride levels, age (45 years and older), and obesity. Similarly, Eastlake *et al*. [24] reported that high cholesterol was significantly associated with BMI and age, with aged firefighters and those who had a high BMI being 1.09 and 1.08 times more likely to have dyslipidaemia, respectively. With regard to ethnicity, inconclusive results were found for dyslipidaemia, with some studies reporting that White firefighters were associated with dyslipidaemia, and other studies reporting no significant associations between ethnicity and dyslipidaemia [11, 26, 56]. The combination of fast-food consumption, high in saturated and trans-fatty acids, and sodium, as well as the continual exposure to environmental and wildland fire smoke have been reported to cause an increase in oxidative stress and to change certain serum haematological parameters, resulting in an increase in TC concentration, increased fat accumulation, especially in the abdominal region, and hypertension, which were all further exacerbated as firefighters aged [41, 57, 58].

The significant associations and increased odds ratios between hypertension, age, obesity, central obesity and dyslipidaemia can be attributed to the synergistic relationship between these CAD risk factors, specifically influenced by an amalgamation of occupational and environmental factors related to firefighting [27, 29, 41, 59]. These factors cause increase in both physical and psychological stress, which was aggravated by the irregular sleeping patterns of firefighters, and duty-related traumatic experiences, irregular eating patterns and preference for easily accessible, high caloric foods, as well as the exposure to hazardous fumes and continual smoke inhalation in the routine performance of their duties, which were augmented as firefighters aged, and were seen predominantly in male firefighters of mixed ethnicity [27, 29, 39, 41, 59].

4.1. Strengths and Limitations

This was the first study in South Africa to report on the association and odds ratios between CAD risk factors in firefighters according to age, gender and ethnicity.

A limitation was that the study used convenient sampling that negatively impacted the external validity. Also, the relatively small sample size of 124 firefighters mandated at the outset of the study by the City of Cape Town negatively impacted the power of the study. The study was also under-represented by female participants.

4.2. Recommendations

It is recommended that future studies use random sampling that be sufficiently powered in order to ensure external validity. In addition, a more representative sample of female firefighters is recommended.

CONCLUSION

Increased age, central obesity, hypertension and dyslipidaemia increased the odds of having other CAD risk factors, that was present predominantly in male firefighters of mixed ethnicity. The City of Cape Town Fire and Rescue Service should emphasize the amelioration of these major risk factors through targeted education programmes and

behavioural modification, specifically aimed at the prevention or reduction of modifiable risk factors, such as hypertension, dyslipidaemia, and obesity, especially as firefighters aged.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was approved by the Biomedical Research and Ethics Committee (BMREC) at the University of the Western Cape, South African (Ethics reference number: BM19/4/3).

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

All subjects gave their informed consent for inclusion in the study.

AVAILIBILITY OF DATA AND MATERIALS

The data will not be made available due to the data set still being in use.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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