Original Research Article

Relationship Between Physical Activity, Coronary Artery Disease Risk Factors and Musculoskeletal Injuries in the City of Cape Town Fire and Rescue Service

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Jaron Ras[1] **and Lloyd Leach**[1]

Abstract

Musculoskeletal injuries in firefighters are a common occurrence, that increase as firefighters age, and may be related to the firefighters' physical activity habits outside of the job. Certain CAD risk factors, such as obesity, cigarette smoking and ageing may be linked to increased injury risk in firefighters. Although firefighters may meet the recommended minimum physical activity minutes, they may remain at risk for sustaining musculoskeletal injuries. Therefore, this study aims to determine the relationship between physical activity and CAD risk factors, between CAD risk factors and musculoskeletal injuries and between physical activity and musculoskeletal injuries. 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 injury, CAD risk factor and physical activity data. The proportion of firefighters who participated in leisure-time physical activity (LTPA) was 63.7%, and those who were physically inactive was 69.4%. The prevalence musculoskeletal injuries among all firefighters was 27.4%. The most prevalent musculoskeletal injury was shoulder injuries in 35.3% of firefighters, followed by multiple injuries in 26.5% and back injuries in 14.7%. Age was a significant predictor of physical inactivity in firefighters [P = .002, OR = 1.08], BMI was a significant predictor of physical inactivity [P = .050, OR = 1.08], cigarette smoking was a significant predictor of firefighters not exercising [P = .007, OR = 2.31] and the total amount of vigorous-intensity exercise was a significant predictor of musculoskeletal injuries [P = .050, OR = 1.00]. In conclusion, older firefighters were more physically inactive and had a higher prevalence of musculoskeletal injuries, and the latter decreased significantly after the age of 50 years. Emphasis should be placed on firefighters exercising in their leisure-time, especially as they aged.

Keywords

firefighters, musculoskeletal, injury, CAD, risk factor, physical activity

[1]Department of Sport, Recreation and Exercise Science, University of the Western Cape, Bellville, Western Cape, South Africa

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Corresponding Author:
Department of Sport, Recreation and Exercise Science, University of the Western Cape, Robert Sobukwe Rd, Bellville, Western Cape 7535, South Africa.
Email: jaronras@gmail.com

What do we already know about this topic?

Age, obesity and physical activity are significantly related to injuries in firefighters. Physical activity may reduce or increase injuries incidence in firefighters, depending on the overall total workload. In addition, the intensity of physical activity has been shown to be significantly related to CAD risk factors and overall injury incidence. However, these relationships are understudied and more research in the field are needed, especially in the City of Cape Town, where firefighters are understudied.

How does your research contribute to the field?

This paper adds new knowledge on physical activity habits, musculoskeletal injuries and coronary artery disease (CAD) risk factors in firefighters, in the City of Cape Town Fire and Rescue Service (CoCTFRS). In addition, this paper adds valuable knowledge to an understudied population in South Africa. The article highlights the need for behavioural education and rehabilitation in the CoCTFRS and where future research needs to be focused.

What are your research's implications toward theory, practice or policy?

This study highlights the relationship between physical activity and catalysing CAD risk factors and occupational induced workload on firefighters (in a developing country), which is likely linked to the premature morbidity, early retirement and mortality seen in this population, and can inform future policy implementation related to physical fitness and health maintenance programmes in firefighters.

Introduction

Firefighting is a strenuous occupation that places tremendous physical workloads on firefighters.[1-3] Firefighters are routinely exposed to environmental hazards that contribute to the high prevalence of musculoskeletal injury and cardiovascular disease.[1,4,5] Firefighter-specific tasks, such as equipment carries, door breaches and hose-drag cause firefighters to be at high risk of musculoskeletal injuries.[1,4,6] These tasks coupled with the environmental factors, such as severe temperatures, and hazardous terrain, cause significant fatigue, which increases the likelihood of injury.[3,6-8] Consequently, if any underlying cardiovascular or musculoskeletal disorders are present, these can lead to significant morbidity and mortality in firefighters.[1,4,5,9] Therefore, firefighters need to be in peak physical condition and in optimal health in order to prevent the occurrence of injuries and cardiovascular events.[10,11]

Current literature indicates that musculoskeletal injuries in firefighters are a common occurrence, that increase as firefighters age, and may be related to the firefighters' physical activity habits outside of the job.[1,3-5] The increase in musculoskeletal injuries as firefighters age, may be related to the progressive decrease in cardiorespiratory fitness.[1,2,4,8,12,13] Obesity is another key factor that plays a role in on-duty injuries in firefighters.[1,4,5,14] Due to increased body weight, especially fat weight, places more strain on the body's musculoskeletal structures while performing occupational tasks, that predispose firefighters to injury, especially if firefighters are not physically fit.[1,4,10] Obesity has been shown to be a significant predictor of on-duty musculoskeletal injuries and poor cardiorespiratory performance in firefighters.[15-17] Various studies report that the majority of firefighters are physical inactive outside of their occupations, which is alarming given the physically intense nature of their occupation.[18-20] Furthermore, physical inactivity is directly correlated to an increase in coronary artery disease (CAD) risk factors.[19-21] Exercise outside of work has been emphasised in firefighters to maintain their physical fitness and readiness for duty.[6,22] However, many firefighters are not participating in physical activity regularly in their leisure time, which is a cause for concern.[11,23,24]

Currently, in the City of Cape Town Fire and Rescue Service (CoCTFRS), research has indicated that a relatively small percentage of firefighters are physically inactive.[25] However, these statistics include occupational activity minutes, not leisure time activity or recreational activity only. Although firefighters may meet the recommended minimum physical activity minutes, they may remain at risk for sustaining musculoskeletal injuries.[6,8,26] This may be attributes to the strenuous nature of firefighting, the accumulation of overall weekly workload or insufficient muscular strength or endurance to cope with the stressors placed upon them.[1,6,8,14,26] In addition, if firefighters' caloric intake exceeds their physical activity levels, they remain at risk for increased adiposity, which is a risk factor for injuries, especially as firefighters ages.[27-30] It is hypothesised that, firstly, leisure time physical activity (LTPA) and physical inactivity based on recreational exercise will be significantly related to CAD risk factors musculoskeletal health. Secondly, that certain CAD risk factors such as cigarette smoking, physical inactivity and obesity will be related to musculoskeletal injuries. These results will add valuable knowledge on the necessity of firefighters to participate in physical activity recreationally, as a means to reduce CAD risk factor

development and reduce the risk of musculoskeletal injuries. In addition, these results may, potentially, inform policy changes in the CoCTFRS. Therefore, this study aims to determine the relationship between physical activity and CAD risk factors, between physical activity and musculoskeletal injuries and between CAD risk factors and musculoskeletal injuries.

Methods

Study Design and Participants

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. The demographic characteristics included were age, gender, family history of CAD, cigarette smoking, and injury type, severity and location, using a researcher-generated questionnaire. Injury type and severity was indicated based on firefighters needing medical treatment/intervention, and excluded injuries that were not medically diagnosed by a physician. The International Physical Activity Questionnaire (IPAQ)[31] was used to gather information about physical activity. The ACSM guidelines were used to categorize physically inactive firefighters, that is, individuals not participating in at least 30 minutes of moderate-intensity physical activity on at least 3 days of the week for at least 3 months, consecutively (American College of Sports Medicine, 2016, p. 27). Firefighters that exercised regularly, but did not meet the minimum recommendations for physical activity and those that did not exercise at all were categories as such.

Research Procedures

The research procedures in the current study have been repeated from a previous published article (Ras and Leach[25]). The principle researcher (Jaron Ras) performed all the physical measures and was responsible for administering the data recording sheet (questionnaire). For further information on the testing procedures followed to determine firefighter stature, body mass, blood pressure, blood glucose and cholesterol, please refer to the article that was previously published (Ras and Leach[25]). Briefly, Stature was measured using a portable stadiometer, standing barefoot and head placed in the Frankfort plane.[32] Body mass was measured with the participant wearing minimal indoor clothing, using a precision electronic scale.[32] Blood pressure was measured using a blood pressure sphygmomanometer and stethoscope, with the appropriate cuff size. The standard auscultatory method of blood pressure measurement was used.[32] Total cholesterol and non-fasting blood glucose were measured using the finger-prick method and a microcapillary blood sample analysed with an AcuTrend® Plus GC meter. Waist circumference was measured at the point of the umbilicus,[32] and hip circumference was taken at the level of the greatest posterior protuberance of the buttocks using a steel tape measure.[33] The research instruments were calibrated, prior to testing, and was assessed for accuracy by comparing the measurements to a calibrated instrument. A minimum test-retest reliability coefficient of .8 was required prior to the commencement of the study and only 1 tester was used in the study.[33]

Obesity was measured as a BMI >30 $kg \cdot m^{-2}$ or a waist circumference for men >102 cm and for woman >88 cm.[32] Hypertension was defined as a resting systolic blood pressure ≥140 mmHg or a resting diastolic blood pressure ≥90 mmHg.[26] Dyslipidemia was defined as total serum cholesterol ≥5.18 $mmol \cdot L^{-1}$.[32] Diabetes is defined as an impaired fasting glucose (IFG) of between 7.77 and 11.04 $mmol \cdot L^{-1}$ or an impaired glucose tolerance (IGT) of 11.1 $mmol \cdot L^{-1}$ or above, confirmed on at least two separate occasions.[32] A family history of heart disease was defined as myocardial infarction, coronary revascularization or sudden cardiac death before the age of 55 years in the father or other male first-degree relative, or before the age of 65 years in the mother or other female first-degree relative.[32] Physical inactivity is defined as individuals not participating in at least 30 minutes of moderate-intensity physical activity on at least 3 days of the week for at least 3 months, consecutively.[32] Age as a risk factor is defined as men ≥45 and woman ≥55, putting them at higher risk for developing CAD.[32] Cigarette smoking as a risk factor is defined as being a current cigarette smoker or those individuals who have quit smoking within the last 6 months or those individuals exposed to second-hand tobacco smoke.[32]

The study took place between September and November 2019. All subjects gave their written informed consent for inclusion before they participated in the study. The study protocol was approved by the Biomedical Research Ethics Committee (BMREC) at the University of the Western Cape (Ethics reference number: BM19/4/3). The study was also approved 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.

Analysis

All data was captured by double-entry into a Microsoft Office Excel spreadsheet, and then cleaned of errors, which involved removal of extra spaces, case and spell checking, and error removal. Thereafter, it was exported to the Statistical Package for the Social Sciences (SPSS) version 27 (https://www.ibm.com/za-en/analytics/spss-statistics-software) for descriptive and inferential data analysis. Descriptive statistics (mean, standard deviation and percentages) and inferential statistics (Kruskal Wallis H, Mann-Whitney U, Chi-squared test, and linear and binary regression) and odds ratios were performed. Nagelkerke R square value and odds ratios were used for all predictions. All assumptions required prior to performing a logistic regression analysis were met. The following assumptions were met prior to conducting the regression analysis: (1) the dependent variable was dichotomous, (2) the independent variables were continuous, (3) there were

Table 1. Prevalence of Musculoskeletal Injuries, Leisure-Time Physical Activity and Physical Inactivity in Firefighters According to Gender, Age-Group and CAD Risk Factors.

	Musculoskeletal Injuries	Leisure Time Physical Activity	Minimum PA Requirements Not met[a]	Physically Inactive
	%	%	%	%
Total Firefighters (n = 124)	27.4	63.7	33.1	69.4
Gender				
Male (n = 98)	27.6	63.3	30.6	67.3
Female (n = 26)	26.9	65.4	42.3	76.9
Age Category				
20-29 years (n = 24)	29.2	79.2	20.8	41.7
30-39 years (n = 55)	29.1	60.0	32.7	72.7
40-49 years (n = 30)	30.0	66.7	40.0	73.3
50-65 years (n = 15)	13.3	46.7	40.0	93.3
CAD risk factors				
Age (n = 29)	28.1	53.1	37.5	84.4
Hypertension (n = 41)	18.1	62.2	37.8	75.7
Diabetes (n = 11)	9.1	81.8	63.6	81.8
Dyslipidemia (n = 50)	24.0	66.0	36.0	70.0
Cigarette smoking (n = 49)	28.6	49.0	16.3	67.3
Obesity (n = 45)	23.9	54.3	37.8	82.6
Central obesity (n = 46)	26.1	52.2	36.9	84.8

[a]firefighters who exercised, but do not meet the minimum ACSM requirements for being physically active.

independence of observations and (4) there was a linear relationship between the logit transformation of the dependent variable and the continuous variable. An analysis of residuals was performed and confirmed the assumptions of linearity.

Results

The mean age of all 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 a mean age, body mass and stature of 37.8 ± 9.8 years, 87.8 ± 18.5 kg and 174.7 ± 6.5 cm, respectively, for females, mean age, body mass and stature were 36.4 ± 5.4 years, 85.9 ± 16.2 kg and 164.8 ± 4.5 cm, respectively. When all participants were separated 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 number of participants with 44.4%, the age-group 40-49 years had 24.2%, and the age-group 50-65 years had the lowest number with 12.1%. For further information on the CAD risk factor prevalence's or mean values for each risk factor, please refer to the previously published article (Ras and Leach[25]).

The proportion of firefighters who participated in leisure-time physical activity (LTPA) was 63.7%, and those who were physically inactive was 69.4% (Table 1). The proportion of male firefighters who participated in LTPA was 63.3%, while those who did not meet the minimum PA requirements was 30.6%, and who were categorized as physically inactive was 67.3%. In female firefighters, 65.4% participated in LTPA, while 42.3% did not meeting the minimum requirements for PA, and 76.9% were physically inactive. The majority (79.2%) of firefighters that participated in LTPA was in the age-group 20-29 years. The age group 30-39 years and 40-49 years had a similar percentage of LTPA and physical inactivity with 60.0% and 66.7%, and 72.7% and 73.3%, respectively. The age group 50-65 years had the lowest (46.7%) percentage of firefighters participating in LTPA and highest prevalence of physical inactivity (93.3%).

The mean occupational minutes per week for low-, moderate- and vigorous-intensity occupational physical activities (OPAs) were 1132.9 ± 641.7 minutes, 900.00 ± 406.2 minutes and 505.7 ± 497.1 minutes, respectively. The mean minutes per week total low-, moderate- and vigorous-intensity physical activity were 916.4 ± 605.1 minutes, 323.1 ± 308.0 minutes and 279.6 ± 415.8 minutes, respectively.

The prevalence musculoskeletal injuries among all firefighters were 27.4% (Table 1). In male firefighters the prevalence of musculoskeletal injuries was 27.3%. In female firefighters, 26.9% had musculoskeletal injuries. The age group 50-65 years had the lowest prevalence of musculoskeletal injury with 13.3%. According to CAD risk factors, Cigarette smokers and firefighters aged 45 years or older reported the highest prevalence of musculoskeletal injuries, with 28.6% and 28.1%, respectively. In addition, aged firefighters and those that had central obesity were the most physically inactive, with 84.4% and 84.8%, respectively. Interestingly, cigarette smokers had the lowest prevalence of

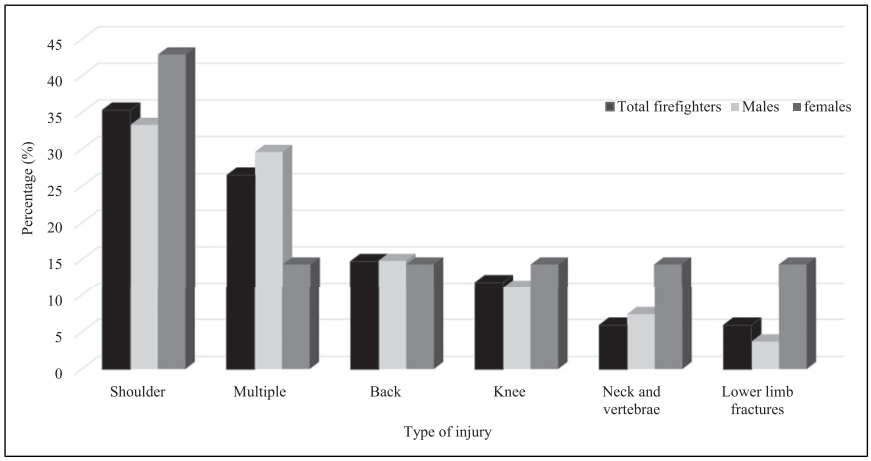

Figure 1. Prevalence of musculoskeletal injuries in firefighters according to gender.

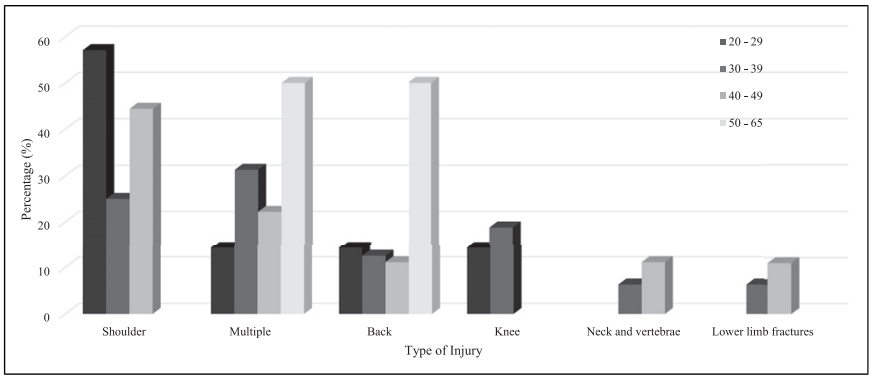

Figure 2. Prevalence of musculoskeletal injuries in firefighters according to age-group.

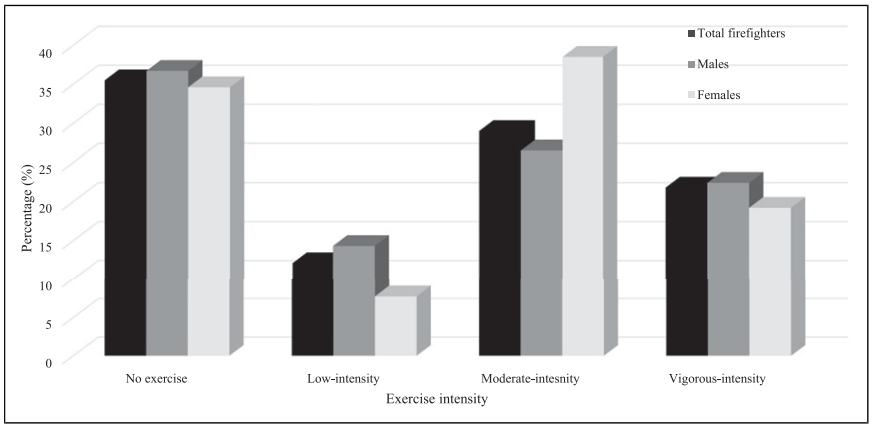

Figure 3. Physical activity intensity during leisure time among firefighters according to gender.

physical inactivity. Most firefighters participated in LTPA (49.0% to 66.0%), but 16.3% to 63.6%, depending on CAD risk factor, did not meet the minimum recommended minutes of physical activity.

In Figure 1, 35.3% of firefighters reported having a shoulder injury that was the most prevalent musculoskeletal injury in firefighters, followed by multiple injuries (defined as 2 or more concurrent injuries sustained) in 26.5%, back injuries in 14.7%, knee injuries in 11.8, neck and vertebra injuries in 5.9% and lower limb fractures in 5.9%. In male firefighters, 33.3% had shoulder injuries, 29.6 had multiple injuries, 14.8% had back injuries, 11.1% had knee injuries,

7.4% had neck and vertebra injuries and 3.7% had lower limb fractures. In female firefighters, shoulder injuries were the most common injury in 42.9%, while multiple, back, knee, neck and vertebra injuries, and lower limb fractures all had the same prevalence of 14.3%. Shoulder injuries was most prevalent in the age-group 20-29 years (57.1%) had shoulder injuries (Figure 2), in the age-group 30-39 years most (31.3%) had multiple injuries. In the age-group 40-49 years, 44.4% reported shoulder injuries, and in the age-group 50-65 years, 50% had multiple and back injuries only.

In total, the majority (35.5%) of firefighters reported not exercising at all during the week, 12.1% reported exercising at a low-intensity, 29.0% reported exercising at a moderate-intensity and 21.8% reported exercising at a vigorous-intensity (Figure 3). The mean exercise time per week for low-intensity exercise was 117.2 ± 97.5 minutes, for moderate-intensity exercise it was 175 ± 121.6 minutes and for vigorous-intensity exercise it was 291.2 ± 364.3 minutes. In male firefighters, 36.7% compared to 36.4% in female firefighters reported not exercising. Males preferred exercising at a moderate intensity with 26.5%, whereas 38.5% of females preferred exercising at a moderate intensity. However, more males exercised at vigorous intensity compared to females (22.4% vs 19.2%). In the youngest age-group 20 – 29 years, 45.8% preferred exercising at a vigorous intensity, and had the lowest proportion of firefighters that exercised at a low intensity (4.2%). In the age-group 30 – 39 years, most (40.0%) reported not exercising, and those that did exercise preferred to exercise reported exercising at a moderate-intensity (29.1%), compared to the age-group 40 - 49 years, where 33.3% reported not exercising, and 30% reported exercising at a moderate-intensity. The age-group 50 – 65 years, 53.3% reported not exercising the highest among the age groups, 26.7% reported exercising at a moderate-intensity, but none exercised at a vigorous-intensity (Figure 4).

The mean ages of the firefighters who did not exercise, and who exercised at a low-intensity, moderate-intensity and vigorous-intensity were 39.2 ± 9.6, 41.9 ± 9.5, 37.2 ± 8.2 and 32.9 ± 7.6 years, respectively, that was statistically significant (H = 11.1, P = .011) (Table 2). The mean WCs for firefighters who did not exercise, and who exercised at a low-, moderate- and vigorous-intensity were 99.4 ± 17.6, 102.7 ± 9.8, 93.8 ± 12.1 and 91.5 ± 9.9 cm, that was statistically significant (H = 11.7, P = .008).

After the Bonferroni correction, there was a statistically significant difference in between those that exercised at a vigorous-intensity and those that did not exercise (U = 23.7, P = .036), and between those exercising at a vigorous-intensity and at a low-intensity (U = 33.7, P = .018). There was a significant difference in WC between those that exercised at a vigorous intensity and at a low-intensity (U = 33.9, P = .017). There was a significant difference in WHR between those that exercised at a moderate-intensity and at a low-intensity (U = 38.9, P = .002), and between those that exercised at a vigorous intensity and at a low-intensity (U = 37.1, P = .007).

There were significant negative correlations between age and vigorous-intensity exercise (r = −.520, P = .004), and between BMI and vigorous-intensity exercise (r = −.416, P = .025) (Table 3).

Exercise in leisure-time was significantly associated with cigarette smoking [$\chi^2(1) = 7.6$, P = .006, OR = 2.9 (95% CI: 1.3, 6.1)] and central obesity [$\chi^2(1) = 4.2$, P = .040, OR = 2.2 (95% CI: 1.0, 4.7)] in firefighters (Table 4). Firefighters who exercised in their leisure-time were 2.9 and 2.2 times less likely to be cigarette smokers and have central obesity, respectively. Physical inactivity was significantly associated with age [$\chi^2(1) = 6.0$, P = .032, OR = 3.0 (95% CI: 1.1, 8.6)], obesity [$\chi^2(1) = 2.9$, P = .0014, OR = 2.2 (95% CI: 1.0, 4.7)] and central obesity [$\chi^2(1) = 8.2$, P = .004, OR = 3.7 (95% CI: 1.5, 9.3)] in firefighters. Firefighters who were physically inactive were 6.0, 2.9 and 3.7 times more likely to be aged, obese and to have central obesity, respectively. Firefighters who did not exercise were significantly associated with cigarette smoking [$\chi^2(1) = 4.9$, P = .027, OR = 2.3 (95% CI: 1.1, 4.9)]. Not meeting the minimum PA requirements for healthy adults as recommended by ACSM was significantly associated with cigarette smoking [$\chi^2(1) = 10.4$, P = .001, OR = 3.9 (95% CI: 1.7, 9.1)] and diabetes [$\chi^2(1) = 4.2$, P = .041, OR = 3.6 (95% CI: .9, 13.1)] in firefighters. Firefighters that did not meet the minimum PA requirements were 3.9 and 3.6 times more likely to be cigarette smokers and diabetic, respectively.

Binary logistic regression was performed with physical inactivity, exercise in leisure-time, not exercising and musculoskeletal injuries as the main outcome variables (Table 5). Age was a significant predictor of physical inactivity in firefighters [χ^2 (4) = 10.996, P = .002, OR = 1.08 (95% CI: 1.02, 1.14)]), and predicted 12% of the variation in firefighters who were physically inactive. Aged firefighters were 1.08 times more likely to be physically inactive than younger firefighters. After adjustment for covariates (BMI and WC), age remained a significant predictor of physical inactivity [P = .024, OR = 1.07 (95% CI: 1.01, 1.13)]). BMI was a significant predictor of physical inactivity [χ^2 (4) = 4.021, P = .050, OR = 1.08 (95% CI: 1.00, 1.17)]), and explained 5% of the variation in physical inactivity. Firefighters with increasing BMI were 1.08 times more likely to be physically inactive. After adjustment for covariates (age and WC), BMI was not a significant predictor of physical inactivity. Waist circumference was a significant predictor of physical inactivity [χ^2 (4) = 5.777, P = .019, OR = 1.04 (95% CI: 1.01, 1.07)]), and predicted 7% of the variation in physical inactivity. Firefighters with increased WC were 1.04 times more likely to be physically inactive. After adjustment for covariates, WC was not a significant predictor of physical inactivity.

Cigarette smoking was a significant predictor of firefighters exercising in their leisure-time [χ^2 (1) = 7.6, P = .007, OR = 2.86 (95% CI: 1.34, 6.12)], and predicted 7% of the variation in leisure-time exercise in firefighters. Additionally,

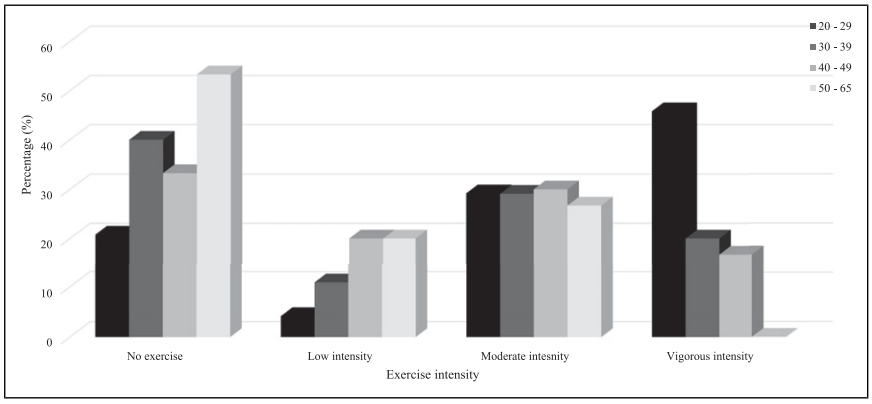

Figure 4. Physical activity intensity during leisure time among firefighters according to age group.

Table 2. CAD Risk Factor Measurements According to Exercise Intensity in Firefighters.

	Exercise Intensity				
CAD Risk Factors	No Exercise	Low	Moderate	Vigorous	
	$\overline{X}\pm$	$\overline{X}\pm$	$\overline{X}\pm$	$\overline{X}\pm$	*p*
Age	39.2 ± 9.6	41.9 ± 9.5	37.2 ± 8.2	32.9 ± 7.6	.011*
Body mass index	30.4 ± 7.4	30.4 ± 7.4	28.8 ± 4.7	27.4 ± 3.3	.111
Waist circumference	99.4 ± 17.6	102.7 ± 9.8	93.8 ± 12.1	91.5 ± 9.9	.008**
Waist-to-hip ratio	.91 ± .09	.96 ± .06	.87 ± .07	.88 ± .06	.002**
Systolic blood pressure	123.4 ± 15.5	124.9 ± 14.7	117.9 ± 14.4	121.1 ± 15.7	.246
Diastolic blood pressure	77.9 ± 10.3	80.8 ± 8.5	74.1 ± 10.9	77.2 ± 15.2	.187
Non-fasting blood glucose	5.7 ± 1.3	7.6 ± 5.3	5.5 ± 1.4	5.8 ± 1.1	.428
Total cholesterol	4.9 ± 1.0	4.7 ± 0.7	4.9 ± 0.9	5.1 ± 0.9	.734

*indicates statistically significant differences <.05; **indicates statistically significant differences <.01.

Table 3. Correlation Between Age, BMI and WC and Exercise Intensity in Firefighters.

Variable	Age	Body Mass Index	Waist Circumference
Low-intensity	−.321	.207	.047
Moderate-intensity	−.054	−.060	−.057
Vigorous-intensity	−.520**	−.416*	−.340

Table 4. The Association Between CAD Risk Factors in Firefighters, Firefighters who Exercised in Their Leisure-Time, Firefighters who were Physically Inactive, Firefighters who did not Exercise and Musculoskeletal Injuries.

Variables	Exercised in Leisure-time	Physically Inactive	Did Not Exercise	Minimum PA Requirements Not met	Musculoskeletal Injuries
	OR (95% CI)	OR (95% CI)	OR (95% CI)		OR (95% CI)
Age	1.8 (.8 – 4.1)	3.0* (1.1 – 8.6)	.6 (.3 – 1.3)	1.1 (.5 – 2.6)	.9 (.4 – 2.3)
Obesity	1.9 (.9 – 4.0)	2.9* (1.2 – 7.2)	.6 (.3 – 1.2)	.8 (.4 – 1.7)	1.3 (.6 – 3.1)
Central obesity	2.2* (1.0 – 4.7)	3.7** (1.5 – 9.3)	.5 (.2 – 1.0)	.8 (.4 – 1.7)	1.1 (.5 – 2.5)
Diabetes	.3 (.1 – 1.8)	.5 (.1 – 2.3)	2.9 (.6 – 13.9)	3.6* (.9 – 13.1)	.2 (.0 – 1.9)
Dyslipidemia	.8 (.4 – 1.7)	1.0 (.6 – 2.3)	1.2 (.5 – 2.4)	.9 (.5 – 2.0)	.7 (.3 – 1.7)
Hypertension	1.1 (.5 – 2.4)	.6 (.3 – 1.5)	.9 (.4 – 2.1)	.9 (.4 – 1.9)	.5 (.2 – 1.3)
Cigarette smoking	2.9** (1.3 – 6.1)	1.2 (.5 – 2.5)	2.3* (1.1 – 4.9)	3.9** (1.7 – 9.1)	.9 (.4 – 2.0)

*indicates statistically significant association <.05; **indicates statistically significant association <.01. OR (95% CI) = odds ratio (95% confidence interval.

Table 5. Binary Logistic Regression to Predict Physical Inactivity, Exercise in Leisure-Time, Firefighters who did not Exercise and Musculoskeletal Injuries in Firefighters.

	Crude					Adjusted				
	B	*df*	R^2	P Value	Or (95% CI)	*B*	*df*	R^2	P Value	Or (95% CI)
Model: Physical inactivity										
Age	.079	1	.12	.002**	1.08 (1.03 – 1.14)	.066	1	.13	.024*	1.07 (1.01 – 1.13)
Body mass index	.800	1	.05	.050*	1.08 (1.00 – 1.17)	.000	1	.13	1.000	1.00 (.84 – 1.19)
Waist circumference	.037	1	.07	.019*	1.04 (1.01 – 1.07)	.017	1	.11	.650	1.02 (.95 – 1.09)
Model: Exercise in leisure-time										
Cigarette smoking	1.052	1	.07	.007**	2.86 (1.34 – 6.12)	1.251	1	.13	.002**	3.49 (1.56 – 7.82)
Model: Did not exercise										
Cigarette smoking	.838	1	.05	.028*	2.31 (1.09 – 4.89)	1.005	1	.10	.012*	2.73 (1.24 – 6.00)
Model: Musculoskeletal injuries										
Total vigorous-intensity exercise	.001	1	.05	.050*	1.00 (1.00 – 1.00)	.001	1	.06	.066	1.00 (1.00 – 1.00)

*indicates statistical significance <.05, **indicates statistical singificance <.01, *B*: Beta coefficient, *df*: degree of freedom, R^2: Nagelkerke R square value, OR (95% CI) = odds ratio (95% confidence interval).

cigarette smokers were 2.86 times more likely not to exercise in their leisure-time compared to non-smokers. After adjustment for covariates (age, BMI and WC), cigarette smoking was a significant predictor of exercise in leisure-time (P = .002; OR = 3.49 (95% CI: 1.56, 7.82).

Cigarette smoking was a significant predictor of firefighters who did not exercise [χ^2 (1) = 8.74, P = .028, OR = 2.31 (95% CI: 1.09, 4.89)], and predicted 5% of the variation in firefighters who did not exercise. Firefighters who, smoked were 2.31 times more likely not to exercise. After adjustment for covariates (age, BMI, WC), cigarette smoking was a significant predictor of firefighters who did not exercise (P = .012; OR = 2.73 (95% CI: 1.24, 6.00).

The total amount of vigorous-intensity exercise (in minutes) was a significant predictor of musculoskeletal injuries [χ^2 (1) = 3.99, P = .050, OR = 1.00 (95% CI: 1.00, 1.00)], and predicted 5% of the variation in musculoskeletal injuries in firefighters. After adjustment for covariates (age, BMI, WC), total vigorous-intensity exercise was not a significant predictor of musculoskeletal injuries. Indicating that aging and body composition influence injury rates in firefighters when they engage in high amounts vigorous-intensity exercise.

Discussion

The present study aimed to determine the relationship between physical activity and CAD risk factors and between physical activity and musculoskeletal injuries in firefighters. The authors hypothesised that LTPA and physical inactivity will be significantly related to CAD risk factors and musculoskeletal health in firefighters. The hypothesis proved to be true in the current study, where a decrease in LTPA and physical inactivity was significantly related to ageing, obesity and cigarette smoking. These results have been consistent with previous research.[11,34-36] In addition, total weekly physical activity minutes was significantly related to musculoskeletal injuries in firefighters which may be attributed to increased overall workload.[1,2,6,14,37] Overall the injury prevalence in the current study is much lower than previous studies.[1,4,6,12,26,37-39] This may be attuited to the current study only considering injuries that were medically diagnosed by a physician, and not subjectively reported, only.

In the present study, the prevalence of musculoskeletal injuries (27.4%) was similar across genders, lowest in the oldest age category (50-65 years) and highest in cigarette smokers. Younger firefighters were generally healthier and were more physically active. However, injury prevalence was similar among the youngest age group (20-29 years) and two middle aged groups (30-39 and 40-49 years). In addition, musculoskeletal injuries were most prevalent in firefighters who were cigarette smokers and were aged. Yoon et al[1] reported a lower prevalence of injuries in 11.66% of firefighters, and that the injuries increased between the ages of 20 and 39 years. In addition, the study reported that former smokers had a significantly higher injury prevalence compared to non-smokers.[1] Cigarette smoking has been linked to reduced tendon health,[40] and with younger firefighters found to have a higher prevalence of cigarette smoking,[25,41-45] can explain why this age range was at most risk. In contrast, Negm et al[3] reported that older firefighters were significantly more likely to have more severe lower-extremity disability and more severe back disability. This may be attributed to the difference in age in the sample between the current study and Negm et al (37.5 vs 42.6 years). There was a trend, in the current results, that as firefighters aged, injuries to the low back became more prevalent, which may be attributed to age related vertebrae and intervertebral disk degeneration.[46,47] Similarly, Nazari et al[5] reported that older firefighters were significantly more likely to have musculoskeletal injuries. The increased musculoskeletal injury prevalence may be accounted for by the age-related decline in soft tissue size and strength, and reduced bone mineral density, which

significantly predisposes individuals to injury, particularly when subjected to repeated high workloads, such as firefighting.[3,5,9,48] An explanation for the similarity of injury prevalence between age-groups in the present study could be due to younger firefighters participating in more vigorous-intensity exercise compared to older firefighters,[4] which have been known to predisposed individuals to injury due to chronic overload.[35,48,49]

In the present study, the most common injury was shoulder injuries (35.3%), which was particularly prevalent in females and the youngest age-group (20-29 years) of firefighters. Neck, vertebra and lower limb fractures were the least prevalent injuries. Vaulerin et al[4] reported that ankle injuries were the most prevalent in 77% of French firefighters. Shoulder injuries was the second most prevalent in 23% of firefighters. The study indicated physical activity was related to increased injuries, which may explain the concentration to the ankle region, due to chronic overuse or fatigue to the surrounding musculature.[4] In the present study, most ankle injuries were not reported as a single musculoskeletal injury and were often reported together with other musculoskeletal injuries. In contrast, Frost et al[6] reported that the most common location of injury was the back (32%), followed by the knees (17%), ankles (15%) and shoulders (13%). The authors attributed the distribution of injuries to a variation in external factors, such as the distribution of on-duty responsibilities, community demographics and climate. Similarly, Nazari et al[5] reported that back (32%) injuries were the most prevalent injury in Canadian firefighters, followed by shoulder (24%) injuries as the second most common injury location. In the present study, back injuries were the third most prevalent musculoskeletal injury, in 14.7% of firefighters. In addition, Nazari et al[5] reported that the overall incidence of injuries among male and female firefighters were similar, with only neck and knee injuries having a prevalence greater than 5% in males compared to females. Moreover, the study reported that the injury incidence increased as firefighters aged.[5] Soteriades et al[50] reported that the most frequent musculoskeletal injuries by location were back (26%), followed by the shoulder (20.6%), neck (18.5%), upper extremities (10.3%), upper back (9.4%) and ankle (5.5%). These studies indicate that similarities in injury locations exist, where the low back and shoulder regions are the more frequently injured areas. These locations may be due to many firefighting duties being related to repetitive upper body movements requiring high force production, such as hose drags, door breaches, victim drags or carries, especially when firefighters are active outside of working hours.[4,6,14,26,38]

In the present study, the prevalence of physical inactivity was unacceptably high (69.4%), and was similar across both genders, and increased as firefighters aged. As with the present study, Seyedmehdi et al[51] reported that an unacceptably high number (67.4%) of firefighters were not physically active. Similarly, Eastlake et al[52] also reported a high prevalence of physical inactivity in 62% of firefighters. A lower prevalence of physical inactivity were reported by Martin et al[20] and Durand et al[11] where the studies indicated that 45.9% and 49% of firefighters were physical inactive. This is supported by Amodeo and Nickelson[53] who reported that 46.7% of firefighters were physically inactive, and 14% did not participate in any moderate-intensity exercise. As with the present results, firefighters do participate in physical activity, but tended to only exercise at a low-intensity or exercised infrequently. Porto et al[54] reported that 34.2% of firefighters were not physically active while on-duty, and that 15.4% of off-duty firefighters were not physically active. High physical activity levels while on duty have been shown to reduce work performance and increased fatigue, which may explain firefighters' reluctance to be physically active on duty.[55,56] The results of the study indicated male firefighters engaged in more vigorous-intensity exercise than female firefighters, and had a lower prevalence of physical inactivity, particularly in the youngest age-group (20-30 years) of firefighters. Similarly, Gendron et al[57,58] reported that fewer females were physically inactive (62%) compared to 70% of male firefighters. In contrast, another study reported that a higher proportion of female firefighters were physically inactive compared to males.[59] In the present study, the oldest age-group (50-65 years) of firefighters had the highest prevalence of not exercising and not engaging in vigorous-intensity exercise. Punakallio et al[60] reported that in the two firefighter age groups (30 – 34 and 40 – 44 years, respectively), the younger age-group of firefighters had a higher frequency of participating in physical activity (PA), that is, 3 or more times per week (61% vs 55%), and exercised at a higher intensity (27 vs 12%). As firefighters age, their proclivity toward physical activity decreases. Punakallio et al also reported physical inactivity was significantly associated with an increase in musculoskeletal injuries. Potentially, younger firefighters found that the overall workload of exercising off-duty and performing their firefighting tasks when on duty tolerable. This could be explained by younger firefighters having a higher work capacity, better overall recovery, and a lower body mass.[49,61,62] In the present study, 35.5% of firefighters did not exercise, and 33.1% of firefighters who did exercise, did not meet the minimum requirements for physical activity, which was more prevalent in females and as firefighters aged. Similarly, Soteriades et al[50] also reported a high prevalence of physical inactivity among firefighters, where 37.2% reported exercising 1-2 times per week, and 16.7% reported never exercising. The prevalence of inactivity increased as firefighters aged, which was likely as a result of the physical stress of firefighting especially among older firefighters and caused a lack in motivation to exercise.[11,23,59,63]

In the present study, physical inactivity was found to be a significant predictor of ageing, increased BMI and WC in firefighters. Choi et al[18] reported that leisure-time activity was significantly associated with BMI and WC. Similarly, Damacena et al[64] reported that central obesity was more

likely in firefighters who had low PA levels. Gendron et al[65] reported that there was a significant difference in WC and obesity in firefighters who trained while on duty than those who did not. Although firefighters remain active while on duty, because they are not exercising at a moderate-to-high-intensity they do not receive the additional benefits of increased energy expenditure associated with fat loss.[11,35,65] The current results indicated that cigarette smoking was a significant predictor of engaging in leisure-time exercise. This may be due to firefighters acknowledging the harmful effects of cigarette smoking on their overall health and engaging in regular physical activity as a positive lifestyle change.[41,66-68] Overall, the majority of firefighters engaged in PA in their leisure-time. However, this did not relate to a decrease in the prevalence of physical inactivity. As stated by Muegge et al[59] many firefighters reported that they were not educated about physical activity, which may explain why many firefighters were physically active, but this did not translate into lower physical inactivity. The results indicated that younger male firefighters were more likely to engage in PA in their leisure-time, which decreased as they aged. Similarly, Muegge et al[59] reported that more male firefighters met the minimum recommendations for PA in healthy adults compared to female firefighters (72.4% vs 65.3%). Punakallio et al[60] reported that less firefighters exercised regularly in their leisure time in the age-group 40 – 44 years, compared to the age-group 30 – 34 years (82.6% vs 64.3). The prevalence of physical inactivity was unacceptably high in the present study, and poses a significant risk from a personal and public safety point of view. The likely reason for firefighters exercising, but not meeting the minimum PA recommendations, may be due to firefighters not being educated in daily PA recommendations and not having access to exercise opportunities.[59] The promotion of PA in firefighters' leisure-time, as a method to reduce the prevalence of physical inactivity, especially as firefighters aged, should be emphasized.[11,51,52,63] This may be especially important in firefighters in the CoCTFRS, where it has been shown that firefighters tended to adopt a negative attitude toward physical activity as they aged.[30]

The CAD risk factors that clustered around physical inactivity were obesity, age and diabetes. In addition, significant differences were found between the firefighters' exercise habits in their leisure-time and age, WC and WHR, where increased exercise-intensity was negatively correlated with each of these variables. Similar, Barry et al[34] reported that vigorous intensity activity was significantly related to WC in firefighters. Vigorous intensity activity has been related to increased energy expenditure and subsequent fat loss.[11,35] Durand et al[11] reported that blood glucose concentrations were highest in the age-group that exercised the least, supporting the current results. Regular physical activity aids in regulating blood glucose homeostasis and maintains insulin sensitivity.[69,70] In contrast to the results of the present study, Yu et al[35] reported that there was a significant relationship between level of physical activity and bodyfat percentage in firefighters, but no other risk factor. However, this may be related to the cohort of firefighters, where very few firefighters had CAD risk factors present, thus, not providing enough statical power to indicate significance. Seyedmehdi et al[51] reported that aerobic fitness decreased with increased cardiovascular disease risk factors, particularly age, BMI, low-density lipoprotein cholesterol and blood pressure. Exercise has been known to increase high-density lipoprotein cholesterol and decrease triglyceride and blood glucose concentrations.[71-73] This may account for the improvement in blood parameters as firefighters regularly exercised.

The total amount of vigorous-intensity exercise per week in firefighters, both in leisure-time and on-duty, was a significant predictor of musculoskeletal injuries in firefighters. Yoon et al[1] reported that there was no difference in injuries between firefighters who exercised less than 3 days per week compared to those who exercised more than 3 days per week. In contrast, the results of Soteriades et al[50] supported the present study, where it found that exercise in leisure-time had a dose-response relationship that was inversely related to musculoskeletal injuries, where more physically active firefighters were less likely to sustain musculoskeletal injuries. The majority of studies reported that physical activity does reduce injuries in firefighters, however, an excess of physical activity may predispose firefighters to injury.[43,62,74,75] The association between increased injuries and the total amount of weekly vigorous-intensity exercise may be due to the progressive increasing weekly workload, resulting in chronic fatigue and/or overuse and, eventually, acute injuries.[4,6]

Strengths and Limitations

This study provides valuable information on the PA habits in firefighters and injury prevalence in firefighters in the CoCTFRS, and the relationship between CAD risk factors and musculoskeletal injuries. To the best of the authors' knowledge, this was the first study conducted in the CoCTFRS to report on the relationship between musculoskeletal injuries, PA and CAD risk factors according to demographic characteristics. A limitation was that the study used convenient sampling that negatively impacted the external validity. Also, the relatively small sample size negatively impacted the power of the study. The study was also under-represented by female participants. Lastly, all injuries and PA were self-reported and were not objectively measured by the researcher, which could have resulted in under-or-overestimation of PA and injuries, particularly in those firefighters who are unfit, obese and at increased cardiovascular risk.

Conclusion

Older firefighters were more physically inactive and had a higher prevalence of musculoskeletal injuries, and the latter decreased significantly after the age of 50 years. The most prevalent injury was shoulder injuries, especially in female firefighters. Increased age, BMI, WC and cigarette smoking were significant predictors of the PA habits of firefighters.

The total amount of vigorous-intensity exercise per week was a significant predictor of musculoskeletal injuries in firefighters. Emphasis should be placed on firefighters exercising in their leisure-time, especially as they aged. In addition, firefighters who participated in vigorous-intensity physical activity in leisure time, while off-duty, should be monitored for their overall workload and recovery, as this could predispose them to injury while on-duty.

Recommendations

For future studies, it is recommended that researchers use random sampling and that the studies are sufficiently powered in order to ensure external validity. In addition, a more representative sample of female firefighters, and that objective measure of musculoskeletal injuries and PA be conducted.

Declaration of Conflicting Interests

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Data Availability

The captured data contains confidential information on firefighters that cannot be made publicly available as part of the agreement with the City of Cape Town Fire and Rescue Service. Only the researchers directly involved in the study, ie, Jaron Ras and Lloyd Leach, have access to this data. If researchers require the data, requests should be submitted to the corresponding author (Jaron Ras: jaronras@gmail.com), where permission will then be requested from the City of Cape Town Fire and Rescue Service and upon signing a data access agreement in compliance with the City of Cape Town data regulations.

ORCID iD

Jaron Ras https://orcid.org/0000-0002-7915-4883

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