Proceedings of Bushfire CRC & AFAC 2012 Conference Research Forum
28 August, 2012
Perth Convention & Exhibition Centre

Edited by
R.P. Thornton & L.J. Wright

Published by:
Bushfire Cooperative Research Centre
Level 5 340 Albert Street
East Melbourne 3002 Australia

Citation: R. P. Thornton & L.J. Wright (Ed) 2013, 'Proceedings of Bushfire CRC & AFAC 2012 Conference Research Forum' 28 August 2012, Perth Australia, Bushfire CRC

Welcome from Editors

It is our pleasure to bring to you the compiled papers from the Research Forum of the AFAC and Bushfire CRC Annual Conference, held in the Perth Exhibition and Convention Centre on the 28th of August 2012.

These papers were anonymously referred. We would like to express our gratitude to all the referees who agreed to take on this task diligently. We would also like to extend our gratitude to all those involved in the organising, and conducting of the Research Forum.

The range of papers spans many different disciplines, and really reflects the breadth of the work being undertaken, The Research Forum focuses on the delivery of research findings for emergency management personnel who need to use this knowledge for their daily work.

Not all papers presented are included in these proceedings as some authors opted to not supply full papers. However these proceedings cover the broad spectrum of work shared during this important event.

The full presentations from the Research Forum and the posters from the Bushfire CRC are available on the Bushfire CRC website www.bushfirecrc.com.

Richard Thornton and Lyndsey Wright

June 2013

ISBN: 978-0-9806759-6-2

Cardiovascular risk screening of volunteer firefighters

Alexander Wolkow [1, 2], Kevin Netto [1], Peter Langridge [3], Jeff Green [3], David Nichols [2, 3], Michael Sergeant [4] and Brad Aisbett [1, 2,]*

[1] Centre for Exercise and Sports Science, Deakin University, Burwood, Australia.

[2]Bushfire Co-operative Research Centre, East Melbourne, Australia.

[3]Country Fire Authority, Burwood East, Australia.

[4]Public Health Management, Melbourne, Australia.

.

Abstract

Background: The work demands involved in firefighting place significant stress on the cardiovascular system. This study investigated the application of the AHA/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire in volunteer Country Fire Brigade (CFA) firefighters. **Methods:** Cardiovascular disease (CVD) risk factors were measured in 3777 CFA firefighters and entered into a modified version of the American Heart Association (AHA)/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire to stratify individuals as low, moderate or high risk. **Results:** Just over half (50.8%) of female and more than two thirds (68.2%) of male CFA firefighters were classified as moderate risk. The questionnaire further stratified 2.6% of female and 5.2% of male CFA firefighters as high risk while the remaining 46.6% and 26.6% of female and male firefighters, respectively, were classified as low risk. **Conclusion:** The majority of firefighters screened were at moderate risk and therefore, would be advised by AHA/ACSM guidelines to undertake and pass a detailed medical examination and a medically supervised exercise test prior to initiating vigorous intensity physical activity. However, considering the financial and practical implications (e.g., reduced emergency response capacity) the introduction of mandatory screening may cause, fire agencies should focus screening for high risk personnel only, while promoting agency wide CVD health education.

Keywords: Cardiovascular disease; risk factors; preparticipation; firefighting; screening

Introduction

Firefighting involves periods of moderate-intensity work interspersed with irregular bursts of high-intensity work performed in a potentially hazardous environment (i.e., extreme heat and carbon monoxide exposure; National Institute for Occupational Safety and Health 2007). The physical and environmental demands associated with firefighting place significant stress on the cardiovascular system. Indeed, acute myocardial infarction are a significant risk for firefighters (Balady *et al.* 1998; Kales *et al.* 2007). Furthermore, cardiovascular disease (CVD) related deaths are the leading cause of on-duty death among firefighters in the United States of America (USA; Kales *et al.* 2007). The majority of these deaths occur in firefighters with a higher prevalence of CVD risk factors or pre-existing CVD (Kales *et al.* 2007). The precipitation of acute cardiac events for personnel with pre-existing CVD risk factors performing hard work (Balady *et al.* 1998; Thompson *et al.* 2007) have compelled firefighting associations in the USA to devise mandatory medical screening strategies to protect the health and safety of firefighting personnel (National Fire Protection Association 2007). Such strategies have proven to accurately identify volunteer firefighters (Gaetano *et al.* 2007), soldiers (Flynn *et al.* 2009) and emergency medical service (EMS) personnel (Gaetano *et al.* 2007) at high risk of adverse work-related cardiac events. Moreover, screening strategies have proven successful in motivating emergency service personnel to seek further health care services (Gaetano *et al.* 2007; Flynn *et al.* 2009). Although effective, the existing emergency service based screening and stratification research is limited to only a few USA based studies.

In contrast to the USA, no national CVD-related mortality data exists for the ~ 250,000 volunteer and career Australian firefighters who protect people and property from a range of natural and manmade disasters. Recently, however, we have shown that Country Fire Authority (CFA; Victorian) volunteer firefighters have similar risk factor profiles to age-matched Australian population norms which lead to an absolute CVD risk greater than that documented for emergency service workers in other countries (Wolkow *et al.* in press). Despite similar occupational demands and on-duty CVD risk (Kales *et al.* 2007) volunteer firefighter recruits may not be subject to the same stringent health-related employment procedures as their paid counterparts (Fahy 2005). For instance, paid Australian firefighters are required to meet minimum pre-employment health standards to become an active firefighter (Country Fire Authority 2012). Without routine screening measures in place for volunteer firefighters, personnel with multiple CVD risk factors and therefore, at high risk of on-duty CVD related events are less likely to be identified.
The introduction of health screening and stratification adds to routine health and safety costs for the respective fire agency. Therefore, to reduce costs it is important the selection of any health screening tool be both time-efficient and accurately identify individuals at high risk (Sharkey and Davis 2008). To aid in correctly selecting a cost effective screening tool prior to large-scale application, it is important to trial the screening intervention on a small sample with an analyses of consequence. Such an evaluation can provide quantitative data to show the effect the screening tool has on participants (e.g., the number of people screened at high risk), from which associated financial costs can be determined (e.g., cost of further medical testing and evaluation etc; Sharkey and Davis 2008).

The physical work-rates involved in firefighting would be considered ‘moderate’ to ‘very-hard’ by the physical activity intensity classifications endorsed by the American College of Sports Medicine (ACSM; American College of Sports Medicine 2009; Balady *et al.* 1998). Moreover, the physical work intensities associated with firefighting are comparable to those required when performing exercises such as vigorous weightlifting and circuit training (e.g., push-ups, pull-ups and sit-ups; Ainsworth *et al.* 1993). Given the comparable physical demands and established cardiovascular risks associated with both intense firefighting and exercise related activities, the application of an exercise based preparticipation screening and stratification device could aid in the protection of volunteer firefighters from on-duty CVD-related risks. Indeed, screening and stratification strategies have proven to accurately identify health and fitness facility members at heightened risk of an adverse CVD event occurring during physical exertion (Shephard *et al.* 1991; Sharkey and Davis 2008). The American Heart Association (AHA)/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire is among the most widely used and recognised preparticipation screening measures (Balady *et al.* 1998). This device uses CVD history, symptoms and risk factors to stratify individuals according to a certain level of risk (i.e., low, medium and high) prior to participation in low to high-intensity exercise (American College of Sports Medicine 2009). Although the effectiveness of the AHA/ACSM questionnaire in reducing CVD has not been investigated directly, this device uses evidence-based risk factor guidelines established by the National Cholesterol Education Program (NCEP). Furthermore, the AHA/ACSM questionnaire is a time-efficient and easily applied tool, and therefore potentially suited for application to large firefighting populations such as the CFA (i.e., 58,000 volunteer members; Country Fire Authority 2009). To the author’s knowledge, only one study overseas (Gaetano *et al.* 2007) and no studies in Australia have investigated the application of CVD risk screening among firefighters. Therefore, by applying a time and cost-efficient CVD screening tool (i.e. AHA/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire), this study aims to assess the cardiovascular health of a volunteer firefighter population and determine those who present with low, moderate and high CVD risk. Furthermore, this study aims to provide an insight into the usefulness of this particular screening tool among firefighters and contribute to an evidence-base from which agencies can make informed decisions regarding further implementation of CVD risk screening.

Methods

Participants

In total, this descriptive cross-sectional study evaluated 3777 volunteer CFA firefighters (3011 males, 766 females). The study cohort represented a convenience sample of volunteer firefighters drawn from Victorian CFA brigades. Following an expression of interest, research staff travelled to each of the participating fire brigade locations and provided on-site CVD risk factor measurement services. Research staff also recruited volunteer firefighters at non-emergency firefighting championships (The Urban and Rural Firefighting Championships). To be eligible for inclusion, participants had to be a volunteer CFA firefighter aged between 18 to 74 years and had fasted for six hours prior to the assessment. Participation in this study at both non-emergency events and individual brigades was voluntary and signed written informed consent from each participant was obtained prior to data collection. All procedures were approved by the Deakin University Human Research Ethics Committee prior to commencing the study.

Cardiovascular Disease Risk Factor Measurement and Collection

Each participant had their waist circumference (WC) measured, and body mass index (BMI) calculated from height (cm) and body mass (kg) measurements. For each of these anthropometric measurements, participants had their shoes and any heavy clothing and/or personal accessories (i.e., wallet, mobile phone, CFA pager etc.) removed. Firefighters' resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using an automatic blood pressure (BP) cuff (Microlife 3AC1-1PC, Microlife Corporation, Switzerland). Participants then provided a fingertip blood sample for analysis of; low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) and blood glucose. Participants were required to fast for a minimum of six hours prior to providing the blood sample. In contrast, a 10-to 12-hour fast was used in other studies which investigated similar CVD risk factors among USA firefighters (Byczek *et al.* 2004; Swank *et al.* 2000). As CFA firefighters can be on-call 24 hours a day, the authors felt it was unrealistic to insist on an extended fast, thus a shortened fasting period was adopted. Previous studies have demonstrated no significant difference in HDL-C (Emberson *et al.* 2002) and only minimal difference in mean LDL-C (- 0.2 $mmol \cdot L^{-1}$) between fasting and non-fasting values (Langsted *et al.* 2008). Therefore, it is unlikely the shortened fasting period had a major impact on these risk factor measurements. Nevertheless, glucose levels have been observed to continue to fall beyond six hours of fasting (Emberson *et al.* 2002). As a result, the number of CFA firefighters identified with impaired fasting glucose (IFG) may be slightly elevated.

The blood sample was obtained using a disposable lancing device (Accu-Chek Safe-T-Pro Plus, Roche Diagnostics, Australia), from which 35 µL of whole blood was collected with a capillary tube (Cholestech LDX Capillary Tube, Hayward, CA). The blood sample was analysed on-site using the Cholestech LDX (Cholestech Corporation, Hayward, CA) device to determine the amount of LDL-C, HDL-C and glucose in the blood sample. The Cholestech LDX point-of-care testing (POCT) device has been used to assess blood lipids and glucose among both USA rural firefighters (Gaetano *et al.* 2007) and Victorian rural community residents (Shephard *et al.* 2005). The device has been validated in reference to classification standards for total cholesterol, triglyceride and HDL-C (Bard *et al.* 1997; Shemesh *et al.* 2006) and the analytical performance of this device has been recently validated in Australian rural community settings (Shemesh *et al.* 2006; Shephard *et al.* 2005).

Following the collection of BP, blood lipids and glucose data, each participant entered their results and personal data (i.e., age, sex, family history of CVD, diagnosed type 1 or 2 diabetes, smoking and exercise habits) into an online database. It should be acknowledged that contrary to AHA/ACSM risk factor classification criteria (American College of Sports Medicine 2009), both BP and blood glucose results in the current study were taken from one-off measurements, and as such, are not a diagnosis of hypertension or IFG, respectively

(Table I). An actual medical diagnosis of hypertension or diabetes is based on multiple measurements taken on several occasions (American College of Sports Medicine 2009). Furthermore, AHA/ACSM risk factor criteria classify individuals as hypertensive and/or dyslipidemic if on antihypertensive or lipid-lowering medications, respectively (American College of Sports Medicine 2009; Table I). In contrast to AHA/ACSM guidelines, the current study did not record current medication use in the sample of CFA firefighters (Table I). The relative impact of these practical limitations of the POCT method could result in the misclassification of hypertension, dyslipidemia and/or IFG should POCT results be mistakenly used as proxies for medical diagnoses.

Cardiovascular Risk Stratification

To determine the CFA firefighters' cardiovascular risk stratification, a slightly modified version of the AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire was applied. This particular screening model was selected because it is an easily administered tool that uses basic risk factor information and has clear cut criteria (i.e., low, moderate or high risk) to specifically risk stratify people planning to begin physical activity (American College of Sports Medicine 2009). Therefore, this tool is more likely to be used as a pre-firefighting work screening tool than other risk functions (e.g., Framingham Risk Score) focussed on medium term disease risk prediction (i.e., 5 or 10 year risk; Wilson *et al.* 1998).

Participant's results for the risk factors age, sex, smoking, exercise/sedentary lifestyle, family history of CVD, SBP, DBP, BMI, WC, LDL-C, blood glucose and diabetes were entered into the AHA/ACSM risk stratification function. One point was allocated for each risk factor above the recommended NCEP risk factor guidelines, except for HDL-C (American College of Sports Medicine 2009; Table I). Risk factor points were then totalled to determine the individual's AHA/ACSM overall risk stratification point score (American College of Sports Medicine 2009). To account for the protective effects of high HDL-C on the cardiovascular system, one risk factor point was deducted from the participant's sum of risk factors if their HDL-C level was > 1.55 $mmol \cdot L^{-1}$ (American College of Sports Medicine 2009; Table I). Conversely, one risk factor point was added if the participant had an HDL-C level < 1.04 $mmol \cdot L^{-1}$ (American College of Sports Medicine 2009; Table I). If an individual had no more than one CVD risk factor they were stratified as low risk (American College of Sports Medicine 2009). Individuals with two or more CVD risk factors were stratified at a moderate risk for CVD (American College of Sports Medicine 2009). Individuals classified at high risk were those with known cardiovascular, pulmonary or metabolic disease (American College of Sports Medicine 2009). However, contrary to AHA/ACSM guidelines (American College of Sports Medicine 2009), the questionnaire used in the current study only inquired about the incidence of diagnosed diabetes (type 1 or type 2). Hence, individuals with other known CVD-related diseases (i.e., cardiovascular, pulmonary and/or metabolic diseases other than diabetes) were not identified and as a result, the percentage of CFA firefighters stratified at high risk could be underestimated in this sample.
It should also be noted that the CVD risk factor classification criteria for the risk factors 'Exercise/Sedentary Lifestyle', 'Smoking' and 'A Family History of CVD' used in the current study differed from their respective AHA/ACSM risk factor criteria (refer to Table I). In

comparison with the AHA/ACSM questionnaire, the criteria used to classify these risk factors in CFA firefighters (Table I) were more lenient (e.g., the current study classified an individual as a smoker if they currently smoked while AHA/ACSM criteria classify a smoker if the individual is a current smoker or has quit in the last six months or is exposed to environmental tobacco smoke) and therefore, may underestimate these particular risk factors among the sample of firefighters.

Positive Risk Factors	**Risk Factor Classification**
Age	Men ≥ 45 years; Women ≥ 55 years
Family History of CVD	CVD related death in two or more close relatives (i.e. father, mother, brothers, sisters); **Myocardial infarction, coronary revascularization, or sudden death before 55 yr of age in father or other male first-degree relative, or before 65 yr of age in mother or other female first-degree relative*
Hypertension	SBP ≥ 140 mm Hg and/or DBP ≥ 90 mm Hg; **as stated, but measurements confirmed on at least two separate occasions or taking antihypertensive medication*
Dyslipidemia	LDL-C ≥ 3.37 $mmol{\cdot}L^{-1}$ (130 $mg{\cdot}dL^{-1}$) *or* HDL-C < 1.04 $mmol{\cdot}L^{-1}$ (40 $mg{\cdot}dL^{-1}$); **as above, but also classified as dyslipidemic if on lipid-lowering medication*
Impaired Fasting Glucose	Fasting blood glucose ≥ 5.50 $mmol{\cdot}L^{-1}$ (100 $mg{\cdot}dL^{-1}$) but < 6.93 $mmol{\cdot}L^{-1}$ (126 $mg{\cdot}dL^{-1}$); **as above, but also classified as pre-diabetic if impaired glucose tolerance = two hour values in oral glucose tolerance test ≥ 7.70 $mmol{\cdot}L^{-1}$ (140 $mg{\cdot}dL^{-}$)[1] but < 11.0 $mmol{\cdot}L^{-1}$ (200 $mg{\cdot}dL^{-1}$) confirmed on at least two separate occasions*
Obesity	BMI ≥ 30 $kg{\cdot}m^{-2}$ *or* WC > 102 cm (40 inches) for men and > 88.0 cm (35 inches) for women
Exercise/Sedentary Lifestyle	30 min of vigorous intensity exercise at least three days per week or moderate intensity exercise two to three times a week or physically active occupation but complete no regular exercise; **Not participating in at least 30 min of moderate intensity (40%-60% VO_2R) physical activity on at least three days of the week for at least three months*
Smoking	Current cigarette smoker; **as stated, but also classified as a smoker if individual has quit in the last six months or exposure to environmental tobacco smoke*
Negative Risk Factors	**Risk Factor Classification Criteria**
High HDL-C	HDL-C ≥ 1.55 $mmol{\cdot}L^{-1}$ (60$mg{\cdot}dL^{-1}$)

Table I. Cardiovascular disease risk factor classification criteria used in risk stratification of CFA firefighters

** AHA/ACSM risk factor classification criteria different to risk factor classification criteria in current study* (American College of Sports Medicine 2009)

SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; LDL-C = Low-Density Lipoprotein Cholesterol; HDL-C = High-Density Lipoprotein Cholesterol; BMI = Body Mass Index; WC = Waist Circumference; mm Hg = millimetres of mercury; $mmol{\cdot}L^{-1}$ = millimoles per litre; $mg{\cdot}dL^{-1}$ = milligrams per decilitre

Statistical Analyses

To determine CFA firefighter's AHA/ACSM risk stratification, risk factor measurements were entered into a custom recorded macro created in Microsoft Excel (Microsoft Corporation, Redmond, WA). All data was presented as means ± standard deviation (SD) unless otherwise stated.

Results

Three thousand and eleven firefighters tested were male (i.e., 79.7%) and 766 (i.e., 20.3%) were female. The age of both male and female firefighters ranged from 18 to 75 years and the average age of the male and female firefighters was 46 ± 15 yr and 43 ± 15 yr, respectively. On average, female and male firefighters had 2 ± 2 and 3 ± 2 CVD risk factors, respectively. Just over half (50.8%) of female participants had two or more CVD risk factors and therefore classified as at moderate risk. In contrast, 68.2% of male participants were classified as at moderate risk with two or more CVD risk factors. Furthermore, 2.6% of female firefighters and 5.2% of male firefighters were stratified as high risk (i.e., diagnosed diabetes) while the remaining 46.6% and 26.6% of female and male firefighters, respectively, were classified as low risk (≤ 1 risk factor). When the sexes were combined, 30.7% of participants in this study were classified as low risk with one or less CVD risk factor, 64.7% of participants could be classified as at moderate risk with two or more CVD risk factors and 4.7% had diagnosed diabetes (i.e., diabetes type 1 or type 2) and were consequently, stratified as high risk (Figure I).

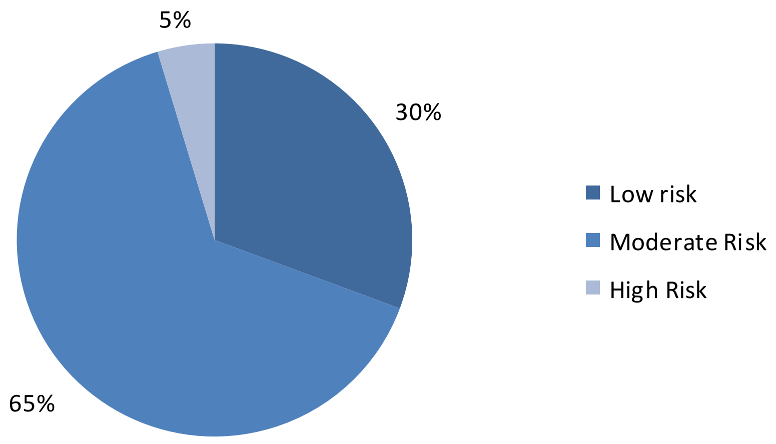

Figure I. Percentage of CFA firefighters with low, moderate and high risk stratification

Discussion

This study investigated the application of a modified AHA/ACSM preparticipation risk screening questionnaire in volunteer CFA firefighters. The questionnaire identified diagnosed diabetes (type 1 or type 2) in 2.6% of female firefighters and 5.2% of male firefighters, as a result, these individuals were stratified as high risk. A further 50.8% of female firefighters and

68.2% of male firefighters were identified as having two or more CVD risk factors and were therefore stratified as moderate risk. In total, 64.7% of the studied CFA firefighters could be stratified as at moderate risk with two or more CVD risk factors.

To the author's knowledge, the current study is the first to have investigated the use of the AHA/ACSM risk screening questionnaire in firefighters. Using similar risk factor thresholds based on Framingham data, Gaetano *et al.* (2007) evaluated the CVD risk factor prevalence of 1,456 volunteer firefighters and EMS personnel in the USA following a mandatory health surveillance examination. From this sample, Gaetano *et al.* (2007) further risk stratified volunteer firefighters and EMS personnel ≥ 45 years (n = 315). Seventeen percent of this cohort had a risk factor score ≥ 9 points which identified unacceptable risk and as a result were assigned a 'C' classification (Gaetano *et al.* 2007). These individuals had their responsibilities limited to tasks of low physical intensity and were only allowed to return to normal duties following the satisfactory completion of a graded exercise test (GXT) or cardiologist examination (Gaetano *et al.* 2007). In comparison, 64.7% of the CFA firefighters' tested presented with moderate CVD risk and therefore, would be advised by AHA/ACSM guidelines to undertake and pass a detailed medical examination and a medically supervised GXT prior to initiating vigorous intensity (70 to 85% of maximum heart rate) exercise or physical activity (American College of Sports Medicine 2009). Furthermore, if the risk stratification of CFA firefighters was narrowed to personnel ≥ 45 years, 77% would be stratified at moderate risk. Both these percentages are considerably higher than the 17% of USA volunteer firefighters and EMS personnel recommended for low activity work and testing (Gaetano *et al.* 2007).

The different risk profiles between CFA firefighters in the current study and EMS and firefighting personnel could be the result of variation in risk stratification methods. In particular, the modified AHA/ACSM stratification criteria could place a larger emphasis on age as a risk factor than the Framingham based model used by Gaetano *et al.* (2007). For example, in the current study male firefighters ≥ 45 years and women firefighters ≥ 55 years received one risk factor point. Therefore, any additional points would place them at a moderate risk. In contrast, Gaetano *et al.* (2007) allocated male and female EMS and firefighters ≥ 45 years either two or three risk factor points, respectively. As a result, male and female personnel required a further seven or six risk factor points respectively, to stratify them as an unacceptable risk (i.e., ≥ 9; Gaetano *et al.* 2007).

The contrast with Gaetano *et al.* (2007) demonstrates the larger emphasis the AHA/ACSM tool places on any one risk factor. The AHA/ACSM model also makes no distinction between someone with two or nine (for example) risk factors and more sensitivity is required. Indeed, evidence suggests that more than half of all Australian adults have more than two risk factors (O'Brien 2005) and therefore, like CFA firefighters, would most likely be stratified as moderate risk if the AHA/ACSM guidelines were applied. Given the large number of CFA firefighters identified at moderate risk, AHA/ACSM screening and stratification could also pose considerable financial cost to the CFA. Indeed, a medical examination and supervised GXT are likely to cost in excess of AUD $280 per person (Norton *et al.* 1998) and require the hiring of skilled staff. Medical and GXT testing of CFA firefighters could reduce the number of available volunteer firefighters in the CFA and consequently, reduce the emergency response across the state of Victoria. Therefore, despite the AHA/ACSM risk tool being widely used and recognised tool for pre-physical activity screening and stratification, it is possible that in its current form of strict application, it may not be the right tool for use among emergency service personnel such as firefighters. Instead, rather than testing (i.e., medical and GXT exercise tests) all firefighters who present at moderate and high CVD risk and excluding those from their duties who fail, the screening tool could be used to assign firefighters to specific, less physically demanding roles within their crew and/or brigade . The use of further medical and GXT testing could then be reserved for those firefighters who present with a moderate to high CVD risk but also play a more active role within their crew or brigade when on the fireground. Alternatively, BMI classifications have also been related to several parameters associated with cardiovascular health (e.g. blood pressure and cholesterol) among firefighters and could be used as a simple screening indicator of CVD risk for firefighters (Clark *et al.* 2002). However, further studies in this area are needed to explore screening options for firefighting and other emergency services.

Considering the financial and practical implications (e.g. reduced emergency response capacity) the introduction of mandatory screening and temporary exclusion of firefighters from physical work may cause, fire agencies should focus screening and stratification for high CVD risk personnel who are operationally active. If, however, volunteer fire agencies in Australia were to peruse mandatory job-screening and stratification of all firefighters, emerging evidence suggests that the assessment of firefighter's job related health and fitness be based on both a preparticipation health assessment (e.g., the AHA/ACSM questionnaire or similar) and their physical capacity to perform essential job functions (Gurkin *et al.* 1995; Pachman 2009; Serra *et al.* 2007). The latter involve describing and quantifying the physical demands relevant to the performance of common firefighting tasks (Serra *et al.* 2007). Furthermore, given the large percentage of firefighters' stratified at moderate CVD risk, fire agencies should aim to improve the CV health of their personnel through agency wide CVD health education interventions. Importantly, effective methodological design and implementation of CVD health education programs by emergency service agencies need to be set on a robust evidence base of previous or existing interventions (Rychetnik *et al.* 2002; Wolkow *et al.* in second review).

The application of a AHA/ACSM function to this sample of CFA firefighters has allowed for an in depth insight into the CVD risk in this population. However, the modifications of the AHA/ACSM model does have a number of limitations that must be considered. In comparison with the AHA/ACSM questionnaire, the modified criteria used to classify certain risk factors (i.e., Exercise/Sedentary Lifestyle', 'Smoking' and 'A Family History of CVD') were less strict and therefore, may underestimate these particular risk factors among the sample of firefighters. However, regardless of the modifications made, these particular risk factors are based on self report responses which may not correspond to actual physical activity, smoking level or CVD family history. A further limitation of the current study is the use of a non-random convenience sampling framework (i.e., voluntary participation of subjects). This method of recruitment may lead to a biased sample of the population as firefighters who are less concerned with their health or who have known health issues may be deterred from participating, while those firefighters who have a greater interest in their health may be more likely to take part. Consequently, selection bias may affect the degree to which the sample is representative of CFA firefighters. However, the large sample size and thus small standard error, enhance the ability to generalise the study's findings back to the wider CFA population as a whole.

Conclusion

A large percentage of volunteer CFA firefighters were classified as moderate risk and if the AHA/ACSM guidelines were applied, could require satisfactory completion of a thorough medical evaluation and medically supervised GXT prior to gaining clearance to undertake vigorous intensity firefighting work. The percentage at moderate risk is greater than the only comparable USA study, which is likely due to the older age of the current CFA participants. The high percentage of CFA firefighters at moderate risk should compel agencies to apply agency wide interventions regarding CVD health education and focus risk screening on personnel considered a high CVD risk and legally defensible job selection procedures around inherent task requirements.

Acknowledgements

This study was wholly funded by the Victorian Community Support Fund and the Bushfire Co-operative Research Centre.

The authors' would also like to acknowledge Jace Drain, Olga Messiakaris, Cara Lord, Sarah Piper, Xavier Cox, Meagan Davis, Paul De Koeyer and Anna Ruzic for their assistance with data collection in this study. The results of the present study do not constitute endorsement by the ACSM and the views expressed are those of the authors, and do not necessarily represent the views of the Boards of the CFA or the Bushfire Co-operative Research Centre.

References

Ainsworth BE, Haskell WL, Leon AS, Jacobs DR, Jr., Montoye HJ, Sallis JF, Paffenbarger RS, Jr. (1993) Compendium of physical activities: classification of energy costs of human physical activities. *Medicine and Science in Sports and Exercise* **25**, 71-80.

American College of Sports Medicine (2009) 'ACSM's Guidelines for Exercise Testing and Prescription 8th ed.' (Wolters Kluwer/Lippincott Williams and Wilkins: United States)
Australian Bureau of Statistics (2004) 'Bushfires.' (Australian Bureau of Statistics: Canberra) Available at:
www.abs.gov.au/Ausstats/abs@.nsf/Lookup/6C98BB75496A5AD1CA2569DE00267E48.

Balady GJ, Chaitman B, Driscoll D, Foster C, Froelicher E, Gordon N, Pate R, Rippe J, Bazzarre T (1998) Recommendations for Cardiovascular Screening, Staffing, and Emergency Policies at Health/Fitness Facilities. *Circulation* **97**, 2283-2293.

Bankhead CR, Brett J, Bukach C, Webster P, Stewart-Brown S, Munafo M, Austoker J (2003) The impact of screening on future health-promoting behaviours and health beliefs: a systematic review. *Health Technology Assessment* **7**, 1-92.

Bard RL, Kaminsky LA, Whaley MH, Zajakowski S (1997) Evaluation of lipid profile measurements obtained from the Cholestech L.D.X analyzer. *Journal of Cardiopulmonary Rehabilitation* **17**, 413-418.

Byczek L, Walton SM, Conrad KM, Reichelt PA, Samo DG (2004) Cardiovascular risks in firefighters: implications for occupational health nurse practice. *American Association of Occupational Health Nurses* **52**, 66-76.

Clark S, Rene A, Theurer WM, Marshall M (2002) Association of Body Mass Index and Health Status in Firefighters. *Journal or Occupational and Environmental Medicine* **44**, 940-946.

Country Fire Authority (2010) Country Fire Authority: What We Do. Available at www.cfa.vic.gov.au/about/whatwedo.htm

Country Fire Authority (2012), Career Firefighter Recruitment Process: Essential Criteria for Applying. Available at
www.cfa.vic.gov.au/volunteerandcareer/career_ff/recruitment_process.htm

Devaney M, Noone P (2008) Is lifestyle screening worth it? *Occupational Health* **60**, 27-29.

Emberson J, Whincup P, Walker M, Thomas M, Alberti K (2002) Biochemical measures in a population-based study: effect of fasting duration and time of day. *Annals of Clinical Biochemistry* **39**, 493-501.

Fahy R (2005) 'US Firefighter fatalities due to sudden cardiac death, 1995 – 2004.' (National Fire Protection Association: Quincy, MA)

Flynn D, Johnson JD, Bailey CJ, Perry JT, Andersen CA, Meyer JG, Cox NA (2009) Cardiovascular risk factor screening and follow-up in a military population aged 40 years and older. *U.S. Army Medical Department Journal* 67-64.

Fodor JG, van Ryn-Holland H, Brownrigg J, LeGrand C.Dafoe WA (1998) A study of cardiovascular prevention among firefighters in Ottawa, Canada. *Homeostasis in Health and Disease* **39**, 14-18.

Gaetano DE, Ackerman S, Clark A, Hodge B, Hohensee T, May J.Whiteman W (2007) Health surveillance for rural volunteer firefighters and emergency medical services personnel. *American Association of Occupational Health Nurses Journal* **55**, 57-56.

Gurkin D (1995) Firefighters: fitness for duty. *Occupational Medicine* **10**, 871-876.

Kales SN, Soteriades ES, Christophi CA, Christiani DC (2007) Emergency duties and deaths from heart disease among firefighters in the United States. *The New England Journal of Medicine* **356**, 1207-1215.

Langsted A, Freiberg JJ, Nordestgaard BG (2008) Fasting and nonfasting lipid levels: influence of normal food intake on lipids, lipoproteins, apolipoproteins, and cardiovascular risk prediction. *Circulation* **118**, 2047-2056.

National Cholesterol Education Program (2002) Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation and Treatment of High Blood cholesterol in Adults (Adult Treatment Panel III): Final Report; National Institutes of Health, National Heart, Blood and Lung Institute.

National Fire Protection Association (2007) 'NFPA 1582: Standard on Comprehensive Occupational Medical Program for Fire Departments.' (National Fire Protection Association: Quincy, MA)

National Institute for Occupational Safety and Health (2007) Preventing Firefighter Fatalities Due to Heart Attacks and Other Sudden Cardiovascular Events. Department of Health and Human Services, Public Health Service, Centres for Disease Control and Prevention, NIOSH, Report 133.

Norton K, Gore C (1998) Applying the sports medicine Australia pre-exercise screening procedures: Who will be excluded? *Journal of Science and Medicine in Sport* **1**, 38-51.

O'Brien K (2005) 'Living dangerously: Australians with multiple risk factors for cardiovascular disease. Bulletin No. 24.' (AIHW: Canberra)

Pachman J (2009) Evidence base for pre-employment medical screening. *Bulletin of the World Health Organisation* **87**, 529-534.

Pai C-W, Hagen SE, Bender J, Shoemaker D, Edington DW (2009) Effect of health risk appraisal frequency on change in health status. *Journal of Occupational and Environmental Medicine / American College of Occupational and Environmental Medicine* **51**, 429-434.

Rychetnik L, Frommer M, Hawe P, Shiell A (2002) Criteria for evaluating evidence on public health interventions. *Journal of Epidemiology & Community Health* **56**, 119-127.

Serra C, Rodriguez M, Delcos G, Plana M, Gomez Lopez LI, Benavides FG (2007) Criteria and methods used for the assessment of fitness for work: a systematic review. *Occupational Environmental Medicine* **64**, 304-312.

Shemesh T, Rowley KG, Shephard M, Piers LS, O'Dea K (2006) Agreement between laboratory results and on-site pathology testing using Bayer DCA2000+ and Cholestech LDX point-of-care methods in remote Australian Aboriginal communities. Clinica Chimica Acta; *International Journal of Clinical Chemistry* **367**, 69-67.

Shephard MD, Mazzachi BC, Shephard AK, McLaughlin KJ, Denner B, Barnes G (2005) The impact of point of care testing on diabetes services along Victoria's Mallee Track: results of a community-based diabetes risk assessment and management program. *Rural and Remote Health* **5**, 1-15.

Shephard R J, Thomas S, Weller I (1991) The Canadian home fitness test: 1991 update. *Sports Medicine* **11**, 358-366.

Swank A, Adams K, Barnard K, Benning J, Ottersbach M, Bowerman J (2000) A comparative analysis of cardiovascular disease risk factors for volunteer firefighters. *Clinical Exercise Physiology* **2**,199-203.

Thompson PD, Franklin BA, Balady GJ, Blair SN, Corrado D, Estes NA, 3rd, Fulton JE, Gordon NF, Haskell WL, Link MS, Maron BJ, Mittleman MA, Pelliccia A, Wenger NK, Willich SN, Costa F (2007) Exercise and acute cardiovascular events placing the risks into perspective: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism and the Council on Clinical Cardiology. *Circulation* **39**, 886-897.

Williams BE, Petersen SR, Douglas K (1996) Physiological responses of training officers during live fire training. *Fire Engineering* **149**, 45-50.

Wolkow A, Netto K, Langridge P, Green J, Nichols D, Sergeant M, Aisbett B (in press) Coronary Heart Disease Risk in Victorian Volunteer Firefighters. *Archives of Occupational and Environmental Health.*

Wolkow A, Netto K, Aisbett B The Effectiveness of Health Interventions in Cardiovascular Risk Reduction among Emergency Service Personnel. Manuscript submitted for publication.