Risk Factors for Fire Fighter Cardiovascular Disease

EXECUTIVE SUMMARY

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FIRE RESEARCH

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FOREWORD

This "Executive Summary" contains the abstract and conclusions of a full study report conducted and led by The University of Arizona. The Fire Protection Research Foundation has provided advisory services in support of this study, including the administration of guidance provided by a panel of subject-matter-experts, and assisting with the dissemination of project results. The full study results will be published in peer-reviewed journals. For additional information, please contact Dr. Burgess at The University of Arizona, Mel and Enid Zuckerman College of Public Health, 1295 N. Martin Avenue, P.O. Box 245163, Tucson, Arizona 85724.

This study evaluates the use of carotid IMT as a medical surveillance tool in firefighters, measures the acute effects of fire suppression on biomarkers associated with heart attacks and tests an active cooling method during firefighter rehabilitation. Sudden cardiac deaths account for 44% of the line of duty deaths in firefighters, and generally occur in firefighters with underlying cardiovascular disease, many of whom have been previously asymptomatic, and fire suppression carries the highest risk for on-duty firefighter cardiac deaths. Current screening tests are not adequate to identify firefighters at high risk of an on-duty cardiovascular event.

This overall study is comprised of the following three components:

1) Over 500 Phoenix and Tucson area firefighters with at least 5 years of firefighting service and without known cardiovascular disease underwent carotid IMT to determine the extent of early atherosclerotic disease. Data on traditional risk factors as well as new biomarkers were collected and analyzed to determine their ability to predict the presence of carotid IMT thickening in this population.
2) The effects of fire suppression on acute measures of systemic inflammation and cardiac function were evaluated in over 50 firefighters at baseline and post-exposure. The contribution of exposure to smoke contaminants and elevation in core body temperature were assessed.
3) In an interventional trial, more aggressive cardiac rehabilitation in 25 firefighters using forearm immersion in cold water at the fire scene, in comparison to 25 firefighters going through standard rehabilitation, was tested to determine the effectiveness in reducing core body temperature and adverse cardiovascular effects.

The Research Foundation expresses gratitude to the study author Jeff Burgess, MD, MPH, and his research team at the University of Arizona, Mel and Enid Zuckerman College of Public Health. The Foundation appreciates the partnership support of the Phoenix Fire Department, Tucson Fire Department, Northwest Fire Department and all others that contributed to this research effort, especially the fire service personnel that directly participated in the data collection efforts. The Foundation expresses gratitude to the members of the Project Technical Panel for their helpful guidance, and special thanks are expressed to the U.S. Department of Homeland Security, AFG Research & Development Grants, for providing the funding for this project through the University of Arizona.

The content, opinions and conclusions contained in this Executive Summary are solely those of the authors.

PROJECT TECHNICAL PANEL

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Sandy Bogucki, Yale University

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Rich Duffy, International Association of Fire Fighters

Frank Florence, NFPA (NFPA 1582 Staff Liaison)

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Tamara Lopes, Reno Fire Department

David Prezant, FDNY

Denise Smith, Skidmore College

Paula Willoughby-DeJesus, University of Illinois at Chicago

This study serves as a tribute to Panel member Frank Florence, who passed away on 27 July 2010 prior to final completion of this project, and all emergency first responders who dedicate their professional careers as emergency responders, only to leave us too early.

PROJECT SPONSOR

U.S. Department of Homeland Security
(AFG Research & Development Grant)

RISK FACTORS FOR FIRE FIGHTER CARDIOVASCULAR DISEASE

***Rationale**:* Sudden cardiac deaths account for 44% of the line of duty deaths in firefighters, and generally occur in firefighters with underlying cardiovascular disease, many of whom have been previously asymptomatic. Fire suppression carries the highest risk for cardiovascular deaths, and yet we do not understand the effects of this activity, including the contribution of smoke and heat exposure, on pathways involved in the development of a myocardial infarction.

***Objectives**:* Current routine screening tests are not adequately identifying firefighters at high risk of an on-duty cardiovascular event. Measurement of carotid artery intima-media thickness (IMT) can detect early atherosclerotic disease but is not currently used in the fire service. We proposed to evaluate the use of carotid IMT as a medical surveillance tool in firefighters, to determine the acute effects of fire suppression on biomarkers associated with heart attacks and to evaluate an active cooling method post fire-suppression.

***Study design and methods**:* For aim #1, a total of 597 Phoenix and Tucson area firefighters with at least 5 years of service and without known cardiovascular disease underwent carotid IMT to determine the extent of early atherosclerotic disease. Health questionnaires were completed, medical history reviewed, and blood drawn for biomarker assays.
For aim #2 the effects of fire suppression and specific exposures to smoke contaminants on acute measures of vascular injury were evaluated in 54 firefighters.
For aim #3, the effects of use of active cooling to reduce core temperature and changes in blood coagulation were evaluated in 50 firefighters exposed to high temperatures during a live-fire exercise involving strenuous activities.

***Results**:* For aim #1, common carotid IMT averaged 0.65 ± 0.10 mm in all firefighters and 73 (12.2%) of firefighters had carotid plaque. Risk factors on multivariate analysis for increased IMT included only age and either total or low density lipoprotein cholesterol (LDL-C). The risk increased at LDL-C concentrations as low as 100-129 mg/dl (Table 1). Risk factors on multivariate analysis for carotid plaque included age, LDL-C, hypertension and sP-selectin, a marker of platelet activation (Table 2).
For aim #2, core body temperature increased, with the peak temperature occurring during the 15 minute rehabilitation period after the fire. C-reactive protein decreased as a result of fire exposure but there were no significant changes in fibrinogen, sE-selectin and sL-selectin, biomarkers of clotting and vascular injury.
For aim #3, forearm cooling resulted in a decrease in post-fire core temperature and heart rate during the post-fire period (Figures 1 and 2). In addition, the live-fire exercise resulted in an increase in the rapidity and extent of clotting as measured by thromboelastogram, as well as increased neutrophil activation, changes which were not reversed by forearm cooling.

Table 1. IMT regression modeling (n=579)

Variable	Crude OR	Adjusted OR*
Age 25-34 yrs	ref	ref
35-44	6.6 (1.5-27.9)	4.9 (1.1-21.2)
45-54	16.5 (3.9-69.1)	13.4 (3.2-56.9)
≥55	29.6 (6.4-137.)	19.3 (4.1-91.7)
LDL <100 mg/dl	ref	ref
100-129	1.9 (1.1-3.1)[†]	1.7 (1.0-3.0)
130-159	3.9 (2.2-6.7)	3.4 (1.8-6.2)
≥160	3.8 (1.8-7.8)	2.9 (1.4-5.9)

*Adjusted for age, gender, smoking, HTN, LDL and HDL; [†]OR 3.6 for age <45 yrs
Gender, HsCRP and BMI significant in crude but not adjusted models

Table 2. Carotid plaque regression modeling (n=579)

Variable	Crude OR	Adjusted OR*
Age 25-34 yrs	ref	ref
35-44	2.2 (0.3-18.2)	1.4 (0.2-12.1)
45-54	15.0 (2.0-111)	9.3 (1.2-70.6)
≥55	31.5 (4.0-250)	21.7 (2.6-180)
HTN	4.9 (2.9-8.2)	3.3 (1.8-6.0)
LDL <100 mg/dl	ref	ref
100-129	2.5 (1.2-5.2)	3.1 (1.0-6.5)
130-159	2.2 (0.9-5.0)	2.5 (1.8-6.2)
≥160	5.5 (2.3-12.9)	6.5 (2.4-17.0)
sP-selectin (ng/ml)	1.02 (1.01-1.04)	1.02 (1.00-1.04)

*Adjusted for age, gender, smoking, HTN, LDL and HDL
Triglycerides, BMI and regular aspirin use significant in crude models only

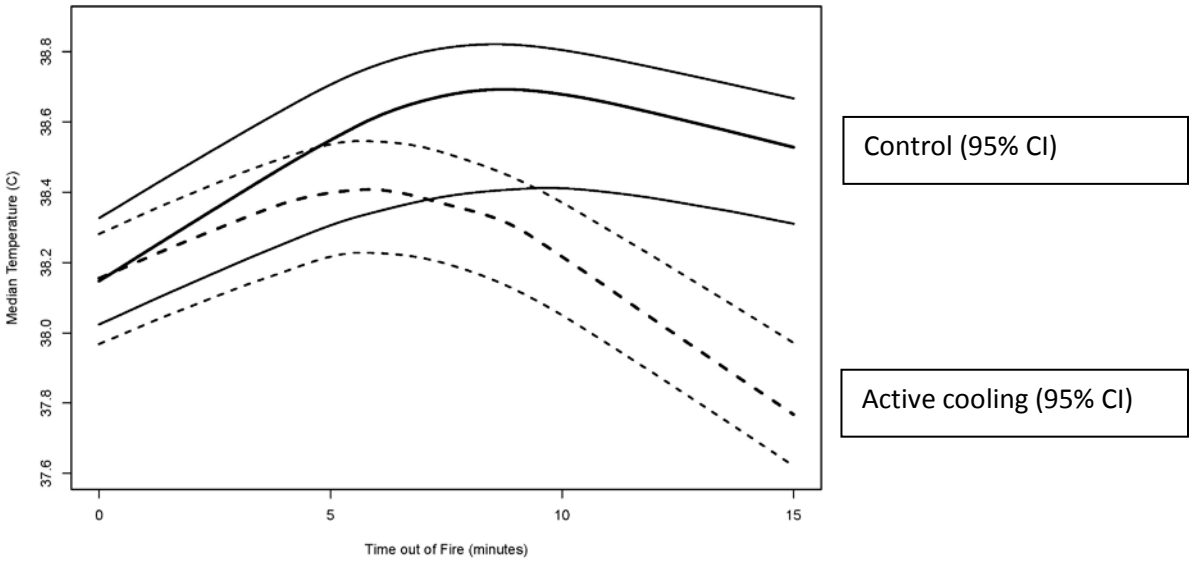

Figure 1. Core temperature during the rehabilitation period.

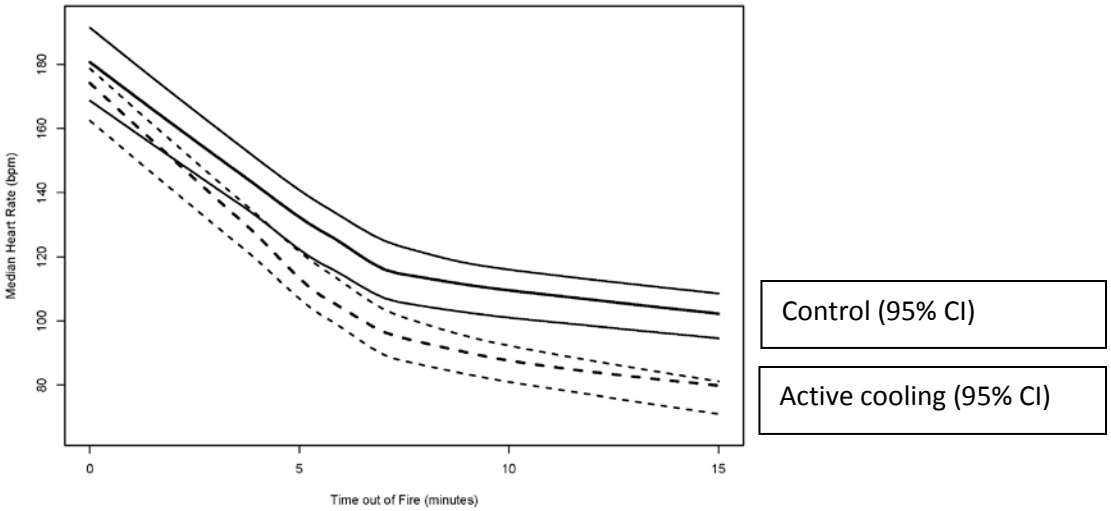

Figure 2. Heart rate during the rehabilitation period.

Conclusions: LDL-C was the major modifiable risk factor for increased carotid IMT, and the risk increased with LDL-C concentrations exceeding 100 mg/dl. LDL-C and hypertension were the major modifiable risk factors for carotid plaque, although the association with sP-selectin suggests that reduction of platelet activation is also a potential pathway for intervention. Exposure to heat during exercise did not markedly alter biomarkers of vascular injury but resulted in a change in several coagulation parameters. Active cooling had beneficial effects on reducing core temperature and heart rate which increased over the duration of the treatment, although this may not indicate return to a physiologic baseline state.

Note: The full study report can be obtained from: The University of Arizona, Mel and Enid Zuckerman College of Public Health, 1295 N. Martin Avenue, P.O. Box 245163, Tucson, Arizona 85724.