The Surveillance and Prevention of Cardiovascular Disease in the Firefighters of Boca Raton

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expression, or writings of another.

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Abstract

The problem is that Boca Raton Fire Rescue Services (BRFRS) has no established protocols specific to the risks of heart disease faced by the department's firefighters. The purpose of this applied research project was do develop a cardiovascular disease surveillance standard operating procedure (SOP) using descriptive research to study and analyze the problem. The results identified the most accurate diagnostic and predictive tools, such as risk calculators, to evaluate how medical conditions modify the risks associated with cardiovascular disease. The results were the basis for the following recommendations and can be used as the foundations of an effective firefighter wellness program: regular medical examinations by a knowledgeable physician, mandatory cardio-respiratory fitness standards, and encourage a heart healthy lifestyle.

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Introduction

The fire service in general depends on responders mitigating a wide variety of emergencies that involve human life and property. An incident will typically begin with an alarm that is transmitted to a station or unit. Followed by an emergency response in heavy apparatus with powerful, noisy diesel engines and an even louder emergency alerting system designed to minimize travel time to the scene of the incident. All of these stressful activities take place before emergency mitigation efforts begin. As expected, the physical and psychological strain on the body over a span of a career in the fire service is tremendous and takes its toll in the form of injuries and possibly even sudden and premature death. Historically, the most common cause of sudden death in a firefighter is cardiovascular disease and myocardial infarction (Smith, Goldstein, Horn, and Petruzelleo, 2008).

Approximately 1.1 million firefighters, both career and volunteer, protect life and property in the United States, and each year approximately 100 fire fighters die in the line of duty (United States Fire Administration [USFA], 2002). The USFA (2002) reports that the single largest killer of firefighters since 1996 is heart attacks, excluding the firefighter fatalities when World Trade Center collapsed in 2001. Heart disease accounted for 45 percent of firefighter LODD since 1977; this figure compares to 22 percent among police officers and police detectives, 11percent among EMS workers and 15 percent among other occupational workers (Kales, Soteriades, Christoudias, Christiani, 2003).

Given those grim statistics, the USFA and the National Fire Protection Association (NFPA) publish a continuous stream of reports with recommendations to improve the surveillance and treatment of firefighters at risk for sudden death due to cardiovascular disease. The problem is that Boca Raton Fire Rescue Services (BRFRS) has no established protocols that are specific to the risks of cardiovascular disease (CVD) faced by the department's firefighters. The purpose of this applied research project was to develop a CVD surveillance SOP to meet the needs of the firefighters of BRFRS.

The Descriptive Method was used for this Applied Research Project. The protocol was developed by collecting and analyzing peer reviewed journals articles and other scientific research data dealing with heart disease in the fire service and the general public. This research will answer the following questions:

1. What are the most reliable diagnostic tools available to measure the extent of incipient cardiovascular disease in BRFRS personnel?
2. How reliable are the cardiovascular risk assessment calculators in predicting cardiovascular disease in BRFRS personnel?
3. What precautions should be taken for other medical conditions that could potentially aggravate the risk for cardiovascular disease in BRFRS personnel?
4. What are the recognized statistically validated guidelines for the medical surveillance of cardiovascular disease for BRFRS personnel?

Background and Significance

The City of Boca Raton was incorporated 1925 and is the second largest city in Palm Beach County, Florida. Boca Raton covers 28 square miles with five miles of oceanfront and 500 acres of parks, truly a city within a park. Located on the southeast coast of Florida, this city is bounded by Broward County to the South and the City of Delray Beach on the North. Boca Raton is a suburban community of 85,296 residents (City of Boca Raton Approved Budget FY 2008-09, 2008). Our population grows to approximately 160,000 during business hours. The majority of the commercial enterprises in the City can be classified as business occupancy and light and high tech industry. There are several major transit corridors that cross Boca Raton including Florida's Turnpike to the west, Interstate 95 that transects the center of the city and the Seaboard and Florida East Coast Rail Road that provide freight and passenger service to the region (City of Boca Raton Approved Budget FY 2008-09, 2008).

Boca Raton Fire Rescue Services is a career fire department that was established in 1925 to serve the residents of Boca Raton. BRFRS is composed of eight stations with 207 full time paid firefighters assigned to four platoons supervised by one Battalion Chief and one Emergency Medical Services (EMS) Captain per platoon. A total of 98 firefighters provide emergency response services to the City of Boca Raton; three are assigned to the Training and Safety Section and six firefighters are assigned to the Fire and Life Safety Division. The Administrative Staff is composed of the Fire Chief, two Deputy Chiefs, five Assistant Chiefs and four Division Chiefs for a total compliment of 218 personnel including clerical and support staff (City of Boca Raton Approved Budget FY 2008-09, 2008).

BRFRS provides a range of emergency and non-emergency services to our residents that include eight Advance Life Support (ALS) suppression units, six ALS transport units, a special operations team (hazardous materials, confined space rescue), Fire Prevention, Plans Review, and Public Education programs. In 2008, BRFRS units responded to 15,979 incidents; approximately 70 percent of these incidents were emergency medical responses; fire responses represent 20 percent and the remaining 10 percent are miscellaneous incidents such as chemical spills and requests for public assistance (City of Boca Raton Statistical Report of Emergency Services, 2008).

Many occupational conditions may precipitate a CVD event in firefighters. Firefighting involves long periods that relatively sedentary actives punctuated by irregular periods of maximum physiological stress (Kales et al., 2003). This physical activity is performed with heavy personal protective equipment (PPE), extended periods of heat stress with fluid and electrolyte loss, noisy environments and chemical exposures the products of combustion including carbon monoxide, particulates and other toxicants (Smith et al., 2008).

The following case study reported by the National Institute for Occupational Safety and Health (NIOSH) following a firefighter fatality investigation. A 44-year-old Captain reported for duty at start of his shift in Kansas and suffered a fatal cardiac event approximately 14 minutes after arriving at a structure fire (Smith, 2007). His duties on the scene consisted of assisting with a water supply using a five inch supply line and performing fire suppression and search and rescue operations for approximately 10 minutes after arrival (Smith, 2007). He collapsed in the rehabilitation area and was pronounced dead at the local emergency room 25 minutes later (Smith, 2007).

This Captain had an extensive CVD history; his first myocardial infarct (MI) was diagnosed at age 30, and a second MI was discovered seven years later after which he underwent coronary artery catheterization and intra-coronary artery stent placement; however, he was allowed back to work after successfully completing the fire department exercise stress test 10 months later (Smith, 2007). Before his death, his private physician conducted exercise stress tests, but the results were never forwarded to the fire department (Smith, 2007). Firefighters performing activities such as fire suppression, emergency response or other strenuous physical exertion are at increased risk for a sudden death cardiac event (Smith, 2007).

As a firefighter ages, other medical conditions such as hypertension, diabetes and obesity increase the risk for CVD and sudden cardiac arrest; Smith et al. (2003) indicate that a male firefighter, after the age of 45, is at greater risk for sudden death. Kales et al. (2003) consider a firefighter older than 45 to be a risk factor for CVD on par with the risk associated with smoking, hypertension and diabetes. Active firefighters with a previous CVD diagnosis are associated with up to a 15 fold increased risk of an on-duty CVD death or disability secondary to heart disease (Geibe et al., 2008)

As of this writing the average age of a Boca Raton Firefighter is 41 years (median 40) that means this department's personnel is entering the period in their career that they are at greatest risk for sudden death from CVD. An effective surveillance program augmented by the mandatory annual medical evaluation for firefighters, can give early indications for those at the most risk of sudden death (See Figure 1). Given those facts the goal of this project was to develop a SOP for BRFRS that would identify those at greatest risk for sudden death associated with cardiovascular disease and establish internal controls that would encourage the appropriate medical surveillance and preventative care.

This applied research project relates to the curriculum of the National Fire Academy's Executive Fire Officer Program (EFOP), *Executive Development* (ED), R123 (National Fire Academy [NFA], 2006). This course is designed to prepare executive fire officers for the challenges of the future and to identify the trends that will predict these changes. The successful fire officer must be able to anticipate change and view the changing landscape to identify opportunities that may exist for the organization, the community and the fire service in general. The author can relate the following units to this research project (NFA, 2006).

Unit 1: Leadership helps the students recognize and define the principles and practices of an adaptive leader. Some of the traits of an adaptive leader include being creative, visionary, and credible to those being led. That means that the safety and health of the followers must be a priority to the leader. This project is about safety and the health of the emergency responder (NFA, 2006).

Unit 2: Teams discuss the theory and practice of team building. One of the foundations of effective teams is trust. To build team trust a leader must demonstrate the ability to identify problems and to find effective solutions to resolve them (NFA, 2006).

Unit 3: Change Management. A goal of this project is to encourage a change in the way we conduct health assessments while on the job. This change in policy, if implemented, may have drastic consequences for a segment of our workforce. How that change is implemented and managed is critical to the success of the initiative (NFA, 2006).

Unit 6: Change and Creativity discussed the process of change and its potentially disruptive effects. The leader must anticipate critical issues that may impact the organization and identify creative and sometimes radical solutions to minimize any negative impact on the individual, the organization and the community as a whole (NFA, 2006).

The research and development of an effective cardiovascular disease surveillance protocol will provide better clues that will identify firefighters that are at special risk for sudden death due because of CVD. This goal is directly related to the first operational objective of the USFA, to reduce the occupational loss of life in the fire service (USFA, 2003).

Literature Review

The purpose of this literature review is to summarize the body of scientific data on the role that cardiovascular disease plays in the risk of sudden death in the firefighter. This review also examines the connection between the risk factor for CVD and the incidence of sudden death in the general population and how that may give an indication of the potential for a sudden death event in the firefighter. This review will also examine research that suggests that CVD risk factors, biomedical markers, cardiovascular fitness, and heart rate recovery profile may be important independent indicators for those at highest risk for a sudden death cardiac event.

The rate of CVD in firefighters parallels the incidence observed in the general public as the most frequent cause of mortality (Soteriades et al., 2005) in the western world. The majority of these premature LODD can be prevented through improved cardiovascular fitness, nutrition and effective medical surveillance (Soterialdes et al., 2005). Therefore, by examining the risk factors for CVD in the general public, firefighters can identify the most significant, modifiable conditions that increase the probability of sudden death secondary to a myocardial infarct or other significant cardiovascular event.

The epidemic of cardiovascular disease began in the 1930's. By the late 1940s this epidemic became the number one killer of Americans (Framingham Heart Study [FHS], 2009). Researchers at the United States Public Health Service wanted to learn which factors and characteristics that were contributing to such a rapid rise in cardiovascular death and disability (FHS, 2009). The first group that entered the study consisted of 5,209 healthy volunteers, men and women, between the ages of 30 and 62 years old in the City of Framingham Massachusetts (FHS, 2009).

Since 1948, volunteers in the study were subjected to physical examinations and lifestyle interviews that were be analyzed for common factors that contribute to the development of cardiovascular disease (FHS, 2009). In 1971, the program was expanded to include a second-generation cohort and a third generation was added in 2002 (FHS, 2009).

The 50 years of data collected from the participants of the FHS (2009) has produced over 1,200 scientific papers. The data also helped identify risk factors associated with heart disease, stroke and other diseases and helped create the culture and science of preventative medicine in this country and around the world (FHS, 2009). The term ‘risk factors’ coined by the study, helped the medical and scientific community understand how we can modify the risks associated with heart disease by changing lifestyle and beginning preventative and therapeutic care as early as possible (FHS, 2009).

The Risk Assessment Tool for estimating a person’s 10-year risk of having a heart attack (http://www.framinghamheartstudy.org/risk/coronary.html) was developed with data from the Framingham Heart Study. The calculator uses seven parameters identified in the Framingham model that can estimate the risk for CVD. The risk assessment data points include, age, gender, total cholesterol, high-density lipid (HDL) cholesterol, smoking status, systolic blood pressure and whether hypertension is controlled by medication to calculate a 10 year risk of a myocardial infarct (FHS, 2005). The Risk Assessment Tool has become the national and worldwide standard for the medical assessment of CVD risks in adults (FHS, 2009).

To better appreciate how the risk of CVD in the general public compares to the risk faced by firefighters, the risk factors for CVD will be compared between to two populations and the relevance to each group will be examined.

According to the American Heart Association [AHA] (2009), age represents a significant risk factor for death from CVD. In 2005 over 83 percent of the victims of CVD were 65 years of age or older. Approximately 2,400 Americans die each day that is approximately 1 death every 37 seconds, 408 of these CVD victims are under the age of 65 (AHA, 2009). The AHA (2009) also estimates that 785,000 Americans will have new heart attacks this year, however there is an estimated 195,000 additional silent (symptom free) heart attacks that occur each year in this country.

In 2008, 36 victims died from sudden cardiac events making CVD events for the second year in a row, the second leading cause of death in firefighters in the United States (Fahy, LeBlanc, and Molis, 2008). The number of firefighters that succumbed to death following a sudden cardiac event increased dramatically with age. The age range from 21 to 30 had one fatality, ages 31 to 40 had three victims, ages 41 to 50 had 11 fatalities, ages 51 to 60 had eight victims and over 60 had 12 fatalities from volunteer fire departments (Fahy et al., 2008). Of the LODD of firefighters over the age of 40 in 2008, more than half died from a MI or other cardiac event; the youngest victim, age 24, had severe atherosclerosis that was discovered during autopsy (Fahy et al., 2008). Over a five year period, 2004 to 2008, firefighters over the age of 50 accounted for 40 percent of all firefighter fatalities, although they represent only 20 percent of all firefighters (Fahy et al., 2008). These statistics support the fact that as the firefighter ages their risk of CVD increases as does the risk of sudden death.

As a general rule, however men are at higher risk for a MI than women and they have CVD earlier in life than women (AHA, 2009). According to the AHA (2009) even after menopause, women’s death rates increase but their risk is not as great as men. There has been very little research done to compare and contrast CVD fatalities in female firefighters. Research papers consulted did not address women in the fire service because of the limited amount of research available.

Cholesterol, a fat-like substance that is soft and waxy is found in the bloodstream and in all of the cells in the body (AHA, 2009). Cholesterol is used to construct the cell membrane, in the production of hormones, and many other functions throughout the body (AHA, 2009). Certain forms of cholesterol, the low-density lipoproteins (LDL), facilitate the development of atherosclerotic cardiovascular disease by adhering to the walls of blood vessels causing the accumulation of fatty plaque (Smith et al., 2008). High-density lipoproteins (HDL) are thought to be ‘good cholesterol’ and have a protective effect on the cardiovascular system (AHA, 2009). Total cholesterol levels tend to increase as we age (Smith et al., 2009).

According to the AHA (2009), adults 20 years old or above with LDL cholesterol level at 130-159 mg/dL are consider borderline to high, a level of 160-189 mg/dL is considered high and LDL cholesterol levels at 190 mg/dL or above very high risk factor for CVD in the general public (AHA, 2009). In 2006, 16 percent (34,400,000) of American adults age 20 and above, had a total cholesterol level equal to or greater than 240 mg/dL (AHA, 2009).

The National Volunteer Fire Council’s Heart-Healthy Firefighter Program (NVFC) conducted health screenings at several fire service trade shows around the country; although not intended to be a scientific study, the screenings however, were used to educate firefighters and their families about nutrition, physical fitness and CVD (Fahy et al., 2009). The program, over a five-year period, screened over 9600 career and volunteer firefighters, and measured blood pressure, cholesterol, body fat and glucose (Fahy et al., 2009). These studies indicate a pattern of increasing cholesterol levels with a parallel increase in obesity in the fire service.

The NVFC report on total cholesterol in 7,904 firefighters tested from 2003 to 2007 found levels at or above 200 mg/dL in 37 percent of the firefighters in that study (Fahy et al., 2009). A similar test involving 1,659 firefighters was repeated in 2008; the results showed that 5.8 percent of the firefighters tested had levels at or above 249 mg/dL and 27.9 had levels 200-239 mg/dL (Fahy et al., 2009). Firefighters with cholesterol levels greater than 240 mg/dL also had a higher incidence of obesity than those with levels below 240 mg/dL and that obese firefighters, when they conducted a six year follow-up, are more likely to suffer a disability requiring time off from work (Smith et al., 2008).

The scientific community is in near universal agreement that smoking is linked with illness and death in Americans. The AHA (2009) reports that between 1997 and 2001 that 428,000 Americans died annually from smoking related illness and disease and that 34.7 percent of these deaths are related to CVD. The average smoker dies earlier when compared to a non-smoker, 13.2 years on average for men and 14.1 years for women (AHA, 2009). Smokers are two to four times more likely to develop CVD than nonsmokers (AHA, 2009). Smoking has declined in adults by over 50 percent in the US between 1965 and 2006; however, as of 2005 over 20 percent (47,000,000) of the American adult population (18 years and older) smoke cigarettes (AHA, 2009).

Smoking has many negative effects on the smoker's cardiovascular system. Exposure to cigarette smoke damages the lining of the blood vessel and increases the potential for clotting (Smith et al., 2009). Smoking has also been associated with an increase in LDL levels, with LDL oxidation, and elevated blood glucose levels (Smith et al., 2009). This cluster of medical effects makes the smoker more susceptible to the formation of plaque in the blood vessels and prone to clot development that may lead to a heart attack or stroke.

According to Smith et al. (2009), 30 percent of firefighters who retired because of CVD were smokers and an estimated 10 percent of active firefighters continue to smoke. A firefighter that continues to smoke has a significantly higher risk for a fatal cardiac event as compared to a nonsmoking firefighter (Geibe et al., 2008).

In 2005, the AHA (2009) estimates that one in three US adults (73,000,000) have high blood pressure (HBP). HBP is defined as systolic pressure of 140 mmHg or higher and a diastolic pressure of 90 mmHg or higher or if the subject is taking antihypertensive medications to manage their blood pressure (AHA, 2009).

HBP has no specific symptoms so it usually goes untreated for many years (Smith et al., 2009). A study among 334 firefighters found that 20 percent had HBP when at rest and another 20 percent were pre-hypertensive as defined by AHA (Smith et al., 2009). A follow up study after four year showed that HPB increased by 23 percent and that 80 percent of the firefighters were not receiving treatment; they all received annual physical examinations and were encouraged to follow up with their personal physicians for follow up care (Smith et al., 2009).

The NVFC screenings between 2005 and 2007 found that 6.2 percent of the firefighters tested had Stage II Hypertension (Systolic blood pressure greater than 160), 28.9 percent had Stage I Hypertension, and 48.0 percent were pre-hypertensive; they reported that only 16.9 percent of the firefighters tested had normal blood pressure readings (Fahy et al., 2009). The results from the 2008 screenings were presented in a different format, 27.9 percent of participants were hypertensive and 49.6 percent were pre-hypertensive; the most encouraging statistic is that in the 2008 screenings 22.5 percent of the participants had normal blood pressure readings (Fahy et al., 2009).

The relationship between hypertension and CVD is direct and independent of other risk factors (Smith et al., 2009). High blood pressure damages the blood vessels and the heart; chronic hypertension leads to permanent changes in the structure of the heart (left ventricular hypertrophy) because of the increased workload (Smith et al., 2009). Firefighter autopsies in a recent study indicate that 56 percent of the LODD had evidence of left ventricular hypertrophy that increases the risk of arrhythmia and is a strong predictor of cardiovascular mortality (Geibe et al., 2008).

In the United Kingdom (UK), most medical providers still use the Framingham Model, but UK researchers say this model over-predicts the risk and identifies the wrong people for treatment (Nainggolan, 2007). Critics further complain that the Framingham model underestimates the risk in women (by about 10%) and minorities that leads to over treatment of some groups and under treatment in others (Nainggolan, 2007).

British scientists have developed a new CVD risk model they say better reflects the risk of people living in the United Kingdom (Nianggolan, 2007). The QRISK was developed using research data from over one million United Kingdom (UK) residents tracked over a 10-year period; the QRISK CVD calculator (www.qrisk.org), like the Framingham Model, uses age, sex, cholesterol/HDL ratio, and systolic blood pressure to calculate CVD risk (QReasearch, 2009). In addition the QRISK calculator also includes body mass index (BMI) and family history to form what QResearch (2009) believes is a more holistic and reliable set of parameters for accurately assessing CVD risk in UK populations.

Ancel Keys, in 1972 found the BMI to be the best proxy for calculating the percentage of body fat and that neither bioelectric impedance or height-weight tables provides no appreciable advantage over BMI in clinical practice (National Institute of Health [NIH], 2000). Adolphe Quetelet, a Belgian mathematician, developed the Quetelet Index or BMI in the mid 19th century (Wikipedia, 2000); to estimate BMI, the provider should multiply the individual's weight in pounds by 703 then divide by the height in inches squared which yields kilograms per meter squared (kg/m^2) which is the format used in medicine (NIH, 2000).

According to the NIH (2000), waist circumference, which measures excess abdominal fat, is an important independent risk factor for disease and that the measure of hip to waist ratio provides no predictive advantage over waist circumference alone. Waist circumference is particularly useful in patients who are classified as normal or overweight by the Quetelet Index;

however, waist circumference provides no more accurate predictions in individuals with BMI greater than or equal to 35 kg/m^2 (NIH, 2000).

The Quetelet Index for men, a BMI of less than 18 kg/m^2 is underweight, 18.5 to 24.9 kg/m^2 Normal weight, 25 kg/m^2 to 29.9 k/m^2 overweight, and 30 kg/m^2 and above obese; men with waist circumference of greater than 40 inches are at higher risk for CVD, diabetes, HBP, and other diseases (NIH, 2000).

Statistics published by the AHA (2009), in 2006 over 66 percent (145 million) of American adults were classified as overweight based on BMI scores. Based on 2006 statistics, the AHA (2009) further estimates that 33.9 percent or 74 million Americans adults were classified as obese. The AHA reports on two studies, the first estimates the annual medical expenditures on overweight and obese patients at $92.6 billion in 2002 dollars; the second study estimates $117 billion spent in 2001 dollars (AHA, 2009). By all assessments overweight and obesity takes a heavy toll on the health of American public and has significant impact to US health care costs.

A study of firefighters conducted between 1996 and 2001 evaluated the prevalence of obesity among male firefighters. The findings are sobering; over the five-year period the percentage of obese firefighters increased from 35 percent of 45 percent over the study period (Soteriades et al., 2005). Further, firefighters in the study gained approximately one pound per year of active duty and those with a BMI at or above 35 gained an average of two pound per year (Soteriades et al., 2005).

The 2005 NVFC data on approximately 2000 firefighters tested for body fat, found that 44.7 percent were obese (defined as 25 percent of more of body fat for men); data collected in

2008 showed that 25.1 percent were classified as overweight while 49.6 were at high risk for obesity (Fahy et al., 2009).

The magnitude of risk face by obese firefighters is significant compared to other predictors of fatal CHD events such as smoking, previous CHD and hypertension (Geibe et al., 2008). The National Institutes of Health [NIH] (2009) considers a BMI or over 25 kg/m^2 to be overweight and over 30 kg/m^2 considered obese. The risk of CVD increases as BMI increases.

The QRISK Model, mentioned earlier, also includes family history as a parameter when calculating a patient's 10-year risk for CVD (QReasearch, 2009). Although not part of the Framingham Calculator, the FHS recognizes that premature atherosclerotic heart disease (ASHD) in a parent or sibling doubles the risk for CVD independent of other risk factors (AHA, 2009). A family history of CVD is defined by the AHA, as the death of a parent or sibling from CVD before the age of 55 for men and before the age of 65 for women (Smith et al., 2008).

A firefighter with a pre-existing history of CVD is a strong independent predictor of mortality; a pre-existing history is defined as an abnormal stress test, history of coronary artery bypass, coronary angioplasty or myocardial infarct (Geibe et al., 2008). When "comparing professionally-active firefighters with those experiencing on-duty CHD events, previous CHD diagnosis was associated with roughly 15-fold and 9-fold increase in the risk of on-duty CHD death or disability retirement due to heart disease respectively, after adjustment for other risk factors (Geibe et al., 2008, p. 588)."

Based on a review of LODD cases some primary care physicians and cardiologist released firefighters to full duty and did not consider the occupational hazards and physical demands of a professional or volunteer firefighter (Geibe et al., 2008). For example, due to severe CVD, a 55 year old Captain was placed on restricted duty by the fire department after failing to successfully complete a physical ability test (PAT) and medical evaluation; his personal physician cleared him to full duty with no restrictions; unfortunately this fire department did not require the fire department physician to review such cases and the Captain died while retaking the PAT in an attempt to return to full duty (Hale, Jackson, and Baldwin, 2007). The value of a physician that understands the strenuous nature of fire suppression and emergency response is difficult to over state; the role of the fire department physician in the evaluation of firefighters and their fitness for duty can have a significant role in saving the lives of firefighters.

The Systematic Coronary Risk Evaluation (SCORE) system has been adopted by the Joint European Societies guidelines for CVD (De Backer et al., 2003). The SCORE Model (which utilizes the HEARTSCORE algorithm) predicts the 10-year risk for fatal CVD events; however some critics say it may underestimate the patient's total CVD risk (D'Agostino et al., 2008). The HEARTSCORE (HS) calculator (www.heartscore.org) is based on a large data set of prospective European studies and can estimate the risk of a fatal CVD event over a 10-year period; it is also possible to produce risk charts tailored for individual countries with reliable mortality information (De Backer et al., 2003).

The SCORE system estimates a 10-year risk for fatal CVD event in an individual; that risk can be extrapolated to the age 60 for healthy asymptomatic subjects (De Backer et al., 2003). The ability to project CVD risk is of particular importance for guiding young adults (such as young firefighters) at a low absolute risk but may already with an unhealthy profile (De Backer et al., 2003). This model uses same risk factors as the Framingham Model (gender, age, blood pressure, total cholesterol, and smoking status); however the SCORE system has several specific qualifiers (family history, elevated cholesterol levels, HBP, diabetes etc) that further stratify patients into high or low risk categories (De Backer et al., 2003). It can be tailored to define the specific risk associated with any one of the 12 European countries that participated in the original study (De Backer et al., 2003).

The SCORE system calculates a five-fold increase risk for a fatal CVD in diabetic women and a three-fold increase for diabetic men (De Backer et al, 2003). In the U.S., the number of adults diagnosed with diabetes as estimated by the AHA (2009) is 7.7 percent (17 million) with an additional 6.4 million (2.9 percent) American adults that are undiagnosed. Type II diabetes represents 90-95 percent of all American adults diagnosed with the disease (AHA, 2009). At least 65 percent of diabetics will die from CVD or stroke; adult diabetics have two to four times the death rates from CVD than non-diabetics (AHA, 2009).

The NFPA 1582 recommends that firefighters should be screened for diabetes before joining the fire department and has with very specific guidelines for monitoring firefighters with Type I or Type II diabetes (NFPA, 2007). Among the 5,065 firefighters that participated in the NVFC program between 2006 and 2007, 2.7 percent were found to be diabetic (non-fasting blood glucose levels greater than or equal to 200 mg/dL) but an additional 5.9 percent pre-diabetic with levels between 140 and 199 mg/dL (Fahy et al., 2009).

NIOSH conducted investigations at 131 fire departments for CVD related LODD. Seventy one percent of the fire departments conducted (pre-employment) candidate medical evaluations and 31 percent conducted annual or periodic medical examinations on all firefighters involved in fire suppression (Hale et al., 2007). Given the level commitment of medical surveillance documented in this study, it maybe implied that there are many cases of undiagnosed diabetes in the fire service that compare to the national average.

The Reynolds risk score (www.reynoldsriskscore.org) was recently published and developed to predict CVD in women; this model incorporates family history of CVD and is one of the first models to include the biomarker high sensitivity C-reactive protein (hs-CRP) levels as a parameter for CVD risk assessment (D'Agostino et al., 2008). The SCORE model uses hs-CRP, but it is used as a high or low risk qualifier and not a basic parameter.

The role of inflammation as a key mechanism in the pathogenesis and development of atherosclerosis and the evolution of an acute atherothrombotic CVD events are well documented by clinical research (Lloyd-Jones, Liu, Tian, and Greenland, 2006). C-reactive protein (CRP) levels has been shown to predict MI, peripheral arterial disease and sudden death; its pro-inflammatory, proatherogenic effects in the endothelial cells has led to positive statements from both the AHA and the Centers for Disease Control (CDC) recommending parameters for CRP levels in individuals as risk for CVD (Devaraj, O'Keefe, and Jialal, 2009).

The success of the Framingham Risk Score does seem to minimize its limitations. For example, 20 percent of all CVD events occur among subjects that have no identifiable risk factors such as high cholesterol; further Framingham scores do not translate to absolute risk across all populations (Ridker, 2009). Therefore, the identification of asymptomatic individuals at high risk for developing CVD is a critical issue in primary preventative medicine (Ridker, 2009).

According to Ridker (2009), 22 prospective studies of hsCRP and the risk of future CVD have all been positive; the Framingham Heart Study provided support for hsCRP as an independent predictor of vascular thrombotic events. The data supports the conclusion that hsCRP levels of less than one (low risk), one to three (moderate risk), and greater than three mg/L (high risk) for CVD is most useful for patients classified as an intermediate risk by the Framingham Model (Ridker, 2009).

A study of 122 firefighters participating in live fire testing was also evaluated for early indicators for CVD; the mean CRP values were 1.57. Twenty percent of the firefighters had levels between one and three, a moderate risk, while 14 percent had CRP values greater than three putting them at high risk for a CVD event (Smith et al., 2008). The use of CRP as a novel marker for inflammation may enhance our ability to identify patients with acute coronary syndromes (ACS) or those at high risk for future CVD events; individuals presenting with elevated levels of inflammation may benefit from aggressive lifestyle modification and preventive drug therapies (Blake and Ridker, 2003).

The AHA (2009) reports that physical inactivity increases the relative risk of CHD and is responsible for 12.2 percent of the heart attack burden worldwide. Since sudden death may be the first manifestation of CHD, a major medical challenge is to identify the seemingly normal person at increased risk for sudden death (Jouven et al., 2005).

Laukkanen et al. (2001, p. 823) stated that “Poor cardio-respiratory fitness was comparable with elevated systolic blood pressure, smoking, obesity and diabetes in importance as a risk factor for mortality.” A study of 1,294 men, aged 42 to 60 years old, participated in a Finnish study that measured cardio-respiratory fitness as maximal oxygen (VO_2 max) uptake and exercise test duration (Laukkanen et al., 2001). The researchers concluded that “maximal oxygen uptake and exercise test duration represents the strongest predictors of mortality in this cohort (Laukkanen et al., 2001, p. 823)”

Another study conducted on 5713 asymptomatic working men between the ages of 42 and 53 without clinically detectable CVD underwent a standardized graded exercise testing;

resting heart rates were measured, heart rates were increased to peak exercise level (220-age), and heart rates were measured one minute after termination (cool down) of exercise (Jouven et al., 2005). During the 23 year follow up, the findings reported in this large group of seemingly healthy volunteers indicates that heart-rate profile during exercise and heart rate recovery during cool down were strong, independent predictor of sudden death; the strongest predictor of sudden death was a slower increase in heart rate (Jouven et al., 2005).

Autonomic imbalance is a term used to indicate a decrease in vagal tone or an increase in sympathetic activity and has been associated with an increase risk of death from CVD and from arrhythmic causes; the risk of death increased when there is a reduction in “tonic or reflex vagal activity” (Jouven et al., 2005, p. 1952). The research data also support the theory that autonomic imbalance may precede other indications of CVD and may contribute to the early identification of persons at high risk for sudden death from heart disease (Jouven et al., 2005).

Studies of the prognostic implication for changes in heart rate (HR) during exercise have been evaluated but the prognostic value of heart rate recovery (HRR) or HR decline was the goal for a group of 2428 patients in the study conducted by Cole and his colleagues (Cole, Blackstone, Pashkow, Snader, and Lauer, 2009). After achieving peak workload (220 – age), patients spent two minutes in a cool down period (recovery period); the value for heart rate recovery was defined as the heart rate one minute after termination of peak exercise (Cole et al., 2009) During the six-year follow up, abnormal HRR (less than or equal to 12 beats per minute after a one minute cool down) was a strong predictor of death (19 percent versus 5 percent); also a failure to use 80 percent of heart rate reserve was an independent predictor or mortality (Cole et al., 2009). Cole et al. (2009) reported that HRR was rapid in athletes and blunted in heart failure patients so they concluded that HRR after exercise is a significant predictor of mortality.

The use of treadmill exercise score and HRR as a predictor for mortality was also confirmed by a study of a cohort consisting of 9454 patients (Nishime, Cole, Blackstone, Pashkow, and Lauer, 2009). The conclusion appears to support the findings reported above, in that HHR (parasympathetic activation) is an independent predictor for all causes of mortality in patients referred for stress tests and among healthy adults in a population based group and should be incorporated in exercise test interpretation (Nishime et al., 2009).

Structural firefighting is a physically demanding profession; the combination of strenuous physical work while wearing heavy, highly insulating personal protective equipment (PPE) in a hostile environment results in significant physiological strain that affects nearly every organ system in the body (Smith et al., 2008). The greatest risk to the firefighter is the cardiovascular and thermal strain; suppression activities in most fire departments accounts for about two to five percent of work activity but accounts for 32 percent of firefighter LODD (Smith et al., 2009). A firefighter is 12 to 136 times more likely to die during fire suppression than during non-emergency duties (Smith et al., 2008).

Given those risks, physical and cardiovascular fitness should be a priority in the fire service; however, of 154 fire departments surveyed after a LODD, 41 percent had fitness programs and 10 percent required participation by all suppression personnel (Ridenour et al., 2008). Firefighter fitness improves the capacity for physical work, improves endurance and cardiovascular capacity; aerobic fitness has important benefits such as increased efficiency of the heart, improves work capacity, improves thermal tolerance, provides cardiovascular protection by enhancing anti-clotting activity of the blood, and enhances the ability of blood vessels to dilate to allow more blood supply to the muscles (Smith et al., 2008).

A study conducted by Smith et al. (2008) consisting of 122 firefighters conducted two simulated firefighting activities nine minutes in length in full PPE including breathing apparatus; the participants had a complete physical examination and laboratory samples collected before and after the evolution. The physiological and hematological results reported showed a two percent increase in core temperature and an 80 percent increase in heart rate; significant signs of dehydration and most important, an increase in the coagulation activation markers (Smith et al., 2008). These results suggest an increase in clotting potential following firefighting activity and that coagulatory and fibrinolytic systems are disrupted by such activities (Smith et al., 2008).

There are no clear guidelines for the stress testing of asymptomatic individuals, even for firefighters, however primary CVD prevention should start with physical fitness promotion (Kales et al., 2003). Kales et al. (2003) reports that comprehensive programs have demonstrated beneficial effects on firefighter risk profiles and scientific evidence strongly links increased physical fitness to decreased cardiovascular risk and overall mortality in the general population.

The role of toxic gases, particulates and other products of combustions were deliberately avoided during this research. Based on the parameters discussed in the ED program, the researcher believes if those subjects were included, this APR would extend beyond what may be considered a reasonable scope.

Procedures

The descriptive research method was utilized for this Applied Research Project to gather and analyze available data that may be beneficial to firefighter safety by preventing CVD in firefighters. The methodology used focused scientific research published in peer reviewed journals and other scientifically relevant bodies that outline emerging trends in CVD risk assessment in the general public that could be adopted within the fire service. This data was used to develop a medical surveillance protocol to better identify the firefighters at the greatest risk of a sudden death secondary to CVD event while on duty.

The initial research for this project was conducted on the Internet utilizing www.scholar.google.com to survey the quality and quantity of information available from articles, journals and other Internet Sites. Research was conducted using keywords such as 'firefighter fatalities,' 'cardiovascular disease in firefighters,' 'predicting sudden death in firefighters,' 'exercise tolerance and sudden death,' 'firefighter fatalities and sudden death events,' and various combinations to locate and evaluate the most relevant references.

Further research was conducted at the following Internet sites: www.americanheart.org, www.cdc.gov, www.who.int, www.qrisk.org, www.niosh.gov, www.framinghamheartstudy.org, and www.nfpa.org. These articles and Internet Sites proved indispensable in formulating a clear understanding of the risks that firefighters face from CVD and sudden death cardiac events. Additional research was conducted at Florida Atlantic University Libraries for journals and other reference reports that were not readily available online.

In order to establish the demographic of BRFRS members, a sample of birth dates was collected for suppression personnel (C. Freeman, personal conversation, September 20, 2009). Microsoft Excel was used to construct a frequency distribution of age groups at 5 year intervals. The final data was presented in a bar graph form in figure 1 that shows that 47 percent of the sample group are aged 40 years old or above and 70 percent are 35 years old or above. The majority of the suppression members are approaching the most dangerous age group for CVD risk factors in a firefighter's career.

The PAT evaluation process and the annual medical evaluation checklist were reviewed and compared to the predominant consensus standard, NFPA 1583 and NFPA 1582 respectively.

Data from PAT conducted between 2005 and 2009 were collected for analysis. The data was previously entered into a spreadsheet which facilitated the summarizing of $V_{O2\ max}$ and percentage of body fat for the Department, which is summarized on figures 2 and 3, respectively.

Results

The descriptive research method allowed for the discovery of a large amount of scientific data to answer the four research questions to be considered in this applied research project.

Question 1: What are the most reliable diagnostic tools available to measure the extent of incipient cardiovascular disease in BRFRS personnel?

The traditional risk factors such as age, gender, smoking, HBP, hypercholesterolemia, obesity and lack of exercise has been shown by standard statistical methods, to increase the firefighter’s risk for a CVD event (Hale et al., 2007). The need for diagnostic tools that will accurately identify those firefighters at greatest risk for CVD continues to be a critical challenge for primary care providers (Ridker, 2004). The prognostic value of CVD risk factors and exercise tolerance to evaluate the risk of a fatal cardiac event is well supported in the literature, however reliability of such indicators as diagnostic tools is subject to debate by medical researchers.

When evaluating a firefighter for coronary artery disease, the NFPA (1582, 2007) requires the physician to assess the disease using a stress test with imaging and/or a coronary angiogram with an assessment of left ventricular function. This researcher considers this method of CVD evaluation to be the most reliable diagnostic process for determining the extent and physiological impact of CVD on the firefighter performing fire suppression and other emergency response activities.

The decision to use coronary angiograms or cardiac catherization for assessing CVD can be guided by prognostic information gleaned from a patient’s exercise test results (Greenland et al., 2001). Other diagnostic tools being evaluated are ankle-brachial index (the ratio of systolic blood pressure between ankle and brachial arteries), ultrasound evaluation of the carotid artery shows promise in patients older than 50 years of age, and the use of electron beam tomography in patients 50 year of age or older maybe of diagnostic value (Greenland et al., 2001).

In addition to the traditional group of risk factors, scientific evidence supports inflammation as a key pathogenic mechanism in the development and progression of CVD and biomedical markers for inflammation may have a significant role in assessing the potential for future CVD events (Lloyd-Jones et al., 2006). CRP correlates to the Framingham high and low risk scores; but this biomarker seems to be most effective at discriminating and categorizing patients that fall into an intermediate risk by the Framingham model (Lloyd-Jones et al., 2006). The firefighters who receive an intermediate score by the Framingham Model and have a CRP level greater than 3.0 mg/L may indicate a high risk for CVD and the need for aggressive preventative therapy (Lloyd-Jones et al., 2006).

Firefighters with untreated hypertension are at higher risk for CVD and sudden death. Firefighter autopsies revealed that 56 percent of the victims had evidence of hypertension; this condition altered the physical structure of the heart and increased the risk individual's of arrhythmia; left ventricular hypertrophy is also strong predictor of mortality in the United States (Geibe et al., 2008). Regular evaluation of a firefighter's blood pressure is a simple yet important tool to identify and monitor chronic hypertension, which often goes untreated by firefighters (Smith et al., 2009).

Given the strenuous nature of firefighting, exercise tolerance appears to be the strongest independent indicator of CVD. According to the NFPA (1582, 2007), a firefighter with a maximal exercise tolerance of less than 12 METS may be an indication of coronary artery disease and would require further cardiac studies of cardiovascular function and health.

Physical ability testing that includes a cardio-respiratory profile indicates low cardio-respiratory fitness has consistently been associated with an increased occurrence of premature death primarily due to CVD (Laukkanen et al., 2001). Autonomic imbalance, the inappropriate activation or deactivation of the sympathetic or parasympathetic system, is an ominous indicator and maybe the earliest sign of a firefighter at high risk for sudden death (Jouven et al., 2005). Studies indicate that abnormal HRR after exercise (inappropriate activation of the parasympathetic system) is a significant predictor of mortality in all populations tested (Cole et al., 2009).

There are no clear guidelines for stress testing asymptomatic individuals; CHD prevention should be grounded with an effective and consistent physical fitness program (Kales et al., 2003). A comprehensive physical fitness program has demonstrated beneficial effects in the reduction of all causes of mortality in the general population (Kales et al., 2003) and can have direct benefits in the preservation of the health of BRFRS personnel.

Question 2: How reliable are the cardiovascular risk assessment calculators in predicting cardiovascular disease in BRFRS personnel?

The Framingham Risk Assessment Tool was the first attempt by evidence based medical researchers to develop a comprehensive risk analysis tool for CVD (FSH, 2009). The Risk Assessment Tool uses seven parameters to estimate the risk of CVD and has been the recognized world wide standard for CVD risk calculators (FSH, 2009). Kales et al. (2003), found that using Framingham Risk Assessment Tool, the predicted CHD risk in these firefighters (hazardous materials team members in Massachusetts), and the results were essentially identical to that of an average person of the same age from that community.

Critics of the Framingham Risk Assessment Tool argue that it underestimates CHD risks in women and minorities and over predicts the risk in men (Nianggolan, 2007). In addition, 20 percent of CVD events occur among patients with no risk factors assessed by the Framingham Risk Assessment Tool (Ridker, 2009).

British scientist developed the QRISK calculator to address the limitations of the Framingham Risk Assessment Tool that was specific to people living in the UK (Nianggolan, 2007). The QRISK calculator uses all seven of the Framingham parameters and adds two additional factors, BMI and family history (QResearch.org, 2009). The limitation of the use of QRISK calculator in the United States (U.S.) is the lack the statistically validated data for its algorithms based on U.S. populations.

The SCORE system, developed and adopted by European scientists, produces a 10 year risk for CVD assessment that can be used to project an apparently healthy, asymptomatic individual's risk to age 60 (De Backer et al., 2003). This flexibility would be invaluable to the fire service as a tool to assess the risk for new firefighters and give the department an opportunity to develop a specific wellness program to minimize the potential for a catastrophic CVD event during the career of a typical firefighter. The limitation for the SCORE system is again the validation of its algorithms in the local demographic.

The Reynolds Score is designed to predict CVD in women; this model is one of the first to include biomarkers for inflammation as a parameter for risk calculation (D'Agostino et al., 2008). There are few CVD assessment tools designed specifically for women therefore the

Reynolds Score may become a part of the standard of care for female subjects in the community as well as the fire service.

The Framingham Risk Assessment Tool appears to be the most reliable based on clinical experience and its worldwide acceptance; however, it has significant limitations that should be considered for subjects with a cluster of CVD risk factors that may put them at extraordinary risk. An intermediate risk classification by the Framingham Risk Assessment Tool, minorities and women are demographics that are not well served by the Framingham Model so it may be prudent to consult other risk calculators for additional insight.

The SCORE system and the Reynolds Score show the most promise for use in female firefighters and would be invaluable to the fire service in addressing CVD risk in the women of the fire service. The ability to more accurately assess CVD risk in women and young adults and be able to project those risks over the span of a firefighters career would be a critical tool for the fire service and community in general.

Question 3: What precautions should be taken for other medical conditions that could potentially aggravate the risk for CVD in BRFRS personnel?

The most dangerous medical condition for a BRFRS firefighter is a pre-existing history of an abnormal stress test, coronary artery bypass graft or MI (Geibe et al., 2008). These conditions represent up to a 15-fold increase risk of sudden death in a firefighter involved in suppression activities (Geibe et al., 2008). The State of Florida has a presumptive clause for CVD in firefighters with proper medical surveillance and early detection, that risk can be minimal to BRFRS personnel.

The relationship between untreated or undiagnosed hypertension and CVD is direct and independent of other risk factors (Smith et al., 2009). The increase in cardiovascular workload leads to structural changes in the cardiovascular system that predisposes the firefighter to cardiac arrhythmia and premature mortality secondary to CVD (Geibe et al., 2008). Routine blood pressure assessment is critical to the health and safety of firefighters involved in suppression activities since they are prone to obesity and its accompanying cluster of CVD risk factors (Smith et al., 2009). Hypertension in firefighters should be diagnosed as early as possible and treated aggressively with appropriate medications given the specific occupational risks already outlined in the NFPA standards.

Diabetes presents a significant risk to the firefighter and the general public. According to the AHA (2009), diabetics are at two to four times the death rates of non-diabetics and at least 65 percent of diabetics will die from CVD or stroke. NFPA (1582, 2007) has very specific recommendations for firefighters diagnosed with Type I or Type II diabetes that will help minimize the risk of CVD from this disease in this group of firefighters.

Firefighters involved in suppression with a low exercise tolerance or an abnormal autonomic response is at extraordinary risk for disability or death (Smith et al., 2009). NFPA (1582, 2007) provides specific fitness assessment guidelines for members of a suppression team that are critical to firefighter safety and survival.

Medical conditions that have the potential to precipitate or exacerbate diseases involving the cardiovascular system require medical surveillance by a knowledgeable physician (Hale et al., 2007). Personal physicians should not be allowed to clear a firefighter for full duty; the fire department physician should be required to clear firefighters for duties involving fire suppression and emergency response (Hale et al, 2007).

Question 4: What are the recognized statistically validated guidelines for the medical surveillance of cardiovascular disease for BRFRS personnel?

The analysis of the annual medical examination checklists confirms that the physicals are fully NFPA 1582 compliant with a few exceptions (M. Barker, personal communication, September 2, 2009). Breast and gynecological examinations for female firefighters have been excluded as well as mandatory age defined stress tests for all firefighters (personal communication with M. Barker, September 2, 2009). Current BRFRS protocols require annual stress test for hazardous materials team members or as requested by the BRFRS physician during annual medical evaluations (P. Kelly, personal communication, August 13, 2009). In 1984, the City of Boca Raton joined the Heart Healthy Program developed by the University of Miami School of Medicine and Metro-Date Fire Rescue (Metcalf, 2002). The program objectives were to raise firefighter awareness of heart disease and to encourage a heart healthy lifestyle (Metcalf, 2002).

The role of inflammation in the development and severity of CVD has been well documented in this research project. CRP may serve as an early warning system and may help identify firefighters with the greatest need for preventative intervention. The addition of CRP to the annual medical examination should of minimal cost to the fire department or to the individual firefighter.

According to the Framingham Risk Assessment Tool, age is a risk factor for CVD and certain age groups are at greater risks for CVD events as the number of risk factors increase or cluster. Firefighters performing suppression activities require near maximal physical exertion that has been shown to precipitate CVD events in at-risk subjects. The early identification of CVD with stress tests may be the best strategy for survival.

It is the opinion of this researcher that firefighters involved in suppression and emergency response with significant independent risk factors or clusters of risk factors for CVD such as

HBP, diabetes, family history, low exercise tolerance or an abnormal HRR profile should begin stress testing earlier than those at average risk. Early identification and diagnosis with biannual stress tests will facilitate early intervention and attenuation of any extraordinary hazard for CVD and sudden death.

The fire department physician shall be required to confirm that firefighters assigned to suppression duties with the conditions listed above are able to safely perform the duties assigned to them. Firefighters may be referred to an employee assistance program for useful strategies designed minimize the consequences of cardiovascular risk factors with the consent of the fire department physician.

Discussion

Emergency response and suppression activities are physically demanding and have adverse effects on the body and its systems (Smith et al., 2008). Fire suppression activities are more likely to cause fatalities to occur in individuals with underlying CVD, whether the condition is diagnosed or undiagnosed (Kales et al., 2007). According to Smith et al., (2009) strategies to lessen CVD fatalities in the fire service must address the following: identify individual risk factors that place firefighters at increased risk for sudden cardiac events and identify conditions associated with firefighting that may trigger a cardiac event in a susceptible individual.

The risk of CVD varies widely among heterogeneous populations which causes traditional risk assessment calculators to miss approximately 20 percent of the subjects that will eventually succumb to heart disease (Ridker, 2004). The Center for Disease Control published several recommendations to minimize the effects of CVD risks in fire service personnel: the fire department needs to provide pre-employment medical evaluations to ensure that candidates are physically capable of performing job tasks, ensure that the fire department physician understands the physical demands of the job and follows the recommended standards developed by the fire service, and implement a comprehensive wellness program for firefighters to reduce the risks of CVD and improve cardio-respiratory capacity (Hales, 2008).

The research implied the need to educate firefighters of the modifiable CVD risk factors and how preventative efforts impact health and longevity. The fire department should encourage firefighters to maintain cardiovascular fitness as a crucial part of long-term health and safety and maintain a metabolic capacity of at least 12 MET to reduce all of the modifiable CVD risk factors. Firefighters must sure that they are fit for duty and make it their personal responsibility to maintain a healthy life style (Smith et al. 2009).

The Heart Healthy program mentioned earlier has been adopted by BRFRS and became mandatory for all firefighters although there are some important exemptions. The Firefighters of Boca Raton, Local 1560 negotiated in their Bargaining Agreement that a firefighter's PAT results will be evaluated based on department averages and not the national standards (Agreement between the City of Boca Raton and the Firefighters of Boca Raton Local 1560, IAFF Inc [IAFF], 2008). Failure to meet the Department's fitness standard would result in a prescribed 16-week fitness program, and physical fitness shall not be the basis for disciplinary action (IAFF, 2008). In addition, the measure of body fat was based on Boca Raton Community Hospital guidelines (IAFF, 2008) although the method (skin fold test) is consistent with the NFPA 1582 Standard (2007).

The analysis of the data collected based on the current PAT program shows inconsistent and an incomplete data. Documentation was found to be haphazard with large blocks of missing data. The data for 2008 could not be found and the 2009 data set was incomplete. The most complete data was between 2005 and 2007 although the whole Department was not represented in the data. The most complete data set (2005 to 2007) was used to calculate the V_{O2max} and the percentage of body fat calculation used for this project.

The perception among the firefighters is that the data is of no used and is not reviewed by the administrative staff (P. Kelly, personal communication, September 20, 2009). To correct this perception, the proposed SOP requires the Wellness Committee to review the data and generate a written report annually to be distributed within the Department.

The results of the analysis of percent body fat in the BRFRS personnel showed that between 2005 and 2007 the average percentage of body fat was approximately 20.5 (see figure 3) percent and approximately 23 percent of the department had a body fat greater the 25 percent. The percentage of body fat in the firefighters in the data trended down, from an average 27 percent in 2005 to an average of 19 percent in 2007. Although a 10 percent drop in body fat is significant, the data is unreliable and needs to be verified.

The analysis of metabolic capacity of the firefighters over the same time period is shown in figure 2. Average V_{O2max} recorded in the three years between 2005 and 2007 was 27; again results seem to trend up from an average of 27 in 2005 to an average of 29 in 2007. This may also be an artifact of the data and should be verified. Laukkanen et al. (2001, p. 829) stated "low V_{O2max} (less than 27.6 mL/kg per minute or 7.9 METs) was associated with a 2.76 fold risk of overall mortality after adjusting for age, examination years, smoking and alcohol consumption compared with men with a high V_{O2max} (> 37.1 mL/kg per minute)." Short exercise test duration was also associated with an increased risk of overall mortality; the relative risk of overall death was 2.72 in men whose exercise duration was less than 8.2 minutes compared with men whose exercise duration was more than 11.2 minutes (Laukkanen et al., 2001, p. 826). Physical ability testing data must record the duration of the test to help analyze firefighter risk.

The overwhelming impression from the literature that this researcher reviewed suggested that cardio-respiratory fitness is associated in reduced all-cause mortality rates. However, it cannot be implied that the PAT and autonomic imbalance indicators are infallible diagnostic tools that will reliably assess the presence or severity of ASHD in a particular individual or group, that is not the case. Some researchers report that an abnormal HRR profile has a sensitivity of 31 percent for ASHD although it provided additive prognostic information to the severity of angiographic coronary disease however, that risk of mortality appears to be independent of the subject’s ischemic burden (Viekananthan et al., 2003). Other studies have reported a higher correlation between exercise results and coronary disease validated by angiographic studies, but those studies are dated (the 1990s) and will not be considered by the researcher.

History of a previous MI places the firefighter at enormous risk for sudden death (Geibe et al., 2008). Regularly scheduled electrocardiograms are essential to identify undiagnosed disease and the potential for a fatal cardiac event. As the firefighter ages, the CVD risks factors increase and cluster (example obesity, with HBP, and elevated cholesterol an so on), so NFPA (1582, 2007) recommends stress tests for male firefighters above 45 year of age (55 year of age for female firefighters) with two or more risk factors, further the stress tests should be scheduled every five years.

It is this researcher’s recommendation that all BRFRS emergency response personnel have biannual stress tests (imaging based on the recommendation of the fire department physician) at age 40 year old or above. Individuals with two or more risk factors such as family history of CVD, diabetes, HBP, elevated cholesterol levels, smoking or with documented autonomic imbalance, should have biannual stress tests (imaging based on the recommendation of the fire department physician) beginning at age 35 or as directed by a knowledgeable physician. This recommendation is based on firefighter fatality patterns which indicate sudden death cardiac events peak for firefighters in their middle forty years (Fahy et al., 2008). Early detection and stratification of CVD risks based of identified risk factors should have a positive impact on the mortality statistics.

Recommendations

The research done to write this Applied Research Project demonstrates the need for further study into the causes and risks associated with CVD in the fire service and that medical surveillance of firefighters is a critical step in reducing the number of fatalities secondary to CVD. The level of physical exertion anticipated during suppression activities places additional burdens on the firefighter's cardiovascular system and could result in a cardiac event that may cause sudden death or permanent disability.

Based on this research, the researcher would recommend the following changes to the wellness program and PAT protocols:

1. Add the CRP test to annual medical examinations for all personnel involved in suppression activities. The test is inexpensive and it may serve as an early indication of the potential for CVD and need for therapeutic and lifestyle changes.
2. Biannual stress test for all firefighters 40 years old or above. Biannual stress tests for firefighters 35 years old or above with any two of the following conditions or as recommended by the fire department physician: BMI of 30 kg/m^3 or above, maximal exercise tolerance of less than 12 METs, diagnosed HBP, diagnosed as a diabetic, a

family history of CVD (as defined by this text), or an abnormal HRR profile during the PAT.

3. Adopt the expanded PAT data points outlined in the SOP. The additional metrics will allow BRFRS to more accurately compare fitness data from BRFRS personnel with the recommendations of the national consensus standards and other scientific research data.
4. Develop and require mandatory participation in Boca Raton Fire Rescue Services physical fitness program. An organized, well managed physical fitness program will encourage firefighters to view fitness as a critical part of their health and safety.
5. Implement the Firefighter Cardiovascular Disease Surveillance SOP. This SOP reflects the most current, published medical research in the surveillance and prevention of CVD and will formalize data collection and analysis in the BRFRS.
6. Augment the current wellness program with regular educational opportunities to raise awareness of the risks associated with CVD and teach strategies designed to minimize an individual's risks of a cardiovascular event. BRFRS should commit to at least one classroom presentation per calendar year.
7. Develop an Employee Assistance Program focused on physical fitness and a heart healthy lifestyle. There many organizations, private and public in this community that can offer assistance to BRFRS in developing and maintaining an effective wellness program, BRFRS should develop a business relationship that could be made available to firefighters needing special assistance with heath and fitness.

8. The Wellness Committee should review the PAT results and produce an annual report summarizing PAT results, any unusual or risky trends and recommendations how the program can be improved. The final report should be distributed within the rest of the Department so everyone can measure organizational progress.

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Figure 1

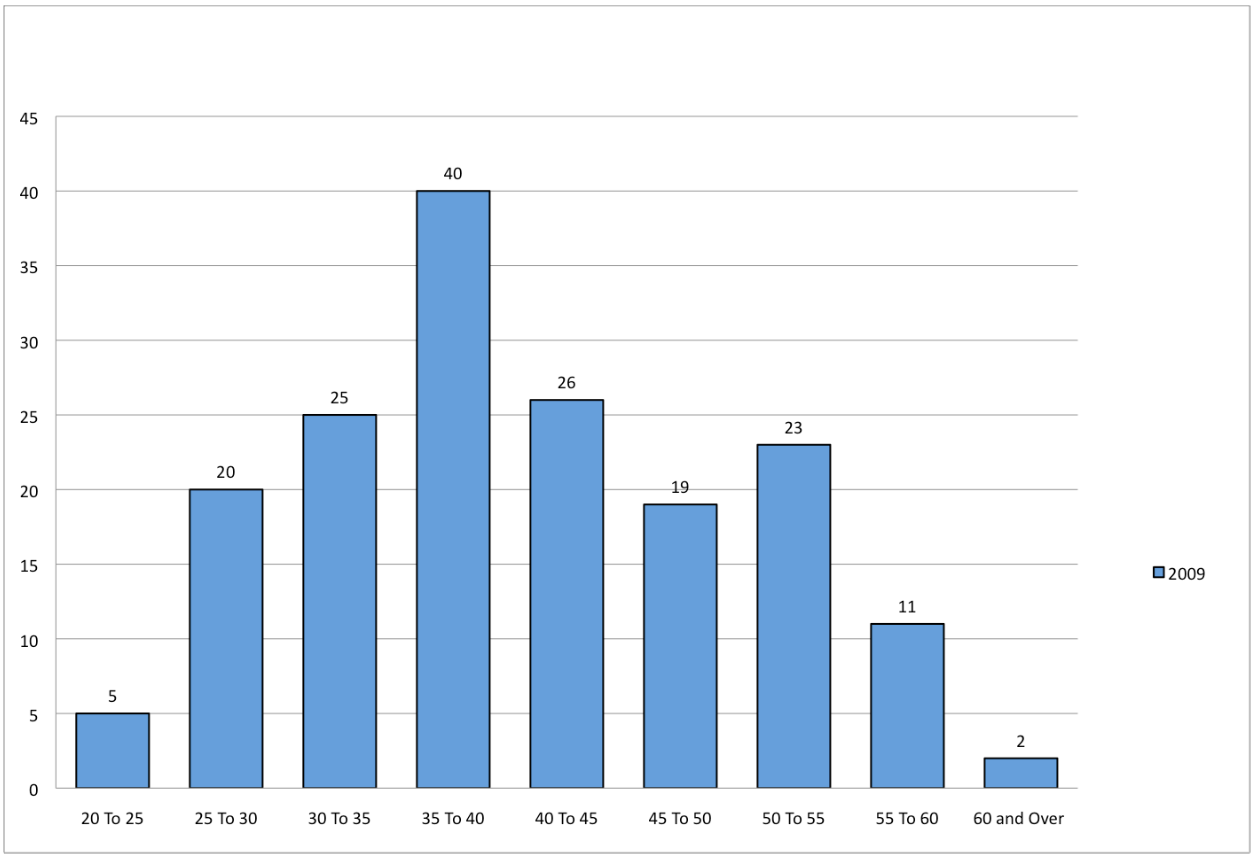

Figure 1. The age of BRFRS personnel arranged into groups in five-year increments.

Figure 2

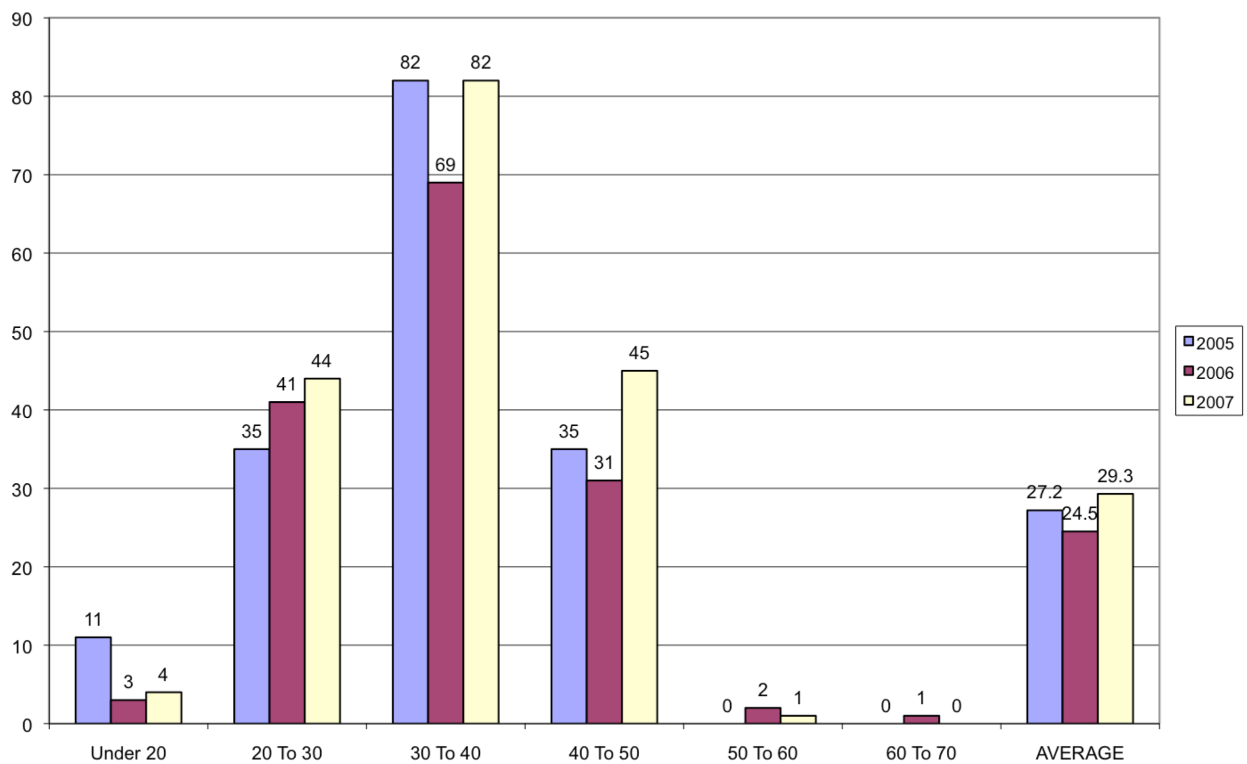

Figure 2. The results of the measurement BRFRS personnel's $V_{O2\ max}$ by year tested, grouped by increments of 10 mL O_2/min/kg. Department averages are on the far right.

Figure 3

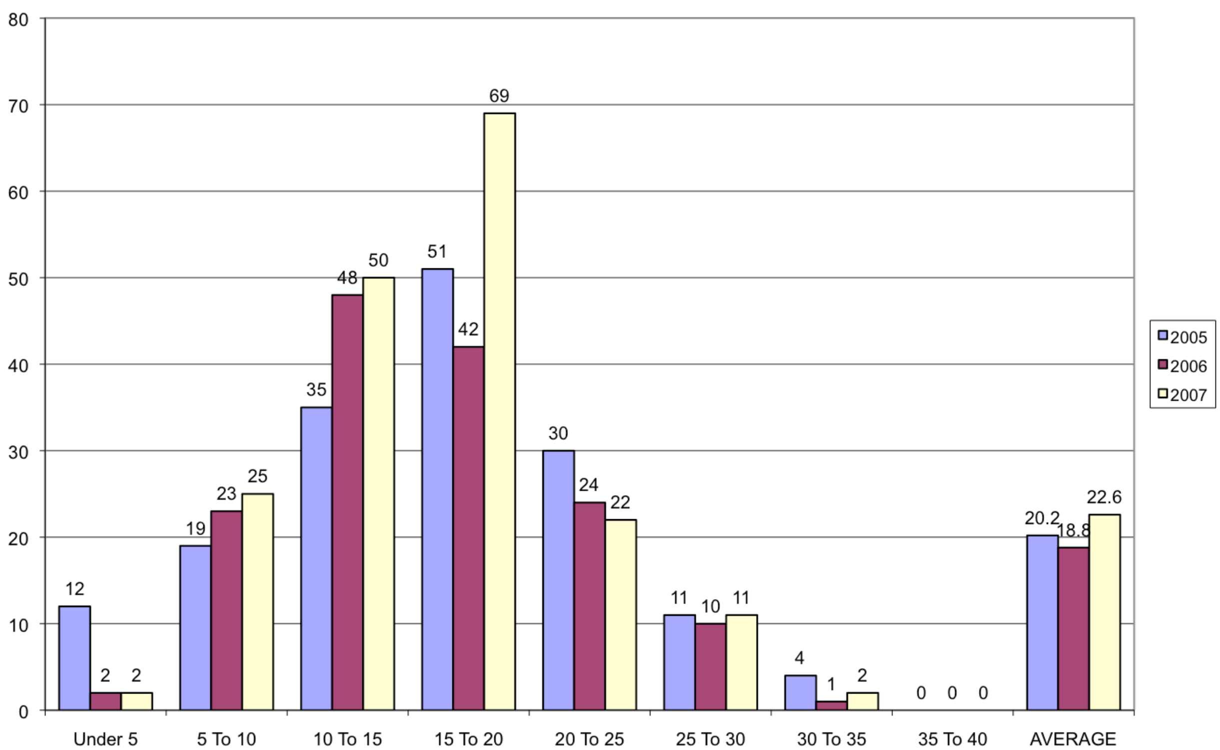

Figure 3. The results of the measurement BRFRS personnel's body fat by year tested, grouped by increments of five pounds. Department averages are on the far right.

Appendix

Boca Raton Fire Rescue Services Standard Operating Procedure __________________________ __________ **Fire Chief Signature** **Date**	**S.O.P. #: Pending** Effective: Revised: Page: 1 of 2

Division: Operations

Subject: **Physical Ability Testing and Cardiovascular Disease Surveillance**

Reference: NFPA 1500, 1582 &1583

Policy: Annual physical ability testing (PAT) shall be mandatory for all uniform personnel and shall conducted according to this procedure.

Scope: All Uniform Personnel

Procedure:

Physical ability testing shall be supervised by the Training and Safety Section and conducted in accordance with the most current Agreement Between the City of Boca Raton and the Firefighters of Boca Raton Local 1560, IAFF Inc. and University of Miami School of Medicine's Heart Health Project.

Medical resuscitation equipment such as an AED or cardiac monitor with an airway bag should be readily available at the testing site.

Conducting the Physical Ability Test

The firefighter will be allowed to wear comfortable clothing or gym clothes with athletic shoes.
The following data shall be recorded for each firefighter during the PAT:

- Employee Number
- Employee Name
- Date Tested
- Height
- Weight – candidate shall be weighed on a three beam scale
- Resting Heart Rate – if resting heart rate exceeds 110 bpm; direct the firefighter to a quiet place to relax for 5 minutes and retested. If no reduction occurred, cancel the test and contract the Training and Safety Section.
- Resting Blood Pressure - if resting blood pressure exceeds 160/100 mmHg direct the firefighter to a quiet place to relax for 5 minutes and retested. If no reduction occurred, cancel the test and contract the Training and Safety Section.
- Percent Body Fat as per Union Agreement
- Body Mass Index – calculated in excel spread sheet
- Maximum heart rate attained during the test
- Duration of aerobic capacity testing
- Heart Rate after 1 minute of cool down
- Heart Rate after 2 minutes of cool down
- Heart Rate after 5 minutes of cool down
- Vo_{2max}
- Grip Strength
- Push Ups
- Curl Up
- Flexibility

Boca Raton Fire Rescue Services Standard Operating Procedure	**S.O.P. #: Proposed** Effective: Revised: Page: 2 of 2

Termination:
The test may be terminated at any time if in the opinion of the training officer (or designee) it is unsafe to continue, the goal have been met or the firefighter wishes to stop.

Firefighters that are unable or unwilling to meet the minimum benchmarks shall be referred to the Training and Safety Section for counseling and follow up.

Reporting:
A summary report containing the PAT data shall be forwarded to the Fire Chief and the Wellness Committee. The report shall contain for following elements:

- Highlight firefighters that were not able to complete the PAT or could not be scheduled because of medical conditions or injury, annual leave, FMLA etc.
- Identify firefighters with a Vo_{2max} <27 mL/kg/min
- Identify firefighters with less than 8 minutes of aerobic capacity testing
- Identify firefighters with abnormal autonomic profile
  - Delayed recovery of less than 12 bpm decrease in heart rate after 1 minute of cool down
  - Unable to achieve target exercise heart rate [220 – age x .85]
- Indicate firefighters that are at risk for obesity using percentage of body fat results
- Trend blood pressure reading to identify firefighters that are at risk for hypertension

The Wellness committee will review the annual PAT results and submit a written analysis with recommendations to the Fire Chief for review and implementation.

Education:
The Training and Safety Section will purchase a variety of physical fitness training programs for the department library so that they can made available to firefighter who request them.

The Training and Safety Section will conduct a wellness training and education program at least once per year that is available for on duty training.