Training to Prevent Line of Duty Deaths Due to Stress and Overexertion

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An unsolvable problem?

Firefighting is and always has been an inherently risky profession, whether paid or volunteer. In fact according to the U.S. Department of Labor, firefighters are three times more likely to die on the job than any other occupation [1,2]. This is largely a known and accepted risk by anyone who is a part of the fire service. We will all willingly risk our lives to save a life. What is absolutely unacceptable, especially in this age of awareness and rapid innovation, is that the same preventable risk factors have been the leading cause of on-duty deaths for decades. On average over the last 25+ years more than half of line of duty deaths (LODDs) can be attributed to stress or overexertion causing sudden cardiac death [1,3]. The International Association of Fire Fighters (IAFF) has categorized these dominant contributing factors to line of duty deaths as health/wellness/fitness [4].

Despite substantial efforts to solve this ongoing problem, the statistics remain unchanged. And when expanded to include non-fatal cardiac events, they are considerably more alarming. An estimated 765 firefighters experienced heart attacks in 2005, with only 8.1%, or 62, resulting in sudden death [1, 2, 5]. That combination of fatal and non-fatal on-duty cardiovascular events affects almost 1 in 1,000 U.S. firefighters every single year [6]. Additional research has shown that for every fatal cardiac event, 17 additional non-fatal cardiac events occur among firefighters [7, 8]. Furthermore, these fatal cardiac events are occurring in firefighters who are younger than those in the general population experiencing the same events

[1, 3]. These trends have remained constant for decades. It is time for an immediate and monumental change in the fire service. It is time to save ourselves.

What happens when we answer the bell?

Every firefighter intuitively knows what happens when the fire alarm goes off and it is time to get ready to fight fire; or when you pull up on-scene and the fire and smoke are raging. The cardiovascular and respiratory stress of fighting fire begins with an increase in heart rate and minute ventilation, caused by a sympathetic nervous system-triggered adrenaline release, as soon as the alarm sounds [1]. The most physiologically and psychologically demanding tasks are usually associated with fire suppression and search and rescue [1, 7]. Accordingly, the greatest number of fatal cardiac events occurs on the fire ground. And risk of a fatal heart attack is 10-100 times higher during fire suppression compared to non-emergency tasks [4, 7]. In the relatively rare instance of finding and removing a victim, the combined physical and emotional stress drive the firefighters heart rates well above 100% of their predicted maximum and keeps it at that level for extended time periods [1].

Are we prepared for that stress?

The Indiana University research emphatically states, "*The discrepancy between the physical preparedness of firefighters and the high demand of firefighting stands at the center of fire service line of duty deaths* [1]." A wide range of studies have shown that approximately 75% of all firefighters are overweight, with up to 40% being classified as obese – including 33% of new recruits [6, 9-12]. These are numbers that exceed the general population of the US, in a profession that is counted on to physically perform at maximum levels of exertion [13].

Inactive firefighters have a 90% greater risk of myocardial infarction (heart attack) than those who are aerobically fit [13]. And firefighters with low aerobic capacity are 2.2 times more likely to sustain injury than their more fit peers [14]. Among unconditioned persons, stressful situations resulting in sympathetic and cardiovascular activation, such as firefighting, can "trigger" acute heart disease events [6, 15]. There are ticking time bombs in your fire department right now. And you are doing them, their families, and your fellow firefighters, the greatest disservice by allowing them to be complacent in their current state, which is at best unfit for duty.

What is VO2max and why is it the key to saving firefighters lives?

VO2max is the maximal oxygen uptake or the maximum volume of oxygen that can be utilized during maximal or exhaustive exercise; it is considered the best indicator of cardiorespiratory endurance [16]. VO2max has been consistently identified as an important factor in the association of firefighting demands and physiological requirements [1, 17, 18]. VO2max is measured in mL/kg/min, with the minimum level recommended for firefighters by the IAFF set at 42 mL/kg/min [7]. It has been shown that individuals with VO2max values below 33.5 mL/kg/min are unable to complete a standard fire suppression protocol [1, 19]. Most importantly of all – research from the University of South Carolina has shown that a low VO2max is a ***greater*** risk factor for cardiovascular mortality than obesity, hypertension, diabetes, high cholesterol, or smoking [7, 16].

Denise Smith et al. explain that lower levels of cardiorespiratory fitness are associated with a markedly increased risk of pathological changes during peak exercise, including: ST segment change, dysrhythmia, and abnormal heart rate recovery [20, 21]. They then go on to state directly that high fitness levels and aerobic capacity have a "*likely protective effect against sudden cardiac death…*" in firefighters [20].

How does your SCBA, specifically your regulator, affect your VO2max?

Operating in your self-contained breathing apparatus (SCBA) might be having a more dramatic effect on your ability to work than you realize, in more ways than you think. Research has shown that during heavy work the SCBA greatly reduces maximal exercise performance [22-25]. Clinical data shows that a full SCBA system lowers VO2max by 14.9% [22]. To show how significant this 14.9% is, let us look at some VO2max values common to firefighters. A sample of paid firefighters was found to have a mean VO2max of 40.57 mL/kg/min [1, 26]. When that is reduced 14.9% by the SCBA, it gets lowered to 34.52 mL/kg/min – or just 1 mL/kg/min over the minimum required for completing the standard fire suppression protocol discussed earlier. 75% of volunteer firefighters tested were found to have a VO2max between 20-39 mL/kg/min [1, 26]. That means when their VO2max values are adjusted for the SCBA, 75% or more of volunteer firefighters do not meet the minimum level to perform a fire suppression protocol.

In 2005 Eves et al. published quantitative data showing that the single biggest factor contributing to the SCBA lowering overall workload was the regulator, not the weight of the pack. The regulator itself, with no weight from the SCBA pack, was responsible for a 13.1% reduction in VO2max [22]. The regulator alone decreases VO2max almost the same amount as the full SCBA. The weight of the SCBA pack was only responsible for a 4.8% decrease in VO2max [22]. Further research from Butcher et al. showed that the regulator, by itself, increased active expiratory resistive work by 59%, inspiratory elastic work by 26%, and total work of breathing by 13% [27]. The potential consequence of this increased work of breathing is the competition for available cardiac output [27]. Eves et al. clearly state, "*The modern SCBA worn by firefighters decreases VO2max and peak power output due to a ventilator limitation imposed by the added expiratory breathing resistance of the SCBA regulator*." Every firefighter knows that it is more difficult to work and breathe in their SCBA. The data reinforces and explains the cause of that worn-out, breathless sensation that everyone has experienced after an aggressive interior attack, or any strenuous assignment completed in an SCBA.

In fact, this may be more than just a previously inexplicable feeling. Smith et al. propose that, "*Ischemia (due to an increase in myocardial oxygen demand) may exceed myocardial demand, resulting in electrical, mechanical, and biochemical dysfunction of the cardiac muscle, precipitating **fatal** arrhythmias.*"[20]

How can we get fit for the fire?

Dr. Jim Brown, Director of Firefighter Health & Safety Research at Indiana University – Bloomington, states, "*Development of an effective physical training program begins with the identification of demand levels a job or event presents.*" And of course, there is no alternative to wearing SCBAs in an immediately dangerous to life or health (IDLH) atmospheres. So, our best chance to reduce LODDs from overexertion is to become accustom to their effects on our cardiorespiratory system. That means training as frequently and realistically as possible. That means training "on-air", not just in masks and tank weight. Because as the research clearly shows, it is the regulator that is responsible for the decrease in a firefighter's VO2max. Ben Mauti, fire service market manager for MSA North America describes the new G1 SCBA system as follows, "*There's one airflow path when the regulator is hooked up to the face piece and a secondary flow path, an open port design, to allow the firefighter to breathe **without** exhalation resistance when in standby mode* [28]*.*" That is a necessary and beneficial feature for recovery on the fire ground, but unfortunately it does not lead to the physiological and psychological adaptations needed to perform adequately and survive the massive workload of fighting fire. In fact, the exhalation resistance is one key contributing factor in reducing the wearer's VO2max [22].

Unfortunately, many departments do not have the resources to train consistently and frequently "on-air". Even large, well-funded departments have difficulties allowing that type of training at the station level. For this purpose, we have created the Breathing Limited Air Situational Training (Blast) Mask. BlastMask training regulators attach to your face piece and simulate real-world SCBA breathing without draining your tanks, so you can train like it is real. They are not for IDLH atmospheres, but can be worn to work through a variety of simulated drills, including: SCBA mazes, dummy drags, the Kaiser sled, high rise drills, hose drags, sled pushes and pulls, CPAT and other physical agility testing, and any kind of general fitness training.

Researchers evaluated the return on investment for implementing a peer-led wellness program and calculated a cost ***savings*** of $2,765 per firefighter, and a return on investment of $4.61 saved for every $1 invested [29]. These savings only account for a reduction in workers compensation claims and medical cost, they noted that the cost savings would have been much higher with expenses like lost work days and overtime pay included [29]. The BlastMask will not just save your department money, time, and resources; it very well might save your firefighters' lives. Kerrigan and Moss might have said it best for *Fire Engineering*, "*Being fit for duty is the most basic requirement for every firefighter – career or volunteer* [30]." It is time to be tactically fit when it counts. It is time to save ourselves.

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