Chapter 5 - Fire Suppression and Safety

Analysis of the thermophysiologica response to cooling techniques in firefighters

R. Marcelo Abreu, António M. Raimundo* and Divo A. Quintela

ADAI-LAETA, Department of Mechanical Engineering, University of Coimbra - Pólo II, Rua Luís Reis Santos, 3030-788 Coimbra, Portugal. antonio.raimundo@dem.uc.pt; +351.239790738

Abstract
Firefighting has often been compared to a fight against an enemy capable of both material and lives’ loss. It is a physical activity that requires a rare combination of strength, flexibility, endurance and intelligence to survive under extreme conditions. When it comes to firefighting, men fighting fires are potential victims of heat stress because they go through long periods of hard work in hot environments. The present work’s target is the analysis of firefighters’ thermophysiological reactions to heat stress situations caused by hyperthermia. Using a software that simulates the human body’s thermophysiological behavior, several aspects, such as the fire intensity’s influence on the thermal state of the firefighter, the exposure time and the body cooling technique used to attenuate heat stress, are highlighted. With the goal of embracing the most possible situations, three intensity levels of impinging radiation that come from the fire and affect men fighting fires are analyzed: low; medium; and high. Three alternative body cooling techniques are considered: the traditional one; by immersion of forearms and hands in water at 20ºC; and by immersion of forearms and hands in 10ºC water. Normal ingestion of water during recovering breaks (matching the cooling times) was also in focus in the simulations.

Keywords: Safety firefighting; Human thermophysiological response; Body cooling techniques

1. Introduction

Firefighting has often been compared to a fight against an enemy capable of both material and lives’ loss. It is a physical activity that requires a combination of strength, flexibility, endurance and intelligence. Men fighting fires are potential victims of heat stress because they go through long periods of hard work in very hot environments (Barr et al., 2009).

Heat stress is defined as the amount of heat that needs to be dissipated or produced in order to maintain the body in a safety thermal balance (WHO, 1969). When the thermoregulatory system is unable to compensate the overload of heat imposed to the human body, the system gets unbalanced and the individual begins to suffer from hot heat stress. This kind of thermal stress occurs due to internal factors, such as the metabolic heat and individual differences, due to the person activity intensity and the garments that uses, and due to the surrounding thermal environment (Sharkey, 1999; McLellan & Selkirk, 2005). Any job or task that may cause an increase in the body core temperature elevates the risk of hyperthermia (heat stress caused by over accumulated heat in the body). Operations involving high air temperatures, high level of moisture, impinging radiation from heat sources, direct physical contact with hot objects, or very intense physical activities have a high potential risk of hyperthermia. Firefighters on duty are potential victims of numerous pathologies related with excess of heat and the consequent increase in body core temperature. These heat-related illnesses are introversion (violent sweating, misleading, amnesia, etc.), heat-stroke (fainting and eventually stop of sweating, central nervous system alteration, etc.), superficial skin damages (pain and first-degree burns), and permanent injuries (second-degree burns or higher, brain damage or, in more serious cases, death).

In order to satisfy all the demands of the firefighting activity, it might be necessary to use recovery strategies for physical recuperation and for body cooling as a way of thermal stress attenuation (Barr et al., 2009). The purpose of the body cooling process after the firefighting activity is to restore the...