Firefighter’s personal protective equipment and the chronotropic index

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The purpose of this study was to investigate the effects of personal protective equipment (PPE) on cardiovascular and metabolic responses during incremental exercise, and to determine if PPE affects the relationship between heart rate (HR) and oxygen uptake when expressed as the chronotropic index (CI). Ten male participants performed graded exercise tests under three conditions: control (CON), (PPE) and weighted vest (WV) (same weight as PPE). Time to exhaustion was significantly longer in the CON compared to the other conditions ($p < 0.01$). Submaximal oxygen uptake and HR were significantly lower in the CON compared to the PPE and WV conditions. The CI (CON, $32.2 \pm 4.5$; PPE, $31.7 \pm 5.7$; WV, $32.6 \pm 4.9$) was similar in all three conditions. This study has shown that additional weight and encapsulating clothing leads to elevations in HR and oxygen uptake compared to a control condition, however, the CI remains unaffected.

Practitioner Summary: Firefighters wear personal protective equipment that is designed to protect the wearer; however, it also imposes a physiological burden. It is known that work in firefighting PPE increases cardiovascular and metabolic strain. This study has shown that PPE does not alter the relationship between heart rate and oxygen uptake.

Keywords: firefighting; personal protective equipment; heart rate; oxygen uptake; chronotropic index

1. Introduction

Personal protective equipment (PPE) is worn by firefighters to protect them from a variety of work related hazards (e.g. fires, sharp objects, biological and chemical substances). It is well accepted that PPE is necessary to provide protection to firefighters and other emergency responders. Over time, the evolution of PPE has greatly increased the level and range of protection. However, despite the many benefits derived from wearing protective clothing, there is also an increased physiological burden and performance impairment imposed by the use of PPE (Havenith et al. 2011).

Firefighting imposes significant cardiovascular strain on the firefighter due to a combination of heavy work, high environmental temperatures and PPE (Smith et al. 1996, Smith et al. 2011). Personal protective equipment contributes to cardiovascular strain in the firefighter largely by increasing energy expenditure and reducing heat dissipation (White and Hodous 1987, Baker et al. 2000, Fogarty et al. 2004, McLellan and Selkirk 2004, Bruce-Low et al. 2007, Chou et al. 2008, Barr et al. 2010). Firefighting PPE increases the metabolic cost of work by increasing the total mass that the individual must transport and by resisting movement (Huck 1988). The restriction of movement caused by the added bulk alters the mechanics of gait and reduces joint movement efficiency resulting in a ‘hobbling’ or ‘binding’ effect (Coca et al. 2008). Furthermore, a pronounced ‘forward lean’ imposed by the shift in the centre of gravity also impacts on locomotion (Dorman and Havenith 2009). In addition, the reduced water vapour permeability across the clothing layers limits the rate of evaporative heat exchange to the environment, increasing thermal strain and further exacerbating cardiovascular strain (Havenith et al. 2011). Operating in firefighter protective clothing also imposes strain on the cardiovascular system due to increased blood requirements of the cutaneous circulation for heat dissipation.

Work in PPE increases the metabolic cost of a given work load (Skoldstrom 1987, Smith et al. 1995, Dreger et al. 2006) and decreases the time that work can be continued (White and Hodous 1987). Even different configurations of firefighting PPE can result in different levels of physiological strain when a standardised amount of submaximal work is performed (Smith et al. 1995).

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