Core temperature and heart rate response to repeated bouts of firefighting activities

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During live-fire firefighting operations and training evolutions, firefighters often consume multiple cylinders of air and continue to wear their personal protective equipment even after fire suppression activities have ceased. However, most studies have only reported core temperature changes during short-term firefighting activities and have shown a very modest increase in core temperature. Therefore, the purpose of this study is to evaluate core temperature and heart rate (HR) during repeated bouts of firefighting activity over 3 h. The results of this study show that core temperatures increase by an average of 1.9\(\pm\)8 C – to a larger magnitude than previously reported – and continue to increase during subsequent work cycles (38.4 vs. 38.7) even after long breaks of more than 30 min. The rate of core temperature increase during work continues to increase later in the training exercise (from 0.036 to 0.048\(\pm\)8 C/min), increasing the risk for exertional heat stress particularly if long-duration firefighting activity is required at these later times.

Practitioner Summary: To date, core temperature and HR changes during firefighting have been reported for short-term studies, which may significantly underestimate the physiological burden of typical firefighting activities. Firefighter core temperatures are shown to increase to a larger magnitude than previously observed and the rate of rise in core temperature increases during subsequent firefighting activities.

Keywords: firefighting; core temperature; heart rate; heat stress

1. Introduction

It is well documented that firefighting leads to increased cardiovascular and thermal strain (Smith and Petruzzello 1998; Smith, Manning, and Petruzzello 2001; Soteriades et al. 2011; Horn et al. 2011). During a typical response, firefighters may perform intermittent bouts of heavy (resistance) exercise interspersed within longer duration (aerobic) exposure while in a hot ambient environment while wearing restrictive and highly insulated personal protective equipment (PPE). In many cases, these bouts of firefighting activity may be repeated several times after short breaks are allowed for recovery and rehabilitation (i.e. cooling, rehydration and change of air cylinder).

Firefighters in the USA typically utilise self-contained breathing apparatus (SCBA) rated for 30 min of air based on a consumption rate of 40 l/min. While fireground work is often conducted without use of SCBA prior to entering a burning structure, the exposure to live-fire conditions is limited by the consumption of air, which often occurs in less than 30 min because air consumption exceeds 40 l/min during heavy work (Williams-Bell et al. 2010). Thus, most research regarding the cardiovascular and thermal strain of firefighting has focused on a bout of firefighting activity that requires 20 min or less (Smith and Petruzzello 1998; Smith, Manning, and Petruzzello 2001; Horn et al. 2011). We have recently documented the timeline of recovery from a short-term bout of controlled firefighting activity lasting 18 min. Our data suggest that ~60 min is required for the firefighter’s (HR) and core temperature to return to baseline levels (Horn et al. 2011). While significant study of repeated bouts of activity in firefighting PPE has been conducted in laboratory settings (e.g. Gallagher et al. 2012; Kim et al. 2013; Smith et al. 2013), the effect of repeated bouts of live-fire field firefighting activities on thermal and cardiovascular strain has not been studied.

Table 1 provides an overview of the few studies that have focused on measuring core temperature from live-fire training and research activities. Most studies have reported core temperature changes during short-term firefighting drills, and the modest increase found in firefighters’ core temperature would not pose an immediate risk of heat illness. However, the values reported in published studies indicate considerable rate of rise for such short bouts of work, which for most firefighters required less than one cylinder of air. During actual firefighting operations and training evolutions, firefighters often conduct significant amounts of work prior to donning their face mask and consuming SCBA air as they enter an immediately dangerous to life and health environment, consume multiple cylinders of air and continue to wear their PPE even after fire suppression activities have ceased (such as during overhaul and clean-up activities). Thus, it is likely that

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