

# Effect of Clothing Layers in Combination with Fire Fighting Personal Protective Clothing on Physiological and Perceptual Responses to Intermittent Work and on Materials Performance Test Results

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*Personal protective clothing (PPC) shields firefighters from thermal and other occupational hazards; however, it also contributes to physiological and perceptual strain. This study examined the effect of clothing layers worn under structural fire fighting turnout gear (TOG) on physiological and perceptual responses during alternating work/recovery cycles and assessed the clothing ensembles' (PPC + base layer) material performance. Values are reported as mean  $\pm$  standard error of the mean. Ten men (age,  $21 \pm 0.3$  yr; height,  $1.74 \pm 0.02$  m; weight,  $74.3 \pm 2.3$  kg;  $VO_{2max}$ ,  $58.9 \pm 2.0$  mL/kg/min) completed a 110-min alternating work/recovery walking protocol (three 20-min exercise bouts/10-, 20-, and 20-min recovery sessions) in a thermo-neutral ( $21.0^{\circ}\text{C}$ , 58.7% RH) laboratory while wearing a cotton t-shirt (COT) or COT and a station uniform (SU) shirt under fire fighting TOG (COT+TOG and COT+SU+TOG, respectively). Changes in heart rate (HR), core temperature ( $T_{co}$ ), skin temperature ( $T_{sk}$ ), rating of perceived exertion (RPE), and thermal sensations (TS) were compared across exercise and recovery periods. During exercise sessions, HR,  $T_{co}$ ,  $T_{sk}$ , and RPE reached similar levels for COT+TOG and COT+SU+TOG. During Recoveries 1, 2, and 3, mean chest  $T_{sk}$  decreased by 3.96, 6.64, and  $6.49^{\circ}\text{C}$ , respectively, for COT+TOG compared with 2.24, 3.78, and  $4.09^{\circ}\text{C}$  for COT+SU+TOG ( $p < 0.05$  for each period). Change in TS differed during Exercise 1; however, mean peak TS corresponded to "hot" for both ensembles. This study demonstrates that the additional layer of clothing in the COT+SU+TOG ensemble imposed no greater level of physiological or perceptual strain during moderate-intensity work bouts compared with the COT+TOG ensemble. However, some modest benefits were experienced during the recovery sessions for the COT+TOG ensemble as evidenced by a lower chest  $T_{sk}$ . In addition, materials performance testing revealed COT+SU+TOG provided greater thermal protection ( $64.8 \pm 1.9$  vs.  $56.4 \pm 0.3$  cal/cm<sup>2</sup>;  $p < 0.05$ ) and equivalent heat dissipation compared with COT+TOG. These findings could guide departmental decisions about the use of station shirts.*

**Keywords** clothing, fire fighting, heat stress, thermal protective performance, total heat loss

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