Predictive Models with Pre-cooling Interventions can Minimize Heat Stress in Firefighters

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Objectives: The objectives of this pilot study were: i) develop a data driven model that can be used to predict if a firefighter would cross the threshold of industrial hyperthermia (core body temperature – CBT > 100.4 ^{O}F) during live-fire training, and ii) pilot test the utility of this model by implementing a proactive intervention: pre-cooling to keep firefighters' CBT within "safe" limit.

Design: A *cross-sectional* design was used in this study in order to test the utility of this model by implementing a proactive intervention: active pre-cooling to keep firefighters' CBT within "safe" limit. The independent variables are the amount of heat/cold exposure and physical activities. The dependent variables are the physiological responses (CBT,HR).

Methods: Twenty-eight full time firefighters' CBT and heart rate (HR) were measured real time while undergoing a live-fire training consisting of three scenarios (Sc1, Sc2 and Sc3).

Classification trees (CT) were used to predict the outcome variable (firefighter crossed the upper threshold of hyperthermia – Y/N). The predictor variables were: age, body mass index, baseline CBT, baseline HR and duration of each scenario. Three CT models were developed, one for predicting CBT response after each scenario. Twenty-eight CTs were developed by randomly leaving out one firefighters' data in each CT to assess the model's efficacy using "leave-one-out" method. Success rate was calculated as: 100*(number of correct classifications)/28.

As a proactive intervention application, we first identified a firefighter who would reach hyperthermia as per the model and his CBT was predicted with a regression tree (RT). The firefighter was cooled (using a cooling vest) before the scenario for 14 minutes.

Results: The success rate of CT models for Sc1, Sc2 and Sc3 were 43%, 61% and 89%, respectively. The CBT predicted using RT (101.35 ^{O}F) was higher than that observed after cooling (100.49 ^{O}F).

Conclusions: The predictive model was successful for Sc3, moderately successful for Sc2 and unsuccessful for Sc1. We piloted the utility of predicting CBT response of firefighters through early identification of a firefighter with high risk of entering hyperthermia and implementing proactive cooling to reduce the CBT. Predictive models with pre-cooling interventions can minimize heat stress in firefighters.

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