

Developing a hybrid cooling vest for combating heat stress in the construction industry

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ABSTRACT

Many frontline workers in the Hong Kong construction industry have to perform physically demanding work under hot working conditions with 35.4 C and 95% relative humidity in summertime, which could reduce work efficiency and time and increase the occurrence of heat cramps, heat exhaustion, and heat stroke. The purpose of this study was to develop a hybrid, new cooling vest to combat heat stress in the construction industry. Following the functional clothing design process, a problem identification was conducted. Preliminary ideas were formed through the analysis of available types, research, a survey, literature review, and brainstorming. Design refinement was obtained by selecting the available PCM packs with the ideal price and desirable properties; employing fans with high wind velocity and long duration; screening the used fabrics with thin and vapor-permeable properties, excellent air resistance, water repellence, UV protection, and abrasion resistance from 19 commercially available fabrics; and identifying clothing ergonomic design with fit, mobility, convenience, and safety. The desirable thermal functional performance in the new cooling vest was previewed through a computer-aided design platform S-smart system. The design criteria were established and a prototype was developed. The prototype evaluations were conducted using treadmill testing by human subjects inside an environmental chamber and wear trials in the construction sites under actual wearing conditions. The environmental chamber testing results showed that, in a hot environment, the mean skin temperature (35.8 C vs. 36.59 C), heart rate (110 beats/min vs. 116 beats/min), and core temperature of the subjects with the new cooling vest were significantly lower than those with the control (without the new cooling vest). A significantly longer exercise time was obtained with the new cooling vest compared with the control (22.08 min vs. 11.08 min). Significant improvements in levels of coolness, dryness, comfort, and physical recovery were simulated and achieved with the new cooling vest. The results of all measurements suggest that the new cooling vest can reduce the thermal stress of construction workers and improve their work performance and comfort.