Project HeatSafe: Effects of Physical Work in Humid Heat on Construction-specific Task Performance in Tropical Natives.

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Introduction

Occupational heat strain can impair motor and cognitive functions, leading to increased injury risk and reduced productivity [1, 2]. Workers in sectors such as construction that involve prolonged heavy physical labour in hot and humid environments and/or the use of work clothing that restricts heat loss are most affected and, consequentially, experience high rates of work-related injuries and fatalities [3-5]. Annual air temperatures in tropical Southeast Asian countries (e.g., Singapore) are expected to rise 0.9-2.5°C by mid-century due to global warming, which will exacerbate the health and safety risks associated with occupational heat strain [6]. Thus, we used Singapore's current and projected environmental conditions to examine the effects of physical work on performance in construction-specific tasks simulated at height (welding and plank-walking) using virtual reality (VR).

Methods

Eighteen healthy men (age: 29±5 years) performed three experimental trials in current [COOL: 24.6±0.2°C wet-bulb globe temperature (WBGT) and WARM: 28.1±0.3°C WBGT] and projected (HOT: 32.4±0.3°C WBGT) conditions. Each trial consisted of three 30-min bouts of treadmill walking at fixed metabolic heat production rates (EX1: 250W, EX2: 350W, and EX3: 450W), separated by completion of a battery of VR-based construction-specific tasks, and 10-min of seated rest. Thermal, cardiovascular, and perceptual measures were recorded during the trials, while measures of task speed and accuracy, postural sway and gait were recorded during the VR tasks.

Results and discussion

Mean body core temperature was higher in HOT as compared to WARM and COOL at the end of EX2 and EX3 (all $P<0.05$; **Figure 1A**). Mean skin temperature ($P<0.001$), mean heart rate ($P<0.001$) and thermal perception (all $P<0.001$) differed between all environmental conditions (HOT>WARM>COOL). Performance (speed and accuracy) on the welding and plank-walking tasks, and gait during plank-walking did not differ between environmental conditions (all $P>0.05$). However, postural sway velocity during welding increased (~18%) after EX3 in HOT ($P<0.05$) but not in COOL or WARM (both $P>0.05$; **Figure 1B**).

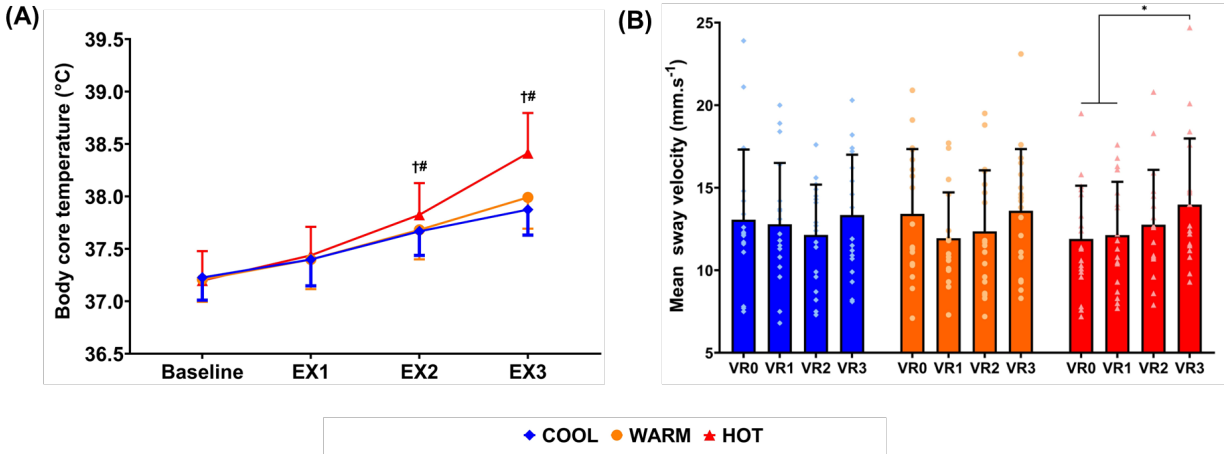

Figure 1. (A) Mean body core temperature at baseline and the end of each work bout (EX1, EX2, EX3) and **(B)** mean postural sway velocity at baseline (VR0) and during the VR-based tasks after each work bout (VR1, VR2, VR3) in COOL, WARM and HOT. † (P<0.05) HOT vs COOL, # (P<0.05) HOT vs WARM and * (P<0.05) between time-points in HOT.

Conclusions

Compared with the current environmental conditions, physical work under Singapore's projected environmental conditions (i.e., HOT) aggravated physiological and perceptual strain. However, performance during the VR-based welding and plank-walking tasks was not negatively affected, possibly due to the relatively short duration (~2.5h) of the trials and the partially heat-acclimatised status of our participants. Nonetheless, postural sway was impaired during the attention-demanding VR-based welding task following physical work in the projected environmental conditions. This may increase the risk of falling, which could be potentially fatal when workers work in high-risk scenarios (e.g., working at height). These findings highlight the need for increased awareness of the health and safety hazards of working in the heat and for more effective strategies to augment heat tolerance to preserve workers' safety and productivity.

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