Body Cooling Strategies on the Cognitive Performance of Test Subjects Under a Simulated Laborer Environment

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ABSTRACT

This research article aims to examine the effects of body cooling strategies on the cognitive performance of test subjects in a simulated laborer environment. The study was carried out as a result of the significant negative effects that heat has on human productivity and the paucity of studies exploring the efficacy of adding various cooling techniques to enhance performance, cognition, perceptual measurements, and physiological responses to work in the heat. In the investigation, 14 healthy, physically active males underwent six 6-hour testing sessions that replicated a workday, with different cooling techniques used throughout each session. Internal body temperature, medical history, and blood pressure of the individuals were tracked throughout the trial. Through a cognitive test intended to replicate typical assembly line activity, the study investigated the impact of various cooling strategies on cognitive function. The study concludes that there isn't significant enough evidence that an increase in duration and frequency of cooling strategies improves cognitive performance in test subjects in a simulated laborer environment.

INTRODUCTION

Heat can be detrimental to human productivity. As temperatures rise, we get hotter and hotter and our bodies as well as our minds are put under strain, which results in poorer health and

reduced productivity (Flouris et al., 2018 and Ioannou et al., 2017). These two things are so important to maintain in our current civilization. With lower productivity due to high temperatures, workers won't be able to perform their best, which causes a decrease in economic output. Moreover, multiple studies have revealed that a single work shift in the heat quadruples the probability of experiencing heat strain. One out of three individuals who work under heat stress report productivity losses (Flouris et al., 2018). This is a serious problem. As seen below, the number of deaths stemming from heat stress is not small and should and can be preventable. Some successful strategies have been developed. One strategy demonstrates that following

Figure 1. Graph of U.S workers killed by heat stress (Tanglis, 2018).

the implementation of a heat mitigation plan (including a medical monitoring program, heat acclimatization protocol for new workers, access to cold water and shade, and training), the median for worker compensation claims decreased by 50% (McCarthy et al., 2019). This shows that these plans and strategies work. To this date, no research has examined the effectiveness of adding various body cooling techniques to improve performance, cognition, perceptual measures, and physiological responses to work in the heat (Morrissey, 2022).

Therefore, our study aimed to examine the effects of body cooling strategies on productivity outcomes and work capacity during simulated work in the heat, specifically the effect these strategies had on cognitive performance.

METHODS

Safety Concerns

My project involved human test subjects that were put in a pretty severe heat environment for an extended period of time. Therefore, subjects were selected based on a medical questionnaire that outlined their medical history. In this questionnaire, we looked for previous heat-related illnesses and a history of cardiac issues as the most important things. This questionnaire, as well as a blood pressure test, were done to see if they were what we were looking for and if they completed the full six 6-hour sessions required for our study (one session for each change in variables). In addition to this, the subject's internal body temperature was monitored and if it went above a certain threshold, the test was paused or even canceled for the day.

Main Method:

My study conducted trials with test subjects, using the following method: we tested 14 healthy, recreationally active males (ages 18 to 45 years old) in this study and compiled data sets for each one. Each subject completed six, 6-hour testing periods that simulated a work day. Every single “work day” followed this schedule:

Time point (min)	**Activity**
ENTER CHAMBER	
~10 mins	Seated Equilibration
~20 mins	Walk protocol 20 mins walk (30-40% vVO2max) at 5% grade
~10 mins	Box lifting activity (5 min) + AMRAP (5 min)

~20 mins	Walk protocol 20 mins walk (30-40% vVO2max) at 5% grade
~15 mins	BREAK
~20 mins	Walk protocol 20 mins walk (30-40% vVO2max) at 5% grade
~10 mins	Box lifting activity (5 min) + AMRAP (5 min)
~20 mins	Walk protocol 20 mins walk (30-40% vVO2max) at 5% grade
~30 mins	LUNCH BREAK Standardized meal consumption
~20 mins	Walk protocol 20 mins walk (30-40% vVO2max) at 5% grade
~10 mins	Box lifting activity (5 min) + AMRAP (5 min)
~20 min	Walk protocol 20 mins walk (30-40% vVO2max) at 5% grade
~15 min	BREAK
~5 min	Walk protocol 20 mins walk (30-40% vVO2max) at 5% grade
~15 min	Performance Testing: Handgrip, box lifting AMRAP, 80-100% of VO2max test to exhaustion
~25 min	Cognitive Test: SALT
END OF EXERCISE: EXIT CHAMBER	

Figure 2. Image of Typical Schedule for a Test Day (Morrissey, 2022).

Then, during the 30-minute lunch break, and depending on the variable, the 15-minute break, a different variable (cooling strategy) was implemented or not included for each of the 6 trials. These different variables were:

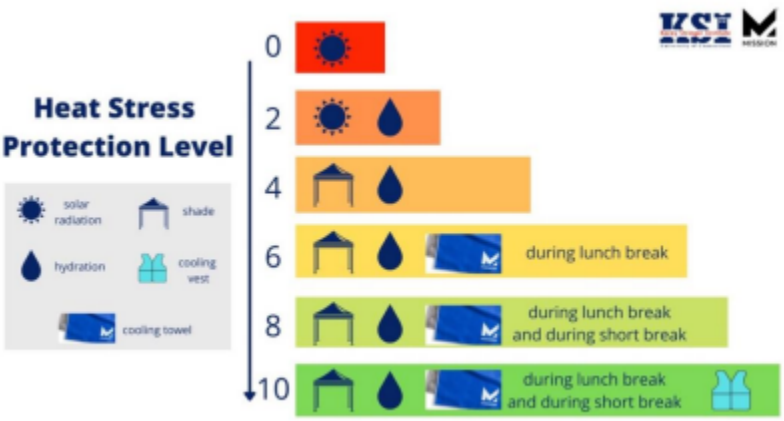
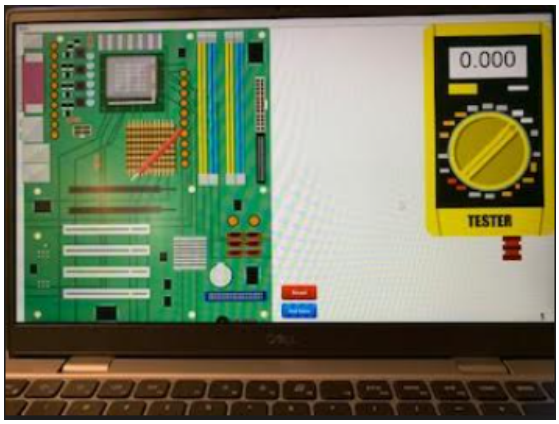


Figure 3. List of different independent variables and their hypothesized effectiveness going from least (red) to most (green) (Morrissey, 2022).

With this research, out of the multiple parts studied, I focused on how these different cooling strategies affected cognitive performance. To do this, at the end of every testing session, there was a cognitive test designed to be mundane and simulate typical assembly line work. This test involved analyzing circuits and seeing if their voltage was or wasn't within a certain threshold.



Finally, I analyzed if the cooling duration and frequency of the heat mitigation strategies increased, then the scores from the cognitive test would improve as well. These scores were: Total mistakes, the time it took to go through each circuit board, the number of boards solved in the allotted

Figure 4. Image of the SALT task that evaluated cognitive performance.

time frame, and the average number of mistakes per board.

Timeline:

The time frame for my study was as follows: October-February was the period for data collection and March was the period for data analysis. After that, my role ended and the manuscript was written in the period of April-June.

RESEARCH TEAM

My research team comprised a principal researcher, research staff, and undergraduate and graduate assistants. Dr. Douglas Casa is the CEO/principal researcher of the "Mission" study. Dr. Margaret Morrissey is the co-principal researcher, and I reported to her and Ms. Gabrielle Brewer, the study lead. Then there were 19 other undergraduate research assistants I worked with to conduct tests for the study and gather data. Finally, I had no ownership in developing the research problem and designing the research methods. I have partial ownership in the analysis and discussion of results since I was one of the people collecting this data. Moreover, I selected which variable I wanted to focus on for my own research article.

RESULTS

13 total male subjects between the ages of 29 and 19 participated in the studies' 6 trials. We started the testing in the winter of 2022 and finished in the spring of 2023. These test subjects had an average height of 173.8 +/- 10.9 (cm), an average body mass of 72.22(kg), and an average

percent body fat of 15.06 %.

The first variable that was analyzed, the total number of boards completed, was unsuccessful in supporting my null hypothesis and failed to reject it due to the p-value of the final data (.746) being higher than our significance value of .05.

The second variable that was analyzed, the total number of mistakes during each trial, was unsuccessful in supporting my null hypothesis and failed to reject it due to the p-value of the final data (.728) being higher than our significance value of .05.

The third variable that was analyzed, the average number of mistakes per board, was unsuccessful in supporting my null hypothesis and failed to reject it due to the p-value of the final data (.802) being higher than our significance value of .05.

The fourth variable that was analyzed, the average time spent on each board, was unsuccessful in supporting my null hypothesis and failed to reject it due to the p-value of the final data (.324) being higher than our significance value of .05

DISCUSSION

The results of this study indicate that when cooling duration and frequency of heat mitigation strategies is increased, there isn't significant evidence to support that this increase also increases cognitive performance. This conclusion was consistent across all four of the variables that we analyzed. As for the study's limitations, a larger sample size could have increased the accuracy of the data. When looking at the average weight of the 13 subjects, 72.22 kg, it is over 17 kilograms less than the national average for men in America (ages 20-39). Moreover, the average body fat percentage of the subjects, 15.06 %, is less than the average American man by 3 %. If the sample size increased these differences could have decreased and might've given us

more accurate data. Additionally, an increase in the difficulty of each trial could have provided better results. Either an increase in duration for each task or by picking more strenuous activities, we could have seen a more significant impact of each cooling strategy or their lack of and its subsequent effect on each subject's cognitive performance.

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