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Environmental Heat Stress and Physiological Heat Strain in Construction Workers During Work in the Summer

Fabiano Amorim, Ph.D.
Zachary Schlader, Ph.D.

University of New Mexico
Indiana University

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8484 Georgia Avenue
Suite 1000
Silver Spring, MD 20910

PHONE: 301.578.8500
FAX: 301.578.8572

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Abstract

Purpose: To measure environmental heat stress and strain among construction workers in two different locations during summer work.
Methods: This report presents the key findings from a study conducted on construction workers in two locations during the summer: Kansas City, Missouri, and Pecos, New Mexico. In Location 1 (Kansas City), 32 commercial construction workers were monitored over 3 days, while in Location 2 (Pecos), 7 male road construction workers were observed for 1 day. Environmental heat stress was assessed through heat index (HI), while heat strain was evaluated by core temperature (Tcore) and skin temperature (Ts) measurements. Urine specific gravity (USG) was used to assess hydration status pre- and post-shift, and changes in body weight were recorded.
Results: In Location 1, peak HI ranged from 27.3 to 35.2°C (81.1 to 95.4°F) with workers in uncovered areas (38.1 ± 0.3°C or 100.6°F) presenting higher peak Tcore than workers covered (37.8 ± 0.2°C or 100,0°F). Peak Tcore exceeded 38.0°C (100.4°F) in 43% of participants, with 4% surpassing 38.5°C (101.3°F). There was no significant change in USG pre- to post-shift (1.022 ± 0.005 to 1.022 ± 0.007), with 63% of workers beginning their shift dehydrated. In Location 2, peak Tcore reached 37.9 ± 0.2°C (100.2°F), and peak Ts was 36.7 ± 0.6°C (98.1°F). The average HI was 24.5°C (76.1°F), and there were no significant changes in USG pre- to post-shift (1.021 ± 0.011 to 1.024 ± 0.008), with 57% of workers starting their shift dehydrated.
Conclusion: Construction workers in both locations experience significant heat strain even during low to moderate environmental heat stress. Workers in uncovered areas face the highest heat strain while working in the summer. Proper hydration strategies and heat stress management protocols (i.e., cooling strategies) are crucial for protecting the health and safety of these workers.

Key Findings

- Most workers arrived dehydrated at the job site.
- Workers had small reductions in body weight indicating that hydration was maintained during the work shift.
- Although water was available to workers during the work shift and workers were not further dehydrated during work, employers should encourage their workers to hydrate themselves before arriving at work.
- In commercial building construction, workers in uncovered areas have increased core temperature even under moderate heat stress.

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Introduction

Construction work is characterized by extensive physical work, resulting in substantial metabolic demand (Poulianiti et al., 2019). Workers perform a wide range of tasks—including roofing, pouring concrete, laying bricks, and glazing—each with distinct metabolic demands and ergonomic challenges. For example, bricklayers often engage in lifting heavy loads as they handle bricks and blocks for 35-60% of their working time (Boschman et al., 2011), while roofers are crawling, squatting, stooping, and in kneeling postures for over 75% of their work time (Breloff et al., 2019; Wang et al., 2017). In addition, construction workers are frequently exposed to extreme environmental conditions, as they are often working outdoors and exposed to solar radiation or in enclosed spaces with limited airflow. Previous studies have shown that construction workers have a 13 times higher risk of heat-related deaths than workers from other sectors (Gubernot et al., 2015). Furthermore, despite construction workers constituting only 6% of the total workforce, they accounted for 36% of all occupational heat-related deaths from 1992 to 2016 (Dong et al., 2019).

Given that heat stress arises from a combination of environmental and metabolic heat from physical work (Tustin et al., 2018), construction workers are vulnerable to heat-related illness, particularly during the summer months. Symptoms associated with heat exposure, such as hyperthermia, dehydration, and fatigue, are indicative of levels of heat strain (Binazzi et al., 2019; Flouris et al., 2018). Core temperature (Tcore) is one of the most common markers of heat strain. For worker safety, the American Conference of Governmental Industrial Hygienists (ACGIH) recommends maintaining Tcore within +1°C for the average person or a threshold value of 38°C (100.4°F) when baseline Tcore is 37°C (98.6°F). Surprisingly, there has been little research done in the United States quantifying overall heat exposure and heat strain among construction workers (Chapman et al., 2021). To our knowledge, no study to date has measured heat strain via Tcore among U.S. construction workers.

Objectives

To assess heat strain and environmental heat stress among construction workers at both a commercial building construction site (Kansas City, Missouri) and a road construction site (Pecos, New Mexico). Specifically, the study aims to measure core body temperature, hydration status, and metabolic demands in these construction settings.

Location 1 – Kansas City, Missouri

METHODS

Over a three-day period, an observational study was conducted at a construction site in Kansas City, Missouri. The study involved 32 construction workers (29 males, 3 females, age = 36.4 ± 12.6 years, height = 173.6 ± 10.0 cm, body weight = 84.3 ± 16.7 kg). Workers were identified as being in one of four groups based on their job descriptions: carpenters (n=6), concrete workers (n=13), laborers (n=8), and roofers (n=5). Additionally, it was noted whether participants worked in a covered (n=24) environment with open air or in an uncovered (n=8) environment with direct sunlight. All participants signed a consent form before inclusion in the study.

During the study duration, participants were instructed to maintain their work-related activities, as well as their daily living routines. Participants arrived at work approximately 30 minutes prior to their normal scheduled time and met with researchers for pre-shift measurements. During this pre-shift period, nude body weight was measured, and a urine sample was collected to assess urine-specific gravity (USG) with a refractometer (Cole-Parmer, RSA-BR90A, Vernon Hills, Illinois). Subsequently, participants were equipped with an iButton sensor for skin temperature measurement (model DS1921H, Embedded Data Systems, Kentucky) and a Polar chest strap (Polar H10, Polar Electro Inc., Lake Success, NY) to record heart rate throughout the work shift. A core-temperature measuring capsule (BodyCap e-Celsius, Caen, France) was then ingested to allow continuous monitoring of Tcore during the work shift. Participants then moved to their worksites, and they performed their regular work for the day. Dry bulb temperature, heat index (HI), and humidity were continuously measured at covered (QUESTemp QT-44, 3 M, Shoreview, Minnesota) and uncovered (Kestrel 5400 Heat Stress Tracker, Nielsen-Kellerman, Boothwyn, PA) locations to quantify environmental heat stress using a heat stress monitor. The thresholds for HI indicated by the OSHA Heat Safety Tool App were used to classify heat stress: Caution – less than 26.7°C (80°F) HI; Warning -- between 26.7 to 34°C (80°F to 94°F) HI; and Danger at 35°C (95°F) HI or >].

At the end of the shift, participants again reported to researchers, and they were asked about their average and maximal perceived exertion (RPE) (Borg, 1982), as well as their average and maximal thermal discomfort (1-comfortable, 5-extremely uncomfortable) (ISO 1995). Participants again provided a urine sample to measure post-shift USG, and nude body weight was also measured. As a marker of dehydration, change in body weight was later calculated as a percentage of pre-shift body weight. Metabolic rate was estimated from the recording of heart rate (Malchaire et al., 2017) and adjusted for the increase in Tcore using standard, validated equations. These equations are based on the linear relation that exists between heart rate and oxygen uptake across a range of workloads, a relation that is modulated increases in Tcore (Bröde et al., 2019), and have been shown to provide estimates within 10-15% of actual values, consistent with the mandatory levels of accuracy for ISO standards. As such, the estimated metabolic rate was calculated as a function of 5-minute averages in heart rate recorded throughout the workday, corrected for individualized estimates of resting metabolic rate, maximal work capacity, peak heart rate observed during the workday, Tcore, and body surface area.

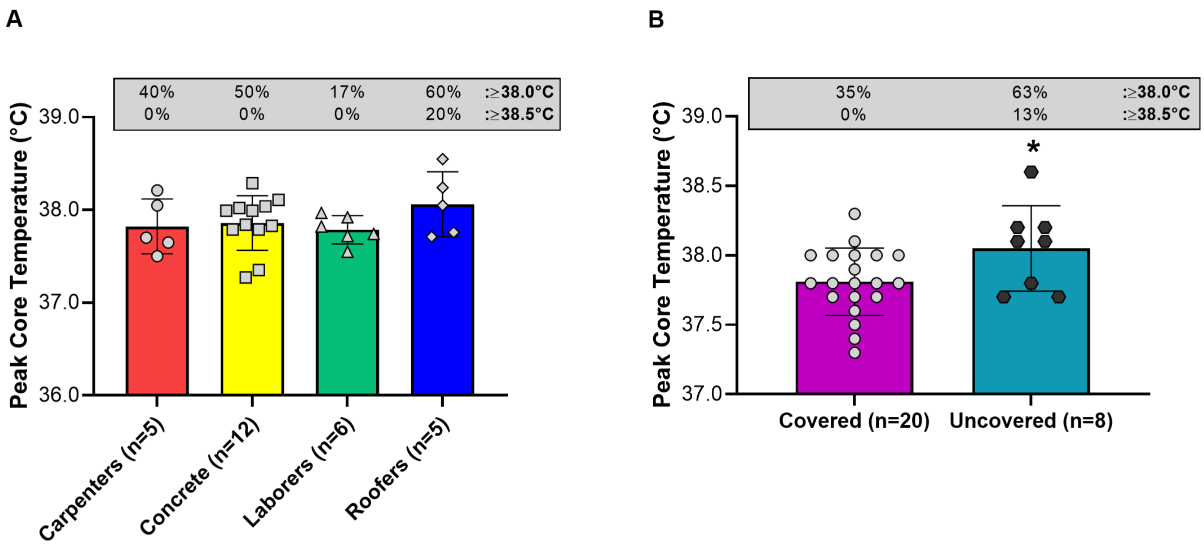
Statistical Analyses: One-way ANOVAs were conducted to compare mean values by job type (carpenter, laborer, etc.) for the following variables: change in body weight and average and peak heat index, metabolic rate, RPE, Tcore, and thermal comfort. Unpaired t-tests were conducted to compare mean values at covered or uncovered locations for the same variables. Mixed-effects models were conducted to assess differences in USG based on timepoint (pre- and post-shift), job type and work environment. Pearson correlations were generated to compare the relationships between peak metabolic rate and peak Tcore, as well as peak heat index and peak Tcore. Statistical significance for all analyses was set at $p<0.05$.

RESULTS

Environmental Conditions: During the three days of data collection, the average peak heat index across all work environments was 30.4 ± 4.0°C (86.7°F). There was no significant difference in peak HI between covered (28.8 ± 3.7°C or 83.8°F) and uncovered (32.1 ± 4.2°C or 89.8°F) areas (p=0.366). Concrete workers were exposed to a significantly lower peak HI (27.5 ± 3.7°C or 81.5°F) than either carpenters (32.5 ± 1.6°C or 90.5°F, p=0.002) or roofers (34.6 ± 0°C or 94.3°F, p<0.001). The peak HI in uncovered areas reached the OSHA Heat Safety Tool App "Warning" level for all three days, while the peak heat index in covered areas reached the "Warning" level two out of the three days.

Metabolic Work and Heat Strain: The average peak metabolic rate calculated was 350.6 ± 94.7 W/m^2 (moderate level – OSHA, 2016), with an average metabolic rate of 188.4 ± 40.2 W/m^2 (low level). While there were no significant differences in peak metabolic rate observed between job types (p=0.227), workers in uncovered areas (423.3 ± 127.2 W/m^2 – heavy level) had a significantly higher work rate than workers in covered areas (316.3 ± 49.9 W/m^2 – moderate level) (p=0.006). Average Tcore throughout the work shift was 37.4 ± 0.4°C (99.3°F), with the average peak Tcore being 37.9 ± 0.3 °C (100.2°F). As seen in Figure 1, there were no significant differences in peak Tcore between job types (p=0.51), but workers in uncovered areas (38.1 ± 0.3°C or 100.6°F) had significantly higher peak Tcore than covered (37.8 ± 0.2°C or 100,0°F) workers (p=0.037). Remarkably, only one roofer experienced a Tcore exceeding 38.5°C (101.3°F), while three out of five roofers (60%) experienced a peak Tcore greater than 38.0° (100.4°F). Additionally, 63% of workers in uncovered areas recorded a peak Tcore greater than 38.0°C (100.4°F), while only 35% of workers in covered areas reached this threshold. Four percent of all workers reached a peak Tcore greater than 38.5°C (101.3°F), while 43% reached a peak Tcore greater than 38.0°C (100.4). Additionally, a moderate, positive correlation was observed between peak metabolic rate and peak Tcore (r^2= 0.38, p=0.001, n=25). A weaker positive but nonsignificant correlation was noted between peak heat index and peak Tcore (r^2= 0.13, p=0.06, n=28).

Figure 1. Peak core temperature values between A) job type and B) work conditions (N=28)



**Indicates significant difference from covered environment (p<0.05).*

Hydration: There were no significant differences in USG between job type or pre- (1.022 ± 0.005) and post-shift (1.022 ± 0.007) values. Interestingly, at both the pre- and post-shift timepoints, 63% of workers had a USG of greater than 1.020, which is considered a threshold for dehydration (Cheuvront et al., 2010). There was an average decrease in body weight by 1.1 ± 0.9% from pre-shift to post-shift. There were no significant differences in body weight change between groups based on job type (p=0.251) and work conditions (p=0.132).

Perception of Exertion: The average peak RPE for all workers was 13.7 ± 3.4, with this average corresponding to a perceived exertion of "somewhat hard." Peak RPE was not significantly different by job type (p=0.11) or work condition (p=0.15). The average RPE for all workers was 11.5 ± 2.8, with this average corresponding to a perceived exertion of "light." Average RPE was not significantly different by job type (p=0.10) or work condition (p=0.18).

DISCUSSION

The aim of this study was to measure environmental heat stress and physiological heat strain in construction workers during work in the summer. Our primary finding was that 43% of workers reached a peak Tcore of greater than 38.0°C (100.4°F), which is greater than the recommended threshold set by ACGIH (ACGIH), and 4% of workers reached a peak Tcore of greater than 38.5°C (101.3°F). This is the first investigation to report Tcore in construction workers during work in the summer in the United States.

The observed positive correlations between peak heat index and peak metabolic rate with peak Tcore suggest that heat strain in construction workers is associated with both environmental and metabolic stressors, consistent with findings among other outdoor occupational workers throughout the world (Ioannou et al., 2021). We found that construction workers working in uncovered areas experienced significantly greater peak Tcore, which may put them at greater risk for heat-related illnesses (Flouris et al., 2018). The higher peak Tcore observed in workers in uncovered areas could be linked to their higher metabolic rate. These workers had a significantly higher work rate (423.3 ± 127.2 W/m^2 - heavy level) than those in covered areas (316.3 ± 49.9 W/m^2 - moderate level). The increased metabolic demand associated with the heavier workload may contribute to the higher Tcore experienced by construction workers in uncovered areas, emphasizing the association between environmental and metabolic stressors in heat strain. While roofers did not have significantly higher peak Tcore compared to other job types, they had a higher incidence of reaching a peak Tcore exceeding the reference values of 38.0°C (100.4°F) and 38.5°C (101.3°F) which may also put them at a greater risk for heat-related illnesses (Flouris et al., 2018). Although no significant differences in peak metabolic rate were observed between different job types, the metabolic demand of constant movement and unnatural positions for roofers paired with working in direct sunlight exposure may increase overall heat strain and ultimately the risk of heat-related illness compared to other construction workers (Breloff et al., 2019), (Wang et al., 2017), (Flouris et al., 2018).

A limitation of this study was that it was conducted during an atypically cool week in July, with a peak dry bulb temperature of 31.4°C (88.5°F), whereas the previous and following weeks reached temperatures of 35°C (95°F) or higher. A study conducted with North American electrical utility workers in a hotter environment (HI ranging between 42 to 48°C) reported higher levels of thermal strain, with the majority of monitored workers achieving a Tcore greater than 38.0°C (prevalence: 75%) and 7 of them reaching Tcore over 38.5°C (prevalence: 22%). Nevertheless, the workers in Kansas City provide evidence that even under conditions of moderate environmental heat stress, construction workers experience significant heat strain. Further research is needed to further quantify heat strain in construction workers across varying degrees of heat stress. Additionally, the small sample size in some job categories reduced the ability to detect significant differences between trades.

Location 2 – Pecos, New Mexico

METHODS

Seven male construction workers (age = 38.9 ± 13.7 years, height = 169.1 ± 6.0 cm, body weight = 86.1 ± 25.4 kg) in New Mexico agreed to participate in this study. Workers were screened for health risks prior to participating. Workers were excluded if (1) their blood pressure was greater than 140x90 mmHg, (2) they were taking any medications known to impair muscle metabolism, (3) they had any physical injury or physical limitations, or (4) they were under the active care of a physician for any condition that could interfere with their safe participation in the study. All data was collected during a single workday, at a single job site, in July 2023.

Immediately prior to their workday, workers met with researchers for baseline measurements, including height and weight. Urine was then collected to assess urine specific gravity (USG) with a refractometer (Cole-Parmer, RSA-BR90A, Vernon Hills, Illinois). Next, workers were given a Polar heart rate chest strap (Polar H10, Polar Electro Inc., Lake Success, New York) to heart ratewear and an iButton (model DS1921H, Embedded Data Systems, Kentucky) skin temperature device was applied to the chest for continuous heart rate and skin temperature recording, respectively. An ingestible core temperature pill (BodyCap e-Celsius, Caen, France), which continuously recorded core temperature every minute, was given to participants to ingest. Following these initial procedures and measurements, workers engaged in their usual work routines for approximately eight hours, and minimal disturbance by researchers occurred during the work shift. All workers were engaged in outdoor work activities, in an uncovered environment with limited opportunities for shade. Tasks varied from building forms, pouring concrete, and operating machinery.

At the end of the shift, body weight was measured in order to calculate the percent change in body weight. A urine sample was again collected to measure USG, and all research equipment was removed from the subjects. Finally, workers were surveyed to identify their peak and average values throughout the work shift by rating perceived exertion (RPE) (Borg, 1982), thermal sensation (TS), and thermal comfort (TC). Heat index, dry bulb temperature, wet bulb temperature, and relative humidity were monitored and recorded continuously in the area where workers were primarily working with a heat stress monitor (Kestrel 5400 Heat Stress Tracker, Nielsen-Kellerman, Boothwyn, Pennsylvania).

Statistical Analysis: Data is presented as mean ± standard deviation. Paired samples T-tests were conducted to assess differences in USG and body weight between pre- and post-work time points. A Pearson correlation was generated to compare the relationships between heat index and peak core temperature. Significance levels were set at $p<0.05$.

RESULTS

The maximal heat index was 34.1°C (93.4°F) with an average of 28.1 ± 3.7°C (82.4°F). The maximum dry bulb temperature was 36.5°C (97.7°F), and the average was 30.0 ± 4.1°C (86.1 °F). The maximum wet bulb temperature was 22.2°C (72.0°F) with an average of 15.3 ± 1.1°C (59.5°F). Relative humidity peaked at 50.4 % with an average of 24.4 ± 8.3%.

Heat Strain: Figure 1A displays the core temperature of all seven workers. Figure 1B presents the average peak core temperature, which was 37.9 ± 0.2°C (100.2°F). Two of seven subjects (29%) reached a peak core temperature greater than 38°C (100.4°F), and the highest value recorded was 38.1°C (100.6°F). The average core temperature throughout the workday was 37.4 ± 0.4°C (99.4°F). The average peak skin temperature was 36.7 ± 0.6°C (98.1°F), and the average skin temperature throughout the workday was 34.2 ± 1.4°C (93.6°F).

Figure 1. Core temperature of road construction workers is displayed as A) average core temperature (red line) ± standard deviation (black line) throughout a work shift and B) individual peak core temperature (N=7)

Hydration: There was no significant difference between USG before (1.020 ± 0.01) and after (1.024 ± 0.01) the work shift (p=0.30). However, there was a significant decrease in body weight from pre-shift (86.1 ± 25.4 kg) to post-shift (85.3 ± 25.2kg) (p=0.023), with an overall percent body weight loss of 0.85 ± 1.0%.

Perceptions of Exertion, Comfort, and Thermal Environment: The reported peak RPE was 14.1 ± 2.5, corresponding to a perceived exertion just between "somewhat hard" and "hard (heavy)." The average RPE was 11.6 ± 1.9, corresponding to a perceived exertion of "light." The peak TC in workers was 2.7 ± 0.8, just below "uncomfortable", with an average of 2.0 ± 0.6, corresponding to "slightly uncomfortable." Finally, the peak TS was 3.1 ± 0.4 "hot", with average TS being 2.2 ± 0.5 "warm."

Heat Index and Core Temperature Correlation

A positive correlation was observed between heat index and core temperature ($p=0.0010$, $r^2=0.3792$). The generated equation, core temperature = 36.74 + 0.0256*(heat index), indicates that for every one-degree Celsius increase in heat index, there is an associated increase of 0.0256°C in core temperature in road construction workers.

DISCUSSION

The purpose of this study was to investigate heat strain in road construction workers during work in the summer and provide novel insight into heat strain by measuring core temperature. Our primary finding was that approximately 29% of workers reached a peak core temperature exceeding the 38.0°C (100.4°F) threshold recommended by ACGIH. This finding provides evidence that some road construction workers experience significant heat strain during work in the summer, which puts them at increased risk for heat-related illnesses (Spector et al. 2015). Additionally, we demonstrated a moderate, positive correlation between heat index and core temperature, indicating that environmental heat is likely related to these elevated peak core temperature values.

An evaluation of exposure limits by Tustin and collaborators (Tustin et al. 2018) suggested that a threshold value of 29.4°C (84.9°F) for heat index may be an effective threshold to identify increased risk in outdoor workers for heat-related illness. The peak heat index of 34.1°C (93.4°F) recorded in our study was much higher (4.7°C higher) than this recommended threshold, suggesting that the road workers in this study were at a significant risk for heat-related illness. This elevated risk was reflected by the 29% of the workers reaching a core temperature greater than

38.0°C (100.4°F). Workers appeared to sense this heat strain, as reflected by an average peak TS of 3.1 ("hot"), and the average peak TCore was 2.2 ("warm"). These findings indicate that road construction workers may appropriately sense heat stress in relation to heat strain. Interestingly, we found that road construction workers had a lower average RPE (11.6 ± 1.9) compared to research done by Roja et al. (2006), who found an average RPE of 15 ± 2. These contrasting values represent a difference between "light" work compared to "hard (heavy)" work, which may be influenced by factors such as workday variation, job sites, environmental conditions, and worker population. This is a notable finding, as this difference in perceived exertion may also be indicative of differences in workload, and therefore potentially metabolic heat production.

A limitation of this study was that we had a small sample size of seven workers. Future research on road construction workers on a larger scale is warranted to further quantify work-related heat strain, explore possible cooling strategies, and identify appropriate risk factors for heat-related illness.
In conclusion, our results demonstrate that some road construction workers experience significant heat strain while working in the summer, with heat strain positively correlated to environmental heat index.

Conclusion

In conclusion, construction workers exposed to moderate environmental heat stress experience significant heat strain during a typical work shift. This strain is likely induced by the combination of environmental and metabolic heat, and companies may consider implementing cooling and preventative strategies for work performed in the summer months, particularly in open areas with solar exposure.

Finally, there has been limited research done on the implementation of cooling strategies for workers in the heat, including cooling gear, enhanced heat dissipation clothing, water dousing, ingestion of ice slush, and electrolyte liquid hydration (Chicas et al., 2020). Further research is needed to determine the effectiveness, and feasibility of these interventions in construction workers in the United States.

Changes/Problems That Resulted In Deviation From The Methods

The initial objective of this study was to assess the metabolic rate, environmental heat stress, and heat strain experienced by cement masonry and roofing construction workers during summer work, comparing the results with recommended threshold limits by NIOSH and ACGIH. Although the study made progress toward achieving this aim, certain adjustments were necessary.

In May 2023, the PI initiated contact with companies interested in participating in the study to plan the data collection during the summer. Unfortunately, some companies did not respond to emails and phone calls. Only one roadwork company showed responsiveness, and the PI successfully scheduled data collection for July 2023. During this period, the PI and co-PI established connections with the La Isla Network, whose representatives had contacts with Turner Construction Company. After an initial meeting, Turner Construction expressed immediate interest in having the study presented to their employees, leading to the scheduling of data collection in Kansas City/MO at the end of July 2023.

Upon arrival in Kansas City and the commencement of recruitment, it became apparent that roofers were reluctant to participate in the study. In response, the PI and co-PI decided to broaden the recruitment scope to include job types not initially considered, such as carpenters and laborers. Throughout the data collection process, some roofers eventually expressed interest, allowing the collection with five individuals.
Furthermore, a second deviation from the original objectives occurred in the method of measuring metabolic rate. Technical issues with the portable metabolic gas analyzer emerged prior to the scheduled trip to Kansas City. In response to this issue, the researchers made the decision to estimate metabolic rate by measuring heart rate and correcting for core temperature. This adjustment was made to ensure the continuation of data collection despite the unexpected equipment malfunction. Additionally, the use of the portable metabolic analyzer would disrupt the work multiple times and take a significant amount of time during preparation for the measurement. Therefore, the PI and co-PI chose to minimize disruption to the workday of the participating workers and not use the metabolic analyzer.

The research received support from the Association of General Contractors of New Mexico (ACGNM). The Principal Investigator (PI) presented the project to local company directors and safety personnel in two separate meetings held in September 2022 and March 2023 at the association. While a couple of companies initially expressed interest in having the project presented to their workers, roofing companies were hesitant due to concerns that the research might influence future OSHA regulations, potentially negatively impacting their operations.

Future Funding Plans

We are in negotiation with Turner Construction Company to conduct a follow-up study with their workers. Furthermore, the investigators are engaged in discussions regarding the development of an R01 project, with plans to submit the proposal to the National Institutes of Health (NIH).

Dissemination Plan

The dissemination plan involves a multi-faceted approach to reach diverse audiences. The PI has already delivered two research presentations at ACG NM sharing the results of the two studies with New Mexico construction companies. A presentation was delivered to Turner Construction Company sharing the results obtained in the study conducted in Kansa City. Also, informational flyers have been distributed to research participants and safety personnel at Turner Construction.

For broader academic outreach, two manuscripts with research data from the two studies are being developed and planned to be submitted to occupational health journals. Two research abstracts listed below were presented in a conference.

Specht J, Tourula E, Hite MJ, Garcia S, Walker C, Yoder H, Schlader Z, Amorim F. Environmental heat stress and physiological heat strain in construction workers during work in the summer. Southwest American College of Sports Medicine Annual Meeting; October 2023; Costa Mesa, CA. **Dr. Gail *Butterfield Student Research Award, Presidents Cup Competition Representative.***

Garcia S, Specht J, Schlader Z, Amorim F. Heat strain in road construction workers during the summer, an observational study. Southwest American College of Sports Medicine Annual Meeting; October 2023; Costa Mesa, CA. *Finalist for Undergraduate Student Award.*

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Appendix

Flyer distributed to research participants and safety personnel at Turner Construction.

STAYING SAFE IN THE HEAT

Findings From the RESEARCH STUDY Conducted in Kansas City

We would like to thank you again for participating in our research study conducted this summer. Your participation in this research project helped us to better understand and address heat stress in construction.

WHAT WE INVESTIGATED

We studied how **HEAT** affects workers in various job types, such as roofers, concrete workers, and carpenters. We also compared how **HEAT** affects workers exposed directly to the sun or in shaded areas.

KEY FINDINGS

- Some workers experienced elevated body temperatures (above 100.4°F) due to work in the heat.
- Workers directly exposed to the sun and with higher work intensity presented with the highest body temperatures.
- Many workers arrived at the job **dehydrated**.

WHAT YOU CAN DO:

- Drink plenty of water, starting before work so you don't get dehydrated.
- Take regular breaks, preferably in shaded or cool areas.
- If it is a hot day, reduce your work intensity and take breaks more often.
- If you start feeling dizzy, weak, or sick, it's crucial to let your supervisor know.