Investigation on the Impact of Heat Stress on Construction Labour Productivity during the Cool Season, Study Case: Phnom Penh

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THERMAL LABORATORY

The CCCA3 Knowledge Sharing Event

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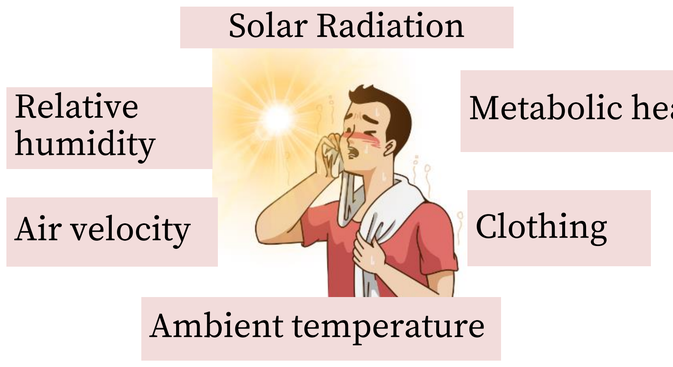
Background and objectives

Global warming is causing a rise in severe and prolonged heat stress, posing a significant occupational risk to construction workers, potentially leading to health issues and decreased productivity [1]. Phnom Penh's cool season heat stress has not been previously studied, which is why this study aims to investigate its impact on construction labour productivity and health during this challenging time.



Clothing
+
Metabolic Heat
+
Environment Factors

Heat Stress [2]

Method

A comprehensive study involving 20 construction workers investigated the impact of demographic, environmental, physiological, psychometric, and activity factors on their performance. Employing R programming, the resulting data underwent meticulous analysis, including descriptive statistics, ANOVA tests, correlation analyses, and linear regressions, revealing crucial insights into worker well-being and productivity.

Before data collection

- Contact the site manager for permission
- Submit the application to the NECHR (National Ethics Committee for Health Research), MOH
- Ethics Approval

During data collection

- Recruited participants
- Sign consent letter
- Data collection (demographic, environmental , physiological, psychometric and worker's activities

After data collection

- Data input
- Data analysis

Figure 1. The flow process of this study

Heat Stress Monitor

Weighing

Wear the heart rate sensor around the workers' chest to measure heart rate.

Heart rate monitor

Environment factor:
Wet Bulb Globe Temperature (WBGT) is the heat stress indicator adopted from , [3].
WBGT(outdoor) = 0.7NWB + 0.2GT + 0.1DB
NWB =Natural Web Bulb Temperature, GT = Globe Temperature, and DB = Dry Bulb Temperature

Physiological factors: Heart rate (bpm)
Heart rate maximum (HRmax) = 220 – Age [5]
The percentage of heart rate maximum (%HRmax) = (HR/HRmax) × 100

Psychometric factors: Thermal Sensation (TS) and Rate of Perceived Exertion (RPE) Perceptual Strain Index [4],
(PeSI) = 5[(TS-7)/6] + 5(RPE/10)

Construction Labour Productivity: %Direct work is considered as Construction Labour Productivity [6].
Direct Tasks (AACE International):

- Make use of wrenches to connect, cut, bend, and modify reinforcing steel bars
- Place reinforcing steel bars
- Carry reinforcing steel bars
- Use meter sticks for measurements

(A) (B) (C)

Direct task

(A) Workers sorted and organized steel bars
(B) Workers used of wrenches to cut and bend steel bars
(C) Workers used meter sticks for measurement

Results

Table 1: Demographic Information

Participants (n = 20)	Mean ± SD	Range
Age (years old)	30.25 ± 12.22	18-54
Height (m)	1.65 ± 0.06	1.56-1.75
Weight (kg)	60.98 ± 9.09	49.1-78.8
BMI (kg/m²)	22.26 ± 2.6	17.67-26.63

Table 2: Level risk of WBGT categories with other variables

WBGT(°C)	CLP (Mean ± SD)	PeSI (Mean ± SD)	%HRmax (Mean ± SD)
High (WBGT>32.1)	0.67 ± 0.18	3.39 ± 1.51	54 ± 4
Moderate (29.4<WBGT<32.1)	0.67 ± 0.26	2.27 ± 1.13	50 ± 7
Low (WBGT<29.3)	0.63 ± 0.28	1.93 ± 1.05	48 ± 8

Table 3: ANOVA Applied

	DF	Sum Sq	Mean Sq	F value	Pr(>F)
PeSI/WBGT	2	15.89	7.9462	6.8755	0.001144**
CLP/PeSI	5	4.735	0.197	6.221	0.0008847***

WBGT had a significant effect on PeSI (P_value < .01);
PeSI had a strongly effect on CLP (P_value < .001)

Table 5: Correlation

	CLP	WBGT	PeSI
WBGT	-0.025		
PeSI	0.101*	0.260***	
%HRmax	0.016	0.123**	-0.042

(Significant codes : * *P* < *.05;* ** *P* < *.01;* *** *P* < *.001)*

CLP and WBGT had a correlation coefficient of -0.025, WBGT with PeSI (0.26).

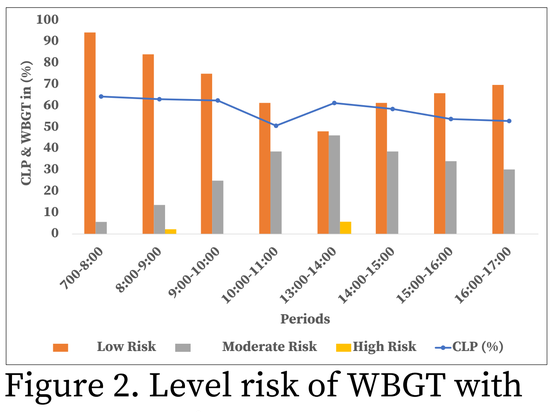


Figure 2. Level risk of WBGT with CLP in percentage

- There is no significant difference value of CLP in both shifts and between the level risks of WBGT.
- Moderate heat strain occurred during the afternoon shift.

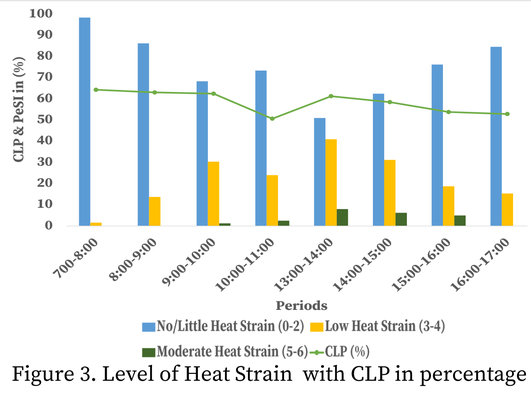


Figure 3. Level of Heat Strain with CLP in percentage

Table 4: Linear Regression Model

R^2 = 0.02	Estimate	Pr(> |t|)
(Intercept)	0.727	0.007**
Age	0.001	0.279
Shift	-0.019	0.471
WBGT	-0.005	0.322
PeSI	0.030	0.011*
%HRmax	0.022	0.902

Conclusion

The morning session, workers experienced less heat strain than in the afternoon session (no heat strain in the morning accounted for 81.61% and moderate heat strain was only 0.95%). When WBGT or heat stress indicator reached 32.93°C during 13:00-14:00, workers experienced more heat strain. Moreover, both shifts had a level of CLP is around 60%, very similar. The results from ANOVA and correlation showed that WBGT has substantially correlated and negative effects on certain psychometric parameters such as PeSI with a *P-value* < *0.01*. Then, PeSI has a deep relationship and effects on CLP with a *P-value* < *0.001*. Therefore, this study suggests that heat stress may indirectly affect construction labour productivity during the cool season in Phnom Penh.
Future studies should focus more on heat-related symptoms to mitigate the heat strain on workers and also improve construction labour productivity.

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