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Factors affecting Cambodian construction labor productivity in hot weather

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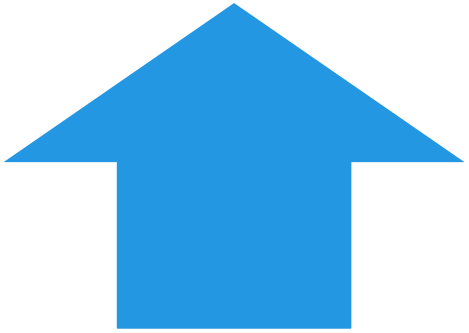
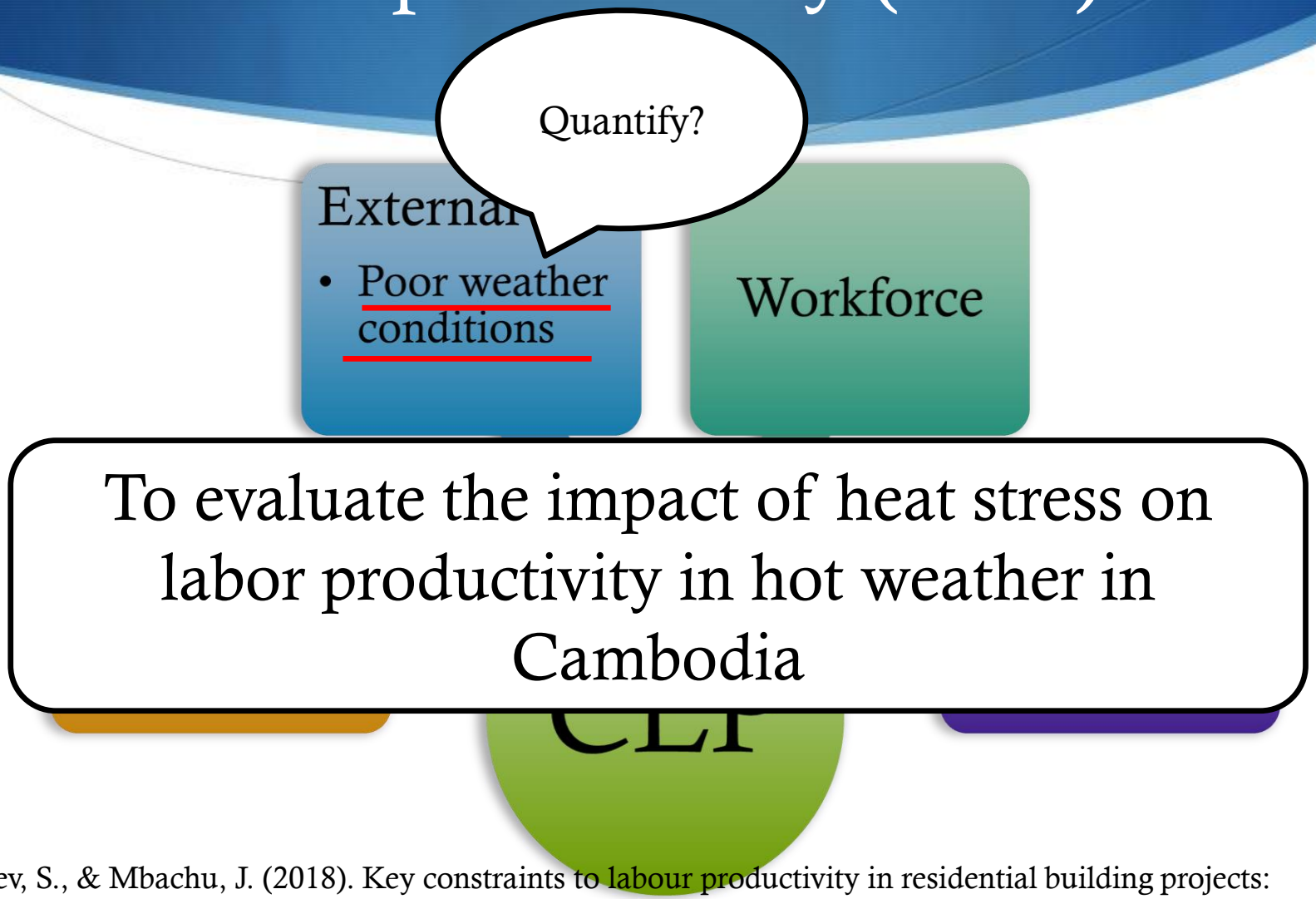
Construction industry in Cambodia

Low productivity; Cost and time overruns

30% to the growth of GDP; Foreign investment



Constraints affecting construction labor productivity (CLP)



To evaluate the impact of heat stress on labor productivity in hot weather in Cambodia

Durdyev, S., & Mbachu, J. (2018). Key constraints to labour productivity in residential building projects: Evidence from Cambodia. International Journal of Construction Management, 18(5), 385-393.

Impact of heat stress on productivity

- Grimm and Wagner (1974) indicated that workmanship declined at relatively high temperatures.
- Thomas and Yiakoumis (1987) and Koehn and Brown (1985) explored a non-linear relationship between CLP and thermal environments.
- Hancher and Abd-Elkhalek (1998) developed a CLP model taking both work conditions and climatic environment into account.
- Srinavin and Mohamed (2003) introduced a CLP model that estimated the impacts of various heat stressors on labour productivity in Thailand.
- In Beijing, Li et al. (2016) found that CLP declined by 0.57% when the temperature increased by 1 °C.
- Yi and Chan (2017) comprehensively assessed the impacts of meteorological, physiological, work-related, clothing, and demographic parameters on CLP in Hong Kong. It indicated that CLP decreased by 0.33% when the temperature increased by 1 °C.

Research methodology

- Quasi-experimental design: one-group research design with posttest measure – evaluate the effect of an exposure on the target population
- Bar fixing worker: One of the most physical demanding and long duration tasks in construction (Chang et al., 2009; Wong et al., 2014).
- Sample size: 12 male Cambodian steel bar fixing workers were randomly selected. The sample size was determined based on previous quasi-experimental field studies at construction sites which had produced some statistically significant data points (Chan et al., 2012a,b).
- CLP at activity level: To facilitate project managers to better estimate, plan, schedule, and manage tasks (Yi and Chan, 2014).

Research de

No.	Questions	Yes	No
	Do you have known major health problems; តើអ្នកបានដឹងពីបញ្ហាសុខភាពអ្វីទេ?		1
1	Hypertension ជំងឺលើសឈាម		1
2	diabetes ជំងឺទឹកនោមផ្អែម		1
3	cardiovascular problem បញ្ហាសរសៃឈាមបេះដូង		1
	Neurological disease ជំងឺសរសៃប្រសាទ		1
	Have you experienced the heat illness symptoms in hot weather; តើអ្នកធ្លាប់មានរោគសញ្ញាដែលបណ្តាលមកពីកម្តៅនៅកន្លែងដែលក្តៅដែរទេ?		
	confusion វង្វេងសម្ងារតិ		1
	drenching sweats ហូរញើស	1	
	Headache ឈឺក្បាល		1
	fainting ដួលសន្លប់		1
	Nausea ចង់ក្អួត		1
	Shortness of breath ដកដង្ហើមខ្លី		1
	Cramps រមួលក្រពើ		1

Measurements

Environment

WBGT (1 min)

Physiology

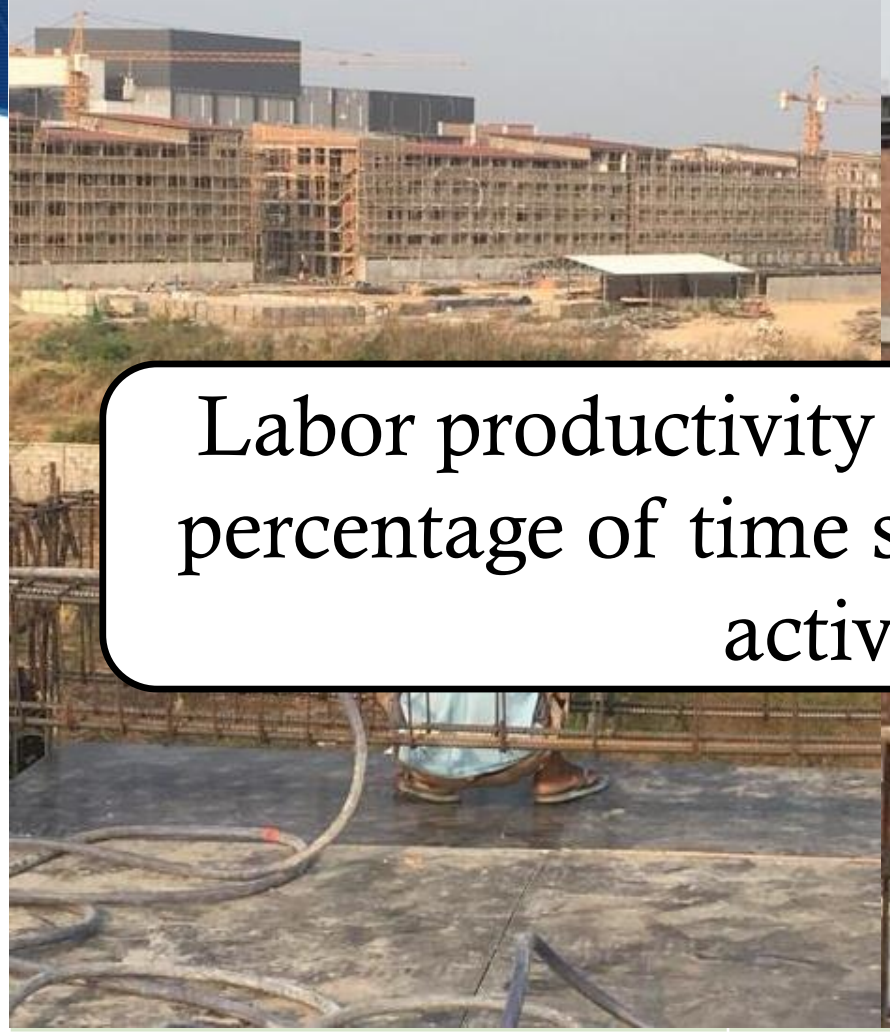
Heart rate (1 s), sweat rate

Rating	Descriptor
0	Rest
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	-
7	Very Hard
8	-
9	-
10	Maximal

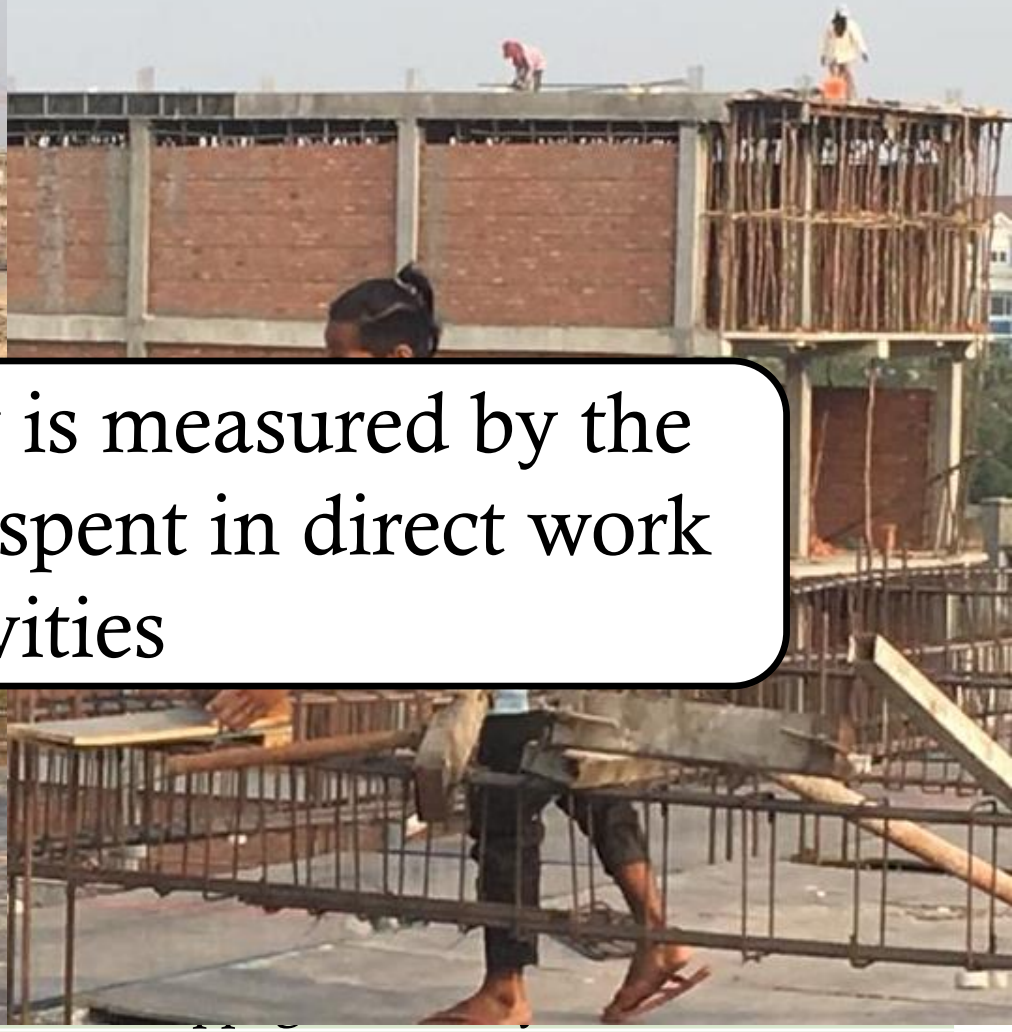
Perception

RPE and thermal sensation (15 min)

Direct work activities
Fixing



Indirect work activities
Taking materials



Labor productivity is measured by the percentage of time spent in direct work activities

C-2	Chat, smoke, sit down, use cell phones, go to the washroom

Data analysis

- Calculations:

Sweat rate (L/h) was estimated by the change of body mass corrected by water mass.

$\%HR_{max}$ was used to describe work intensity (HR_{max}=220-age).

The WBGT threshold temperatures were adopted by the United State Military's guideline (Department of Army, 2016) as follows: below 29.3 °C is low risk, between 29.4 °C and 32.1 °C is moderate risk, and 32.1 °C above is high risk.

- Synchronize data:

WBGT and $\%HR_{max}$ during direct work activities were taken at 15 min average.

%CLP was defined as the percentage of direct work time within 15 min.

A total of 343 data sets of environmental, physiological, and perceptual parameters were captured.

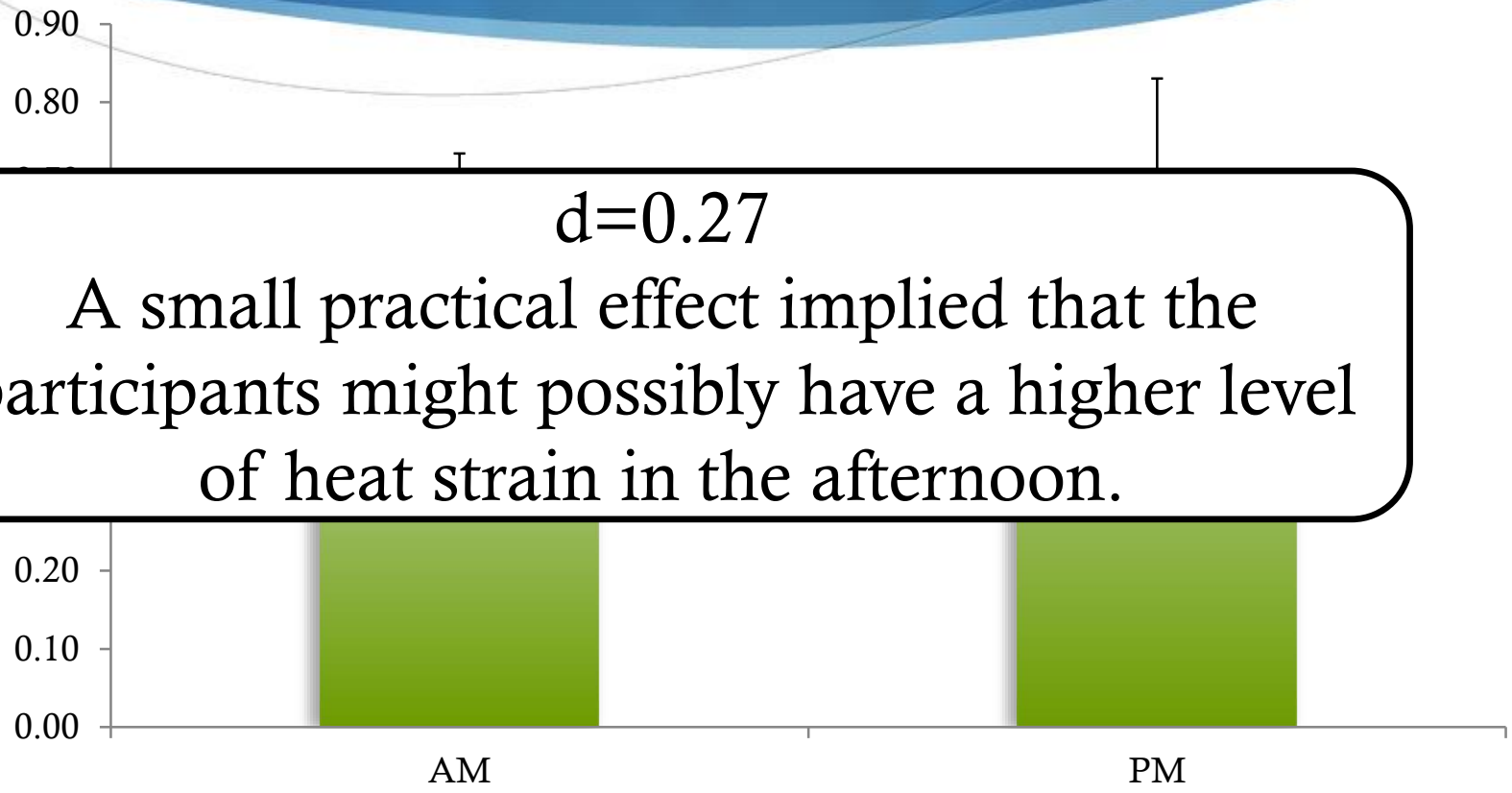
- Statistical analysis:
- Chi-square test was performed to examine whether distributions of WBGT and $\%HR_{max}$ categories differ by AM and PM sessions.
- Kruskal-Wallis test was used to assess the difference in RPE and TS between AM and PM work sessions.
- Effect size was calculated to assess the practical effect in sweat rate between AM and PM sessions. A Cohen's d of <0.2 is classified as a trivial effect, 0.2–0.4 as a small effect, 0.4–0.7 as a moderate effect, and ≥ 0.8 as a large effect (Christensen and Christensen, 1977).

- Dependent variable: %CLP
- Independent variables: WBGT, $\%HR_{max}$, TS, RPE, and work session (1=morning, 2=afternoon)
- **A linear mixed-effects model (LMM)** with repeated measures was used in this study to evaluate the effects of environmental, physiological, and perceptual variables on productivity:

(1) repeated measures taken for the same participant might be dependent from each other, which is explicitly violated in traditional regression analysis (Peretz et al., 2002);

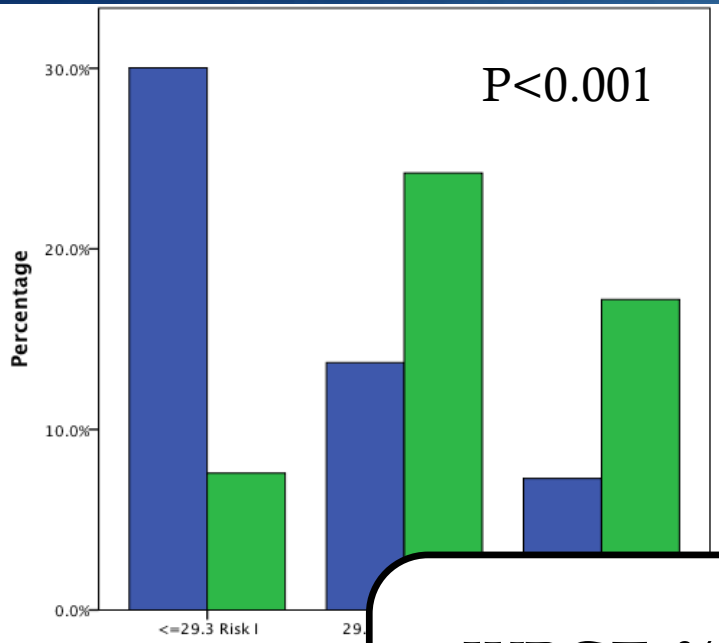
(2) fixed effects could provide estimates of the average responses to a specific parameter, while randomly selection of the participants resulted in random effects of the participants that accounted for the natural heterogeneity in the responses of different participants (Peretz et al., 2002; Cnaan et al., 1997).

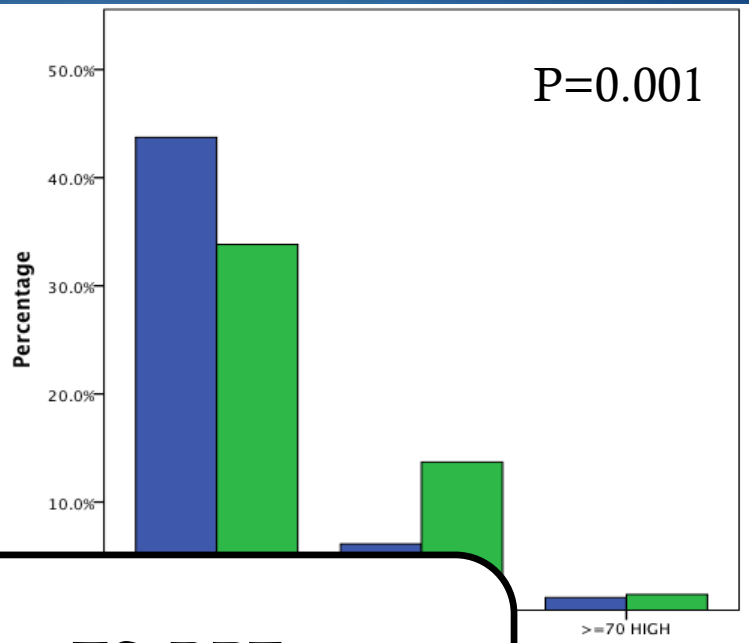
Findings



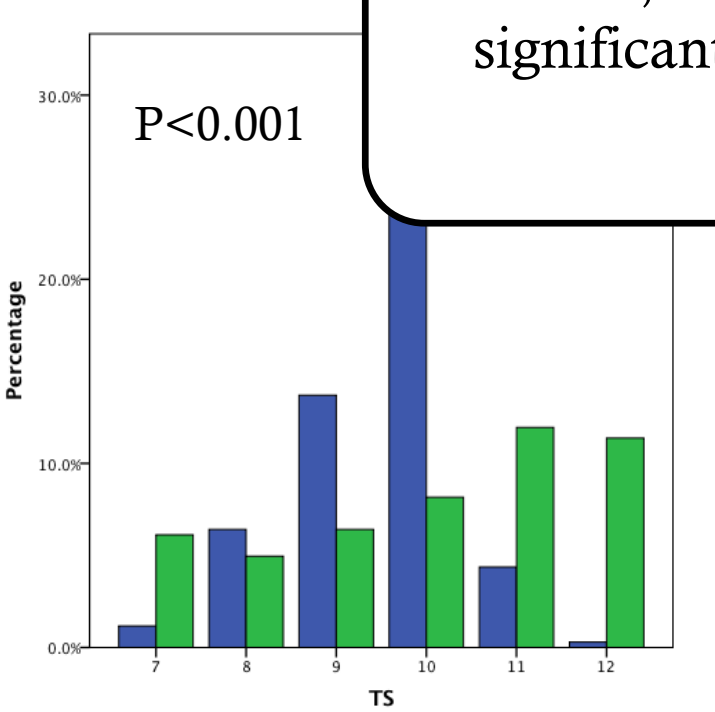
d=0.27

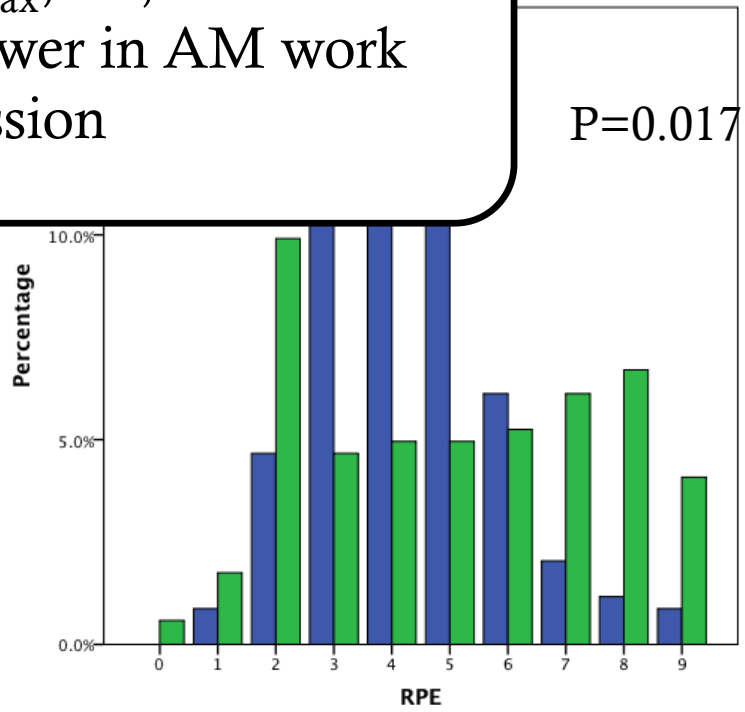
A small practical effect implied that the participants might possibly have a higher level of heat strain in the afternoon.





WBGT, %HR_{max}, TS, RPE were significantly lower in AM work session





- Main effects on %CLP

Parameters	Coefficient	Standard error	p value
Intercept	0.13	0.23	0.568
WBGT	0.01	0.01	0.388
$\%HR_{max}$	0.52	0.19	**0.005**
TS	-0.01	0.01	0.608
RPE	0.02	0.01	**0.006**
Work session Morning[a] (PM is a ref. group)	0.10	0.03	**0.001**

Recommendations

- Labor productivity was significantly higher in the morning work session. **More direct work activities can be shifted to the morning work session**.
- Labor productivity of rebar workers was mainly determined by physical efforts but not affected by thermal environment. **Further research should be conducted to investigate the environmental and managerial factors affecting workers productivity by enlarging the sample size**.

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TDC

High Rise Steel
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