Exposure to Heat from Natural Working Environment and Cardiovascular Strain: A Study in Male Agricultural Workers in southern Bengal

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Abstract: Agriculture is one of the most important occupations in informal sector in India, including West Bengal. Agricultural workers are engaged in the field throughout the day irrespective of the climatic conditions. Unfavorable environmental condition may have some impact on the health of the individuals working in agricultural field. In this backdrop, present study has been undertaken to evaluate the effect of work and workplace heat exposure on cardiovascular parameters in 35 male agricultural workers (21-31 years) of southern Bengal. It has been found that environmental condition was above the recommended threshold value making the activity strenuous as conveyed from the computed physiological strain indicators.

1 Introduction

The total land area of West Bengal is 88,752 sq km [19]; whereas the estimated population of the state is almost 91.3 million [8]. 62.7% of rural work force and 70% of the rural population of the state depends on agriculture. Studies have reported that physical work capacity and work-performance are getting negatively affected [12, 20, 23-24, 35] in high temperature [3, 4, 10, 27-28, 35]. In this backdrop, the present study has been undertaken to evaluate the effect of workplace heat exposure on cv strain in male agricultural workers of southern Bengal.

2 Methodology

The present study was conducted on 35 consenting adult male individuals (age range 21-31 years), with a minimum working experience of three years, and without any history of chronic illness (self - reported). Information regarding age (year), socio – economic status (SES) [33], working experience (year), and average working time (hr.day-1) was recorded in a pre-designed schedule. Dry bulb temperature (TDB), wet bulb (TWB) temperature (º C), globe temperature (Tg) and natural wet bulb temperature (T nwb) were noted during the working hours. The values of Wet bulb globe temperature (WBGT) [17], corrected effective

temperature (CET) [7], and discomfort index (DI) [14] were found out. Body height (cm) and body weight (kg) were measured using anthropometric measurement kit and a pre calibrated weighing scale respectively and BMI was calculated. The resting heart rate (beats. min-1), systolic and diastolic blood pressure (mm Hg) were recorded. Physiological strain indicators in terms of peak heart rate (HR peak) (beats.min-1) [15], heart rate reserve (HRR) [36], net cardiac cost (NCC) [9], relative cardiac cost (RCC) [6] and estimated energy expenditure (EEE) (kcal.min-1) [32] were found out. The environmental and cardiac response data were collected during morning, around noon and afternoon hours, respectively referred to as first to third spell (S1-S2-S3). Obtained data were tabulated and statistically analysed. P value lower than 0.05 ($P < 0.05$) was considered significant.

3 Results

Background information of the participants has been presented in Table 1.

Table 1 Background information of the study participants

Variables	Values
Age (year)	27.8 ± 2.35
Marital Status (%)	80
SES	Lower Middle
Working experience (year)	8.1 ± 2.56
Working time (hr.day^{-1})	8.5 ± 1.66

The environmental condition is presented in Table 2.

Table 2 Indicators of thermal environmental condition in three different spells

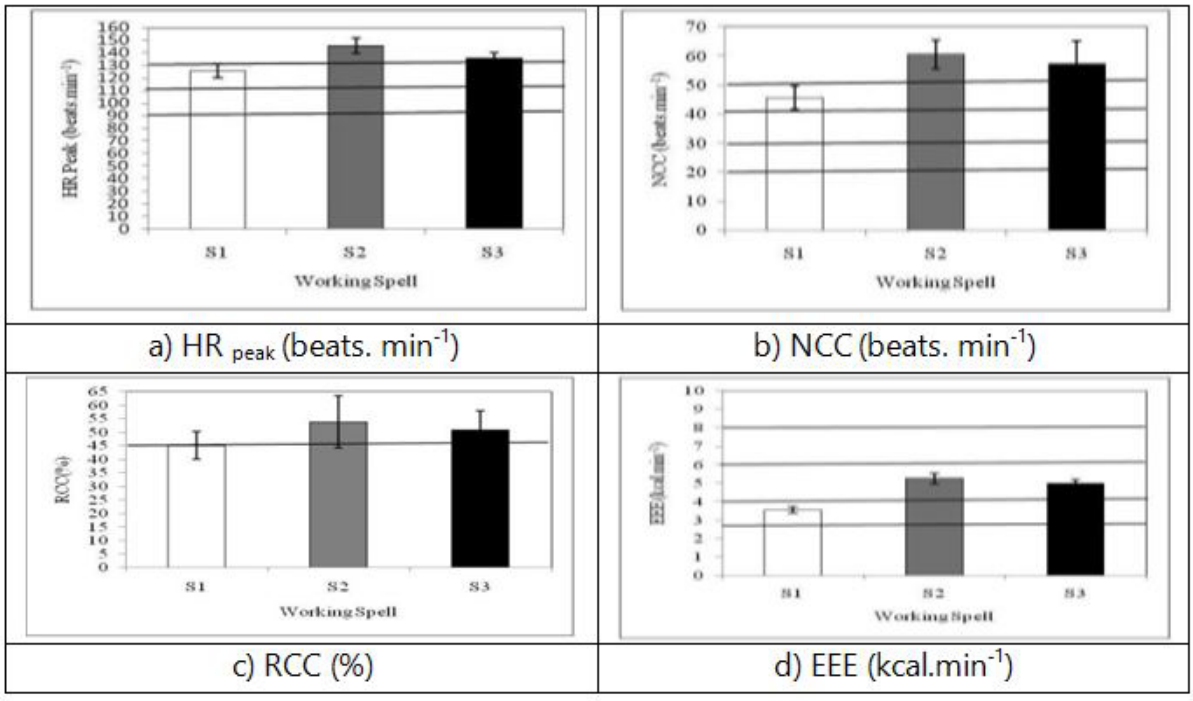
Environmental indicators	Spell 1	Spell 2	Spell 3
WBGT (^{0}C)	28.5 ± 1.61	34.0 ± 1.79	33.9 ± 1.65
CET (^{0}C)	26.4 ± 0.55	32.0 ± 1.31	31.5 ± 2.41
DI (^{0}C)	28.3 ± 1.03	32.0 ± 2.15	31.3 ± 2.04

The physical characteristics in terms of some anthropometric parameters and the physiological characteristics are presented in table 3.

Table 3 Physical and physiological characteristics of the study participants

Variables	Values
Body height (cm)	167.5 ± 3.12
Body weight (kg)	65.5 ± 4.42
BMI	22.5 ± 1.45
$HR_{Pre\ work}$ (beats. min^{-1})	82.2 ± 9.75
HR_{max}(beats.min^{-1})	191.5 ± 5.77
HRR (beats.min^{-1})	115.2 ± 5.12
$SBP_{Pre\ work}$ (mm Hg)	125.2 ± 8.05
$DBP_{Pre\ work}$ (mm Hg)	85.5 ± 5.46

In figure 1 the cardiac response profile in terms of HR peak (beats. min-1) (a), NCC (beats. min-1) (b), RCC (%) (c), EEE (kcal.min-1) (d) of the study participants has been presented.



a) HR $_{peak}$ (beats. min^{-1}) b) NCC (beats. min^{-1})

c) RCC (%) d) EEE (kcal.min^{-1})

Fig 1 Cardiac response profile of the study participants in terms of HR $_{peak}$ (beats. min^{-1}) (a), NCC (beats.min^{-1}) (b), RCC (%) (c) and EEE (kcal.min^{-1}) (d)

Degree of physiological strain [2, 9, 5 and 32] has been presented in Table 4.

Table 4 Degree of physiological strain in terms of indicators of Physiological Strain

Indicators of Physiological Strain	**Categorization**		
Working Spell	**S1**	**S2**	**S3**
HR $_{peak}$ (beats. min^{-1})	H	VH	VH
NCC (beats. min^{-1})	M	H	H
RCC (%)	M	H	H
EEE (kcal.min^{-1})	M	H	H

M= Moderate, H= Heavy, VH= Very Heavy

4 Discussions

Thermal comfort is a zone or span of conditions where 80% sedentary or slightly active person finds the environment thermally acceptable [14, 25, 30]. In the present study, in the first spell, the human resources should work ideally upto 75% of the total working time during the spell. In the second spell, no work is permissible [1, 13, 14, 22]. Whereas, in the third spell only 'light' category of work is ideally allowable and human resources should

work ideally upto 25%;similar trend of result has been observed in an earlier study [18]. The average values of CET indicate at first spell, there is no restriction for carrying out any work. Whereas at second spell, only 'light' category of work is permissible and at third spell 'moderate' category of work is permissible [7]. The average values of DI are very similar to the WBGT index calculated in the present study. In the present study at the first spell individuals feel hot but physical work may be performed with minor difficulties. The second and third spell of the working hours, the environmental exposure is felt to be 'stressful' to the working human resources [14]. It has been further observed that in the first, second and third spells the average values of HR Peak, one of the most important indicators of physiological strain [2, 11, 26], indicating 'heavy', 'very heavy' and 'very heavy' category of physiological strain [(Figure 1(a)]; the findings are in agreement with earlier findings [29, 31, 34]. Averages NCC (beats.min-1) values indicate 'moderate' work load in the first spell, whereas the second and third spells fall under 'heavy' category [Figure 1(b)]; this is in agreement with the finding of an earlier study [16]. Similar trend of results were also observed for RCC values 1(c)]. The average EEE values in the first spell, in-dicating the strain to fall under 'moderate' category; whereas in the second spell and the third spell it is considered 'heavy' category [Figure 1(d)]; this is also in consonance with the finding of earlier studies [21, 29, 34].

5 Conclusion

From the results of the present study, it may be concluded that environmental condition adjudged by selective heat stress indices are shifted, i.e. above the recommended threshold values, making the task strenuous for the human resources engaged as indicated from the indicators of physiological strain.

Acknowledgement

Authors are thankful to all volunteers for their participation.

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