*Indian Journal of Biological Sciences, 24 : 31-44, 2018 : ISSN No. 0972-8503*

# A COMPARATIVE STUDY ON THE IMPACT OF THERMAL WORKING ENVIRONMENTAL FACTORS AND WORKLOAD ON CARDIAC RESPONSE INDICATORS IN MALE FOOD CROP CULTIVATORS OF TWO ETHNIC GROUPS

**Ayan Chatterjee, Sandipan Chatterjee, Surjani Chatterjee, Neepa Banerjee, Shankarashis Mukherjee***

Human Performance Analytics and Facilitation Unit

Department of Physiology, University Colleges of Science and Technology

University of Calcutta, Rashbehari Shiksha Prangan

92 AcharyaPrafulla Chandra Road, Kolkata 700 009, India

ABSTRACT ■ Indian agriculture is characterized by overwhelmingly small holdings due to higher population density and nearly two-third of its population residing in the rural villages. Moreover, the different agricultural task is most commonly seasonal, and the cultivators often spend long hours under the open air. In order to ensure health, safety, wellbeing and achieving better work performance, the assessment of cardiac response indicators is considered as an essential factor. In this backdrop the present study has been undertaken to assess the impact of thermal working environmental condition and workload on workers' health status and cardiac response profile in 36 Bengalee male paddy cultivators (age range 21-30 years) involved in manual traditional threshing task during 'Boro' type of paddy cultivation and compared it with 31 male individuals engaged in similar type of task belonging to the Santhal tribe group. Indicators of thermal working environmental condition were calculated. Cardiac response indicators and physical fitness status of the study participants werealso calculated. From the present study it may be concluded that, cardiac strain was significantly higher in Bengalee male workerscompared to their age matchedSanthal counterpartswhilephysical fitness status was significantly higher in Santhal male workerscompared to their age matched Bengalee counterparts.

**Key words:** Agricultural workers, thermal working environment, cardiac strain, Santhal, Hooghly, threshing task

## INTRODUCTION

Rice (*Oryza sativa* L.) is a plant belonging to the family of grasses, Gramineae. It is one of the major food crops of the world and forms the staple diet of about half of the world's population. The global production of rice has been estimated to be at the level of 650 million tones. Asia is the leader in rice production accounting for about 90% of the world's production. India has a long history of rice cultivation. Globally, it stands first in rice area(West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Tamil Nadu, Bihar, Orissa, Assam, Karnataka and Haryana are the major paddy producing states in India) and second in rice production, after China. Paddy is grown almostinall the states in India (Roy and Kaur, 2015; Adhikari*et al*., 2012). Different agricultural tasks during the paddy cultivation period includeploughing, transplanting, reaping, threshing and parboiling, in Indiaandare to large extent non - mechanized

* **Corresponding author** : e-mail: msasish@yahoo.co.in

tasks; requiring substantial physical involvement engagement of a large number of human resources (Santra*et al*., 2015; Dewi and Septiana, 2015). Moreover, the agricultural work is ~~most~~ commonly seasonal, and during summer harvest, workers often spend long hours undertheopen sky, in intense heat, performing arduous physical labour (Goswami*et al*., 2012). These manual tasks may be physically demanding through their energy requirements and are commonly regarded as a source of the drudgery that have some adverse health outcomes to the agricultural workers (Sabharwal and Kaushik, 2011). There are reports that physical work capacity and work-performance are getting affected due to adverse thermal conditions prevailing in the working environment in different occupations (Kjellstrom*et al*., 2016) including agriculture (Chatterjee*et al*., 2016a; 2016b, 2018d, 2018f). In order to ensure health, safety, well being and thereby improving the work performance, the assessment of physiological strain is considered as an essential factor for understanding the cardiac response profile of the agricultural workers. In this backdrop the present study has been undertaken to assessthe impact of thermal working environmental condition and workload on cardiac response profile and workers' health status in terms of indicators of physiological strain in Bengalee male paddy cultivators primarily engaged in traditional manual(beating the panicles on a hard or wooden surface) threshing (threshing is the physical process of separating the grains from the rice straw) task during the period of 'Boro' (i.e. summer paddy; cultivating period December – May and threshing of the 'Boro' type of paddy usually done in April- middle of May)type of paddy cultivation and compare it with the agricultural workersof comparable age group from similar location engaged in similar type of task belonging to the Santhal tribe group.

## METHODS

Present study was carried out on a group of agricultural workers primarily engaged in traditional manual threshing task during the paddy cultivating time. Individuals were approached for consent to participate in the study. On obtaining individual consent from the participants, the study was carried out on mutually convenient dates. 36 adult Bengaleemales (age range 21-30 years) permanently residing in an and around Village Badanganj, Block Goghat, District Hooghly (latitude 23°01'N to 22°39' N and longitude 88°30'E to 87°39' E) and having a minimum working experience of three years and regularly working for a period of six to six and half hours per day in the agriculture field constituted the experimental group 1 (EG 1). 31 adult Santhal male agricultural workers (age range of 21 – 30 years), permanent inhabitant of the above mentioned location, primarily engaged in traditional manual threshing task constituted the experimental group 2 (EG2).Individuals, belonging from both the EG1 and EG 2 areengaged in the traditional manual threshing task i.e. separating the grains from the rice straw by beating on hard or wooden object in same working environmental condition during the 'Boro' type of paddy, an importantfood crop, cultivating time. One of the traditional procedures for threshing of rice is to pick up the sheaf of rice and strike or beat the panicles against a hard surface (Singh and Vinay, 2014). The separated grains are spread on a clean surface. The agricultural workers of the present study usually start their work around 6.00 a.m. and work for about three hours in the first spell. Then, they generally take a

break for breakfast for about half an hour and resume the work thereafter to continue the work in the second spell for about 2½ -3 hours. Then they have a little longer break for about one and half to two hours to have bath, lunch and little rest, and generally start their third spell of work at 3 p.m. and work for about 2 hours. During the working time the agricultural workers usually weara full sleeve cotton shirt and trouser. Information regarding participants' age (year), ethnic background, working experience (year), and average working time ($hr.day^{-1}$) were recorded in a pre-designed schedule. Socio – economic status (SES) – was assessed by using the modified version of Kuppuswamy's socioeconomic scale (Ravi Kumar *et al*., 2013). Ambient temperature (Ta) (ºC), wet bulb temperature (TWB) (ºC), globe temperature (Tg) (ºC) and natural wet bulb temperature (T nwb) (ºC) were periodically noted during the working hours in the agriculture field. The values of wet bulb globe temperature (WBGT) (ºC) (Heidari*et al*., 2015), corrected effective temperature (CET) (ºC) Brake and Bates, 2002), and discomfort index (DI) (ºC) (Epstein and Moran, 2006) were recorded. Stature (cm) and body weight (BW) (kg) were measured using anthropometric measurement set and weighing scale respectively. Body mass index (BMI), a somatometric indicator and body surface area (BSA) ($m^2$) were calculated from the measured stature (cm) and body weight (kg) data. Somatotyping characteristics of the participants were calculated (Carter and Heath, 1990). The pre work heart rate (HR Pre-work) (beats. $min^{-1}$), pre work systolic and diastolic blood pressure (SBP Pre-work) and (DBP Pre-work) (mm Hg) were recorded in the morning hours before the individuals started workingusing a stop watch and an automated blood pressure monitorrespectivelyin sitting condition. The oral temperature (°C) (Christensen, 1969), one of the most important biomarkers of stress due to heat and work, was measured before the work and immediately at the end of each spell. It was recorded by a clinical thermometer and it was noted in °Fahrenheit (°F) and expressed in °Celsius (°C) (Christensen, 1969). Physiological strain indicators - peak heart rate (HR peak) ($beats.min^{-1}$) (Astrand and Rodhal, 1986), estimated energy expenditure (EEE) ($kcal.min^{-1}$) (Ramanathan*et al*., 1967), net cardiac cost (NCC) ($beats.min^{-1}$) (Chamouxet al., 1985), cardio vascular strain index (beats) (Trites*et al*., 1993) were found out. The 'heaviness' of work has also been adjudged in terms of - peak heart rate (HR peak) ($beats.min^{-1}$), estimated energy expenditure (EEE) ($kcal.min^{-1}$), net cardiac cost (NCC) ($beats.min^{-1}$), cardio vascular strain index (CSI) (beats)and Oral temperature Recovery (OTRecovery) (°C). Physical fitness profile in terms of human physical drudgery index (HPDI Score) (Joshi *et al*., 2015) and VO2 max ($ml.kg^{-1}.min^{-1}$) (Hodges and Kennedy, 2011) were calculated.Datawere collected during the period of April – May 2017. The environmental and cardiovascular response data were collected at regular intervals during morning [6.15 - 9am], around noon [9.30 - 10.00 am to about 1pm] and after noon [3.00pm-5 pm] respectively referred to as first (S1) and second spell (S2) and third spell (S3). Obtained data were statistically analyzed. P value lower than 0.05 ($P<0.05$) was considered as significant.

**RESULTS AND DISCUSSIONS**

The general characteristics of both the groups are presented in Table 1. There is no significant difference in respect of age (years), SES, working experience (year) and average working time ($hr.day^{1}$).The assessment of physical characteristics and body composition

**Table 1.** General Characteristics of Study Participants

| Variables | Values | |
|---|---|---|
| | **EG 1** | **EG 2** |
| Age (years) ^ | 27.0 ± 3.55 | 25.8 ± 3.52 |
| Ethnic Background | Bengalee | Santhal |
| SES ^ | Lower Middle | Lower Middle |
| Working Experience (years) ^ | 8.3 ± 1.25 | 7.7 ± 1.89 |
| Working Time ($hr.day^{-1}$) ^ | 7.3 ± 0.55 | 7.5 ± 0.81 |

AM ± SD, ^ ns

**Table 2.** Physical and Physiological Characteristics of the Study Participants

| Variables | Values | |
|---|---|---|
| | **EG 1** | **EG 2** |
| Stature (cm) ^ | 163.3 ± 4.95 | 165.0 ± 5.15 |
| BW (kg) ^ | 57.1 ± 5.11 | 55.0 ± 7.17 |
| BMI ^ | 21.7 ± 4.07 | 20.6 ± 3.17 |
| BSA ($m^2$) ^ | 1.65 ± 0.092 | 1.62 ± 0.072 |
| Somatyping Characteristics | Mesomorphic Endomorph | Ectomorphic Mesomorph |
| $HR_{Pre\text{-}work}$ ($beats.min^{-1}$) ^ | 71.0 ± 6.14 | 69.1 ± 5.09 |
| $SBP_{Pre\text{-}Work}$ (mm Hg) ^ | 122.7 ± 9.11 | 121.5 ± 8.19 |
| $DBP_{Pre\text{-}Work}$ (mm Hg) ^ | 73.1 ± 6.19 | 71.7 ± 7.15 |
| $OT_{Pre\text{-}work}$($^0C$)* | 36.9 ± 0.08 | 36.8 ± 0.11 |

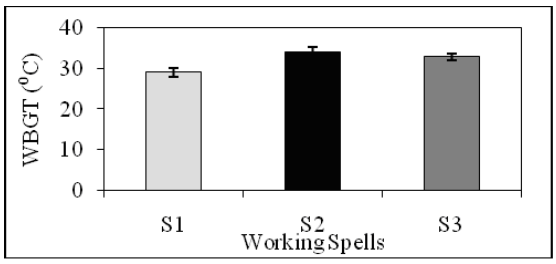
AM ± SD, ^ ns, *P<0.5

are important, particularly with reference to work performance. The physical and physiological variables of the study participants are presented in Table 2. EG 1 and EG 2 individuals do not differ significantly in terms of their stature (cm), body weight (kg), BMI, BSA ($m^2$), HR Pre work ($beats.min^{-1}$), SBP Pre work (mm Hg), and DBP Pre work (mm Hg). But significant difference exists between EG 1 and EG 2 participants in terms of OT Pre-work (°C). The mean values of BMI of EG 1 and EG 2 individuals are 21.7 $kg.m^{-2}$ and 20.6 $kg.m^{-2}$; which indicated that the participants were in 'normal weight' category as per the classification given by WHO (WHO, 2000). This finding is not surprising as the workersparticipating in the present study were carrying out manual threshing tasks during paddy cultivation time, as earlier studies observed that, individuals taking part regularly even in different forms of recreational physical activity in a planned and systematic way have beneficial role in achieving favorable body composition, enhancing fitness and hence facilitate maintaining a normal BMI (Banerjee *et al.*,

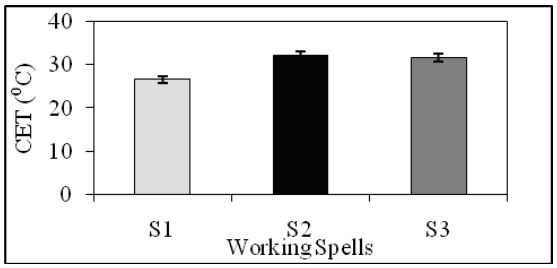
2015a; 2015b, Mukherjee *et al*., 2014a; 2014b, Mukherjee *et al*., 2013. Higher values of BMI have also been found to be associated with more chance of work related musculoskeletal disorder among sedentary workers (Chatterjee*et al*., 2015a; 2014). Another indicator of physical characteristic is Somatotype; an important tool that describes the momentary morphological state of an individual; provides information about three components: endomorphy- indicating share of adipose tissue, mesomorphy- relating to muscle mass and ectomorphy- expressed in relationships between body height and weight. Although the above method of description is three-dimensional, individual characteristics of human body build can be also represented in a two-dimensional somatogram (Carter and Heath, 1990). In the present study, the somatotyping score of the EG1 and EG2 individuals belonged to mesomorphic endomorph and ectomorphic mesomorph category; similar trend has been observed in one of our earlier studies carried out on workers engaged in agricultural sector (Chatterjee*et al*., 2015b). In terms of Heart rate pre working recorded for the subjects, it can be mentioned that they are not having either bradycardia or tachycardia.

In order to measure the working performance it is necessary that the working environment should be within comfortable limits (Banerjee *et al*., 2014, Santra*et al*., 2014). There are several indices that quantify human comfort levels, relating fromenvironmental factors to physiological responses. In the present study, the thermal environmental condition in terms of three indicators of thermal environmental status- WBGT, CET and DI are presented in figure 1.

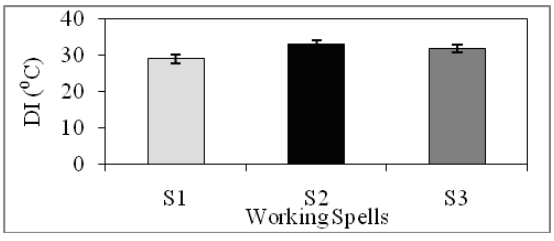
In the present study the average values of WBGT index, one of the popular indicators of thermal environmental condition, in the first, second and third spell is 29.0°C, 34.0°C and 32.8°C respectively [Fig. 1(a)]. In the first spell, there is no restriction on 'light' type of work, for 'moderate' type, upto 75%, for 'heavy' type, upto 50%, for very heavy', upto 25% of time,




a) Comparison of WBGT (°C) values along spells




b) Comparison of CET (°C) values along spells




c) Comparison of DI (°C) values along spells

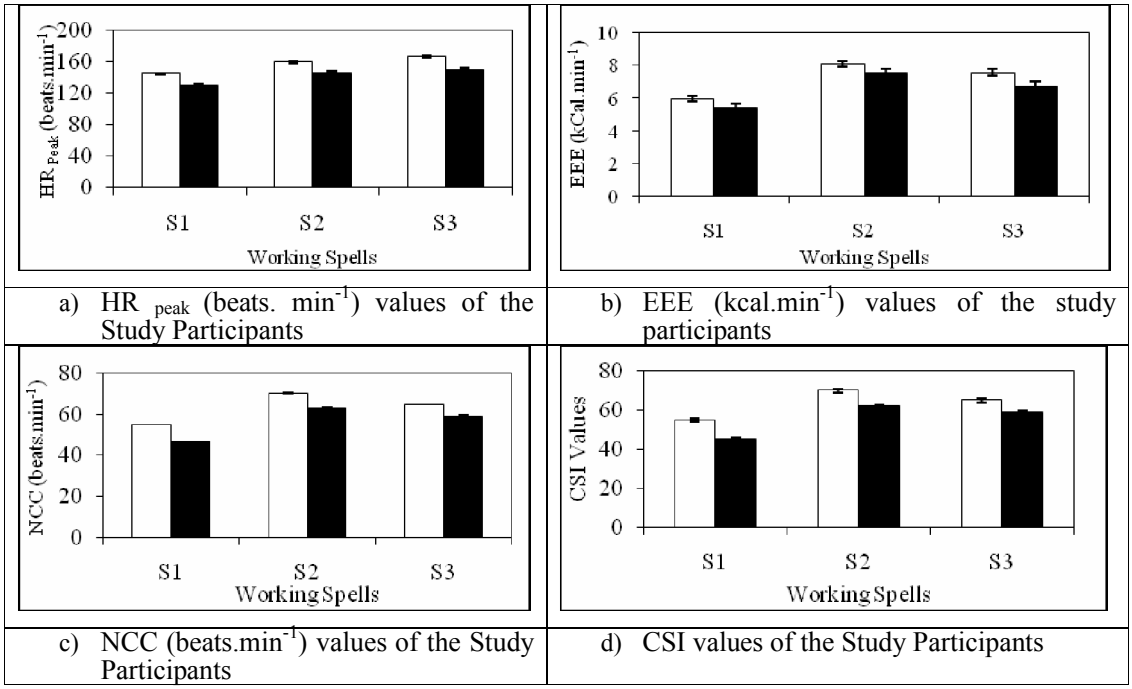
$S_1$, $S_2$, $S_3$- Working spells

**Fig. 1:** Indicators of Thermal Environmental Status along the spells

each hour work is allowable in work rest cycle. In the second and third spell of the working hours no work is ideally allowable (ACGIH, 2008; Habibi*etal*., 2015; Miller and Bates, 2007). The average values of CET in the present study in the first, second and third spell is 26.6°C, 32.2°C and 31.6°C respectively [Fig. 1 (b)]. In the first spell, there is no restriction recommended against carrying out of the work. Whereas in second spell no work is allowable and in the third spell of the working hoursupto 'moderate' category of work can be carried out (Epstein and Moran, 2006; WHO, 1969). Average values of DI in the first, second and third spell are 29.1°C, 33.1°C, 32.1°C respectively [Fig. 1 (c)]. In the first, second and third spell of the working hours heat load is considered severe, and agricultural workers engaged in physical work are at increased risk for heat illness(Epstein and Moran, 2006; Sohar*et al*., 1962). The trend of the result regarding thermal working environmental condition in terms of WBGT, CET and DI in agreement with the earlier studies carried out on workers engaged in ploughingtask during 'Aman' type of paddy cultivation (Chatterjee*et al*., 2015c; 2015d). It may be noted that there is agreement among the three indices indicating similar environmental condition. This is further affirmed by significant positive correlation coefficient values among these three heat indices [WBGT and CET ($P < 0.05$)], [CET and DI ($P < 0.05$)], and [WBGT and DI ($P < 0.05$)]. Added to this, continuation of work for long time in such adverse environmental condition especially during the second and third spell of the working hours there is a risk of developing different degree of physiological strain among the study participants. The finding of the present study regarding the thermal working environmental condition was in consonance with the findings of earlier studies in which theworkers engaged in different informal sector also (Kjellstrom*et al*., 2016; Venugopal*et al*., 2016; Lucas *et al*., 2014; Parsons, 2014; Mukherjee, 2015; Banerjee *et al*., 2015c). From the result of the thermal working environment, it was clearly observed that the individuals working in the agricultural field would feel very hot and uncomfortable most of the day time, especially during the second and third spell of the working hours. The environmental heat load might be one of the reasons for increased physiological strain. Moreover, the global climate change is increasing andaverage temperature is becoming more extreme. This is of significance in various locations of India which already remain hot in most months of the year; and affect directly the occupational health status and the work output of the different workers engaged in different types of outdoor occupational task (Kjellstrom*et al*., 2016; Venugopal*et al*., 2016; Kiefer *et al*., 2016).

The indices of physiological strain in terms of HR peak (beats. $min^{-1}$), EEE (kcal.$min^{-1}$), NCC (beats.$min^{-1}$) and CSI of EG 1 and EG 2 individuals along the working spells has been presented in figure 2.

Among the indices of physiological strain, HR is an important indicator of the overall physiological demand of work and it has the additional advantage of being very much easier to measure in the field (Singh, 2012). In the present study the HR peak value for the EG 1 and EG 2 individuals was 151-168, $\pm$ 8.14 (beats. $min^{-1}$), 135-145, $\pm$ 8.05 (beats. $min^{-1}$). [Fig. 2 (a)]. This finding of the present study regarding the HR peak value was in consonance with the finding of an earlier study conducted in Odisha (Mohanty*et al*., 2008); in which the workers are engaged in manual (beating the panicles on a hard or wooden surface) paddy threshing task. The




a) HR $_{peak}$ (beats. min$^{-1}$) values of the Study Participants

b) EEE (kcal.min$^{-1}$) values of the study participants

c) NCC (beats.min$^{-1}$) values of the Study Participants

d) CSI values of the Study Participants

**Fig. 2:** Comparison of Indices of Physiological Strain along the Working Spells, ☐ EG 1, ■ EG 2, S1, S2 and S3 are the Working spells

increase in HR values of the agricultural workers might be due to imposed strain. Several evidences revealed that HR increase during work as a result of cardiovascular responses might be due to physical stressor and also due to work-related stress (Kivimäki*et al*., 2006). HR acceleration is the main cardiovascular response to demands for the increased oxygen necessary for the performance of physical work, over and above that required at rest (Savonen*et al*., 2006). On the other hand, in any activity requiring physical effort, work is performed at the expense of energy. The amount of energy spent, however, depends on the level of physical activity. The energy expenditure, a physiological parameter, has been in broad use in the evaluation of muscular effort (Groborz and Juliszewski, 2013; Hodges and Kennedy, 2011). Average EEE values in EG 1 and EG 2 individuals ranged between 5.95 - 8.05,kcal.min$^{-1}$and5.25-7.57,kcal.min$^{-1}$respectively [Fig. 2(b)], this finding was in consonance with an earlier study (Jena and Mohanty, 2014). In terms of NCC expressed in beats.min$^{-1}$, of the work carried out, another important indicator of physiological strain. NCC value was significantly higher ($P<0.05$) in EG 1 individuals compared to their age matched EG 2 counterpart in all the three spells of the working hours [Fig. 2 (c)]. Similar trend of result has beenfound in case CSI values [Fig. 2(d)]; as per the CSI, there is cardiovascular strain of different degree in different spells. And the maximum such strain was recorded among the EG 1 individuals in the second spell. The trends of the result in consonance with the findings of an earlier study carried out in male agricultural workers engaged in manual paddy threshing task (Nag, 2014).

Physical fitness status in terms of HPDI score

and VO2 max (ml.kg$^{-1}$.min$^{-1}$) of EG 1 and EG 2 individuals has been presented in figure 3.

Physical fitness status of the study participants was assessed in term of HPDI score and VO2 max (ml.kg$^{-1}$.min$^{-1}$) values. HPDI, one of the most important indicators to assess the physical fitness profile especially for the working individuals (Joshi *et al*., 2015); can be calculated based on linear combination method using the scores obtained from time spend onthe activity, task performance score, difficulty score ofthe activity, body posture adopted, frequency of posturalchange, load/ force and postural discomfort. HPDI score was significantly higher in all the three working spells in EG 1 individuals compared to their age matched EG 2 counterpart. Higher values of HPDI score denoting the less working efficiency; so, from the result it may be mentioned that physical fitness status of EG 2 individuals was significantly higher compared to their age matched EG 1 counterpart [Fig. 3 (a)]. Another important indicator is the maximal oxygen uptake (VO2max) has been accepted to be the most reliable and efficient measure of one's cardio-respiratory function, physical fitness as well as of maximum work output. The values of VO2 max was significantly higher in case of EG 2 individuals compared to their age matched EG 1 counterpart. Higher values of VO2 max denoting better working efficiency. In the present study it was found that, during the first spell of the working hours the values of VO2 max was higher compared to the second and third spell of the working hours. In the second spell of the working hours the value of HR Peak increases and the values of VO2 max decrease in both the EG 1 and EG 2 individuals. Whereas during the third spell of the working hours it was found that, HR Peak value decreased and VO2 max values increased in comparison to the second spell of the working hours. So, from the findings of the present study it may be mentioned that the values of VO2 max was significantly higher in case of EG 2 individuals compared to their EG 1 counterpart [Fig. 3 (b)]. The finding of the present study regarding the physical fitness status of the individuals was in consonance with the finding of an earlier study conducted among the male agricultural workers primarily engaged in manual ploughing task during 'Aman' type of paddy cultivation (Chatterjee*et al*., 2018b).

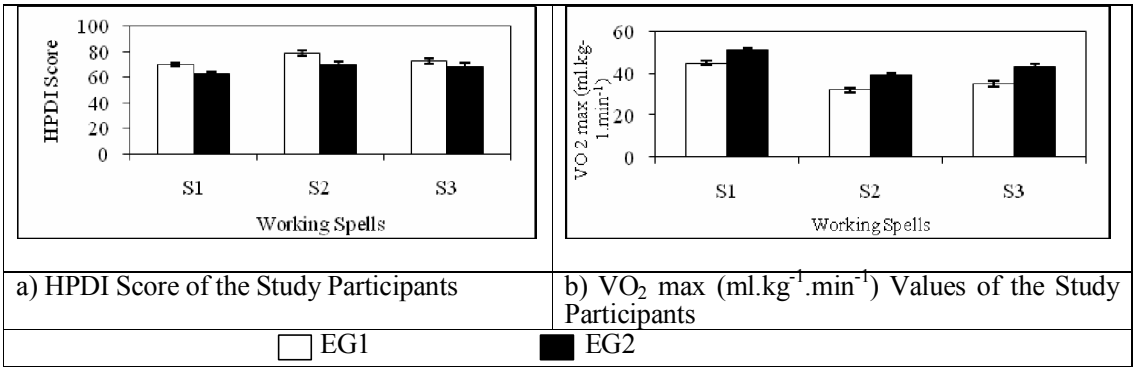



**Fig. 3:** Physical fitness profile of the study participants in terms of HPDI Score (a) and VO2 max (ml. kg$^{-1}$.min$^{-1}$) (b)

Physiological gradation of workload has been proposed by different researchers in respect of the physiological response to different activities at work. These classifications are either based on the monitoring of some

principal parameters like heart rates, both during work and recovery, energy cost or on some derived parameters - NCC. The heaviness of work in terms of different indices of physiological strain - HR peak (beats. $min^{-1}$), EEE (kcal.$min^{-1}$), NCC (beats. $min^{-1}$), OT Recovery (°C) and CSI has been presented in Table 3.

The heaviness of workload is categorized as 'light', 'moderate', 'heavy', 'very heavy' and 'extremely heavy'. In the present study the EG1 individuals, the average values of HR Peak, was found to be falling into 'extremely heavy' category in all three working spells, whereas the workers belonging to EG2 group experienced 'heavy' category workload in the

**Table 3.** Heaviness of workload in terms of indices of Physiological Strain

| Indices of Physiological Strain | EG 1 | | | EG 2 | | |
|---|---|---|---|---|---|---|
| | Working Spell | | | Working Spell | | |
| | S1 | S2 | S3 | S1 | S2 | S3 |
| $HR_{peak}$ (beats. $min^{-1}$) | EH | EH | EH | H | VH | H |
| NCC (beats. $min^{-1}$) | H | H | H | H | H | H |
| EEE (kcal.$min^{-1}$) | VH | EH | EH | H | VH | H |
| $OT_{Recovery}$ (?C) | H | VH | VH | H | VH | H |
| CSI | S | S | S | NS | S | S |

H- Heavy, VH- Very Heavy, EH- Extremely Heavy, S- Strain, NS- No Strain

first and third working spell and 'very heavy' in the second spell. Assessing the physiological strain, in terms of EEE (kcal.$min^{-1}$), it was found that, the workersbelonging to EG1 group experienced 'very heavy' category of workload in the first, third spell and 'extremely heavy' in the second spell, but the workload for the human resources belonging to EG 2 group fall in 'heavy' category in the first and third spell and 'very heavy' category in the second spell (Table 3). In respect of NCC, it was found that, the workload is falling in to 'heavy' category throughout the working spell for both the EG 1 and EG 2 individuals. In terms of OT Recovery (°C) the workload is found to be 'heavy' in case of EG 1 individuals in the first spell and 'very heavy' in both second and third working spell. Whereas, in case of EG 2 individuals in terms of OT Recovery (°C) the work load is found to be 'heavy' in the first and second spell whereas 'very heavy' in the third working spell.In case of CSI, the workload was fallen into 'strenuous' category throughout the working spells in case of EG 1 individuals; whereas in case of EG 2 individuals the workload was fallen into 'strenuous' category in the second and third working spells. In so far as assessment of intensity of workload is concerned, the EG 1 group has been found to be most stressful in terms of indicators of physiological strain. A comparison has been made between the values of HR peak, EEE, NCC and CSI obtained in the present study with other studies in which the workersare involving different types of paddy cultivating task. It was observed that the human resources experienced highest degree i.e. 'extremely heavy' degree of physiological strain while engaged in manual (beating the panicles on a hard or wooden surface) paddy threshing task compared with the other task during paddy cultivation period- ploughing (dry and wet ploughing) (Chatterjee*et al.*, 2015c; 2015d, 2017a), transplanting (manual) (Chatterjee*et al.*,

2016b; 2015e), threshing (by mechanized thresher and electrically driven paddy thresher) (Chatterjee*et al*., 2016a,; 2018c, 2018e) and reaping (manual) (Chatterjee*et al*., 2016a; 2017b), parboiling (Chatterjee*et al*., 2018a). Moreover, manual threshing during 'Boro' type of paddy cultivation is more strenuous task compared to the others tasks during the paddy cultivating time in terms of the indices of physiological strain. Another important reason in this context may be attributed to body physique or the somatotyping characteristics of the EG 2 individuals; the Santhaltribegroup showed ectomorphic mesomorph characteristics whereas EG 1 individuals showed mesomorphicendomorph characteristics, i.e. EG 2 individual showed low endomorphy with high ectomorphic component helps to dissipate greater amount of heat through evaporation, especially in tropical environmental conditions which is humid and hot (Ghosh and Malik, 2010). In the light of the observations presented, it may be mentioned that agriculture particularly being an open air work is strenuous, as adjudged in terms of so many indicators of physiological strain like HR Peak (beats.min$^{-1}$), EEE (kcal.min$^{-1}$), NCC (beats.min$^{-1}$), CSI and the degree of difficulty is rising with adverse impacts due climate change caused among other by global warming being on the rise. The strain has been found to be more in EG 1 individuals, compared to the EG 2 counterparts. Moreover, the workers were ignorant about the balance between work ability and job demand which could be attributed to the lack of awareness on health and safety issues. Moreover, the socioeconomic status compelled the workers to be least concerned for their health and working situation.

## CONCLUSION

From the present study it may be concluded that, the agricultural work – paddy cultivation - is strenuous and has health implications for the workers; as indicated from the indicators of the physiological strain. Added to this, the thermal environmental conditions adjudged by the heat indices are not favorable, i.e. they are above the recommended threshold values, making the task laborious for the workers. It may be also mentioned that, physiological strain was significantly higher in Bengaleemale paddy cultivators compared to their age matched Santhalcounterpart; as adjudged by the indices of physiological strain. While the physical fitness status was significantly higher in Santhal male paddy cultivators compared to their age matched Bengalee counterpart. Agriculture being an open sky occupation and manual threshing is one of the strenuous tasks in paddy cultivation there is need for simultaneous attempt to use more human factor designed devices than being absolutely dependent on manual effort. The workload could be minimized by implementing- sufficient work-rest pauses, water intake, and required the use of some personal protective equipment.

## ACKNOWLEDGEMENTS

We are thankful to all volunteers for their participation.

## REFERENCES

ACGIH. (2008). Threshold Limit Values and Biological Exposure Indices, Cincinnati. Ohio.

Adhikari, B., Bag, M.K., Bhowmick, M.K., Kundu, C. (2012). Rice in West Bengal-Rice Knowledge Management. 1- 88.

Astrand, P.O., Rodhal, K. (1986). Threshold Limit Values and Biological Exposure Indices, Text Book of Work Physiology, (McGraw Hill. New York).

Banerjee, N., Santra, T., Chatterjee, S., Mukherjee, S. (2015a). Prevalence of Overweight in Rural

Sedentary Human Resources in Southern Part of West Bengal. In: Ergonomics for Rural Development (ISBN 978-93-5174-905-9), 89 – 96.

Banerjee, N., Chatterjee, S., Chatterjee, S., Ghosh, K., De, S., Mukherjee, S. (2015b). Impact of Indian Traditional Recreational Activity on Novel Anthropometric Markers of Diabetes in Bengali Females. International Physiology (ISSN: 2347-1505). 3: 11 – 15. Doi-10.21088/ip.2347.1506.3115.1.

Banerjee, N., Chatterjee, S., Chatterjee, A., Chatterjee, S., Mitra, S., Agrawal, K.M., Mukherjee, S. (2015c). Climate Change: Occupational Health and Performance Implications for Informal Sector Human Resources. In: Managing Sustainable Development: Innovations and Best Practices, Springer (India).

Banerjee, N., Chatterjee, S., Santra, T., Mukherjee, S. (2014). Significance of Thermal Comfort Standard for Indian Urban Household: A Review. In: Impact of Pollution: Assessment and Awareness (ISBN 978-81-921083-8-4), 147-151.

Brake, R., Bates, G.A. (2002). Valid Method for Comparing Rational and Empirical Heat Stress Indices. Ann Occupational Hygiene. 46: 165-174.

Carter, J.E L., Heath, N.H. (1990). Somatotyping Development and Applications, Cambridge: Cambridge University Press, 398- 420.

Chamoux, A., Borel, A.M., Catilina, P. (1985). Pour la Standardization D'unifrequence Cardiaque de repos. Arch Mal Prof. 46 : 241-250.

Chatterjee, A., Chatterjee, S., Chatterjee, S., Banerjee, N., Banerjee, N., Mukherjee, S. (2018a). Diurnal Variation in Thermal Working Environment, Workload and Physiological Strain in Women Workforces Engaged in Manual Parboiling Task, Advance Technologies in Agriculture for Doubling Farmers' Income (ISBN: 978-93-86453-61-7) New Delhi Publisher, 199-210.

Chatterjee, A., Chatterjee, S., Chatterjee, S., Banerjee, N., Banerjee, N., Mukherjee, S. (2018b). Assessment of Physical Fitness and Cardiac Response Profile in Male Paddy Cultivators of a Southern District of West Bengal, Proceedings of the National Conference on Physical Education and Sports Sciences in the 21st Century, Jadavpur University, 35, 2018.

Chatterjee, A., Chatterjee, S., Chatterjee, S., Bhattacharjee, S., Santra, T., Banerjee, N., Ghosh, K., Mukherjee, S. (2018c). Assessment of Physiological Strain in Male Cultivators Engaged in Mechanized Paddy Threshing Task Using Two Different Types of Threshers, Science and Culture (ISSN 0036 8156), 191-197.

Chatterjee, A., Chatterjee, S., Banerjee, N., Santra, T., Chatterjee, S., & Mukherjee, S. (2018c). Assessment of Thermal Working Environmental Condition and Cardiac Response Indicators in Male Agricultural Workers Engaged in Traditional Manual Paddy Threshing Task. In: Technology Enabled Workplace Design (ISBN: 978-93-88237-27-7) Excel India, 6.

Chatterjee, A., Chatterjee, S., Bhattacharjee, S., Santra, T., Banerjee, N., & Mukherjee, S. (2018d). Assessment of Postural Discomfort in Male Paddy Cultivators in Southern Bengal. In: Technology Enabled Workplace Design (ISBN: 978-93-88237-27-7) Excel India, 7.

Chatterjee, A., Chatterjee, S., Santra, T., Banerjee, N., & Mukherjee, S. (2018e). Assessment of Cardiac Strain in Male Paddy Cultivators Using Two Different Type of Paddy Thresher: A Comparison. Proceedings of the National Symposium on Role of Resource Management in Agriculture in the Context of Food Security, Nutrition and Economy, Institute of Agricultural Science, University of Calcutta, 17.

Chatterjee, A., Chatterjee, S., Banerjee, N., Chatterjee, S., &Mukherjee, S. (2018f). Climate Change: Implications for the Human Resources Occupationally Engaged in Paddy Cultivation in a Southern District of West Bengal. Proceedings of the 3rd Regional Science and Technology Congress, Bidhannagar College, 223.

Chatterjee, A., Chatterjee, S., Chatterjee, S., Bhattacharjee, S., Banerjee, N, Mukherjee, S. (2017a). Work Place Heat Exposure and Cardiovascular Status: A Study in Male Paddy Cultivators. In: Molecular Physiological and Nutritional Responses during Pathological Alteration of Cell Function (ISBN: 81-89169-33-5), 110-124.

Chatterjee, A., Chatterjee, S., Chatterjee, S., Santra, T.,

Banerjee, N., Mukherjee, S. (2017b). Assessment of Physiological Strain Due to Work and Exposure to Different Thermal Working Environmental Condition in Male Paddy Cultivators of a Southern District of West Bengal. Ergonomics for Improved Productivity (ISBN 978-93-86724-25-0) Excell India, 195.

Chatterjee, A., Chatterjee, S., Banerjee, N., Chatterjee, S., Santra, T., Mukherjee, S. (2016a). Seasonal Distribution of Thermal Comfort: A Study to Assess Physiological Strain in Male Paddy Cultivators in Southern Bengal. Proceedings of the International Conference on Humanizing Work and Work Environment (ISBN: 978-93-83006-81), 157-162.

Chatterjee, A., Chatterjee, S., Banerjee, N., Chatterjee, S., Santra, T., Mukherjee, S. (2016b). Assessment of Physiological Strain Due to Work and Exposure to Heat of Working Environments in Male Paddy Cultivators. Advances in Applied Physiology (ISSN 2471-9692- Print, 2471-9714 - Online). 1: 8-11. doi: 10.11648/j.aap.20160101.12.

Chatterjee, A., Chatterjee, S., Chatterjee, S., Santra, T., Banerjee, N., Mukherjee, S. (2015a). Musculoskeletal Discomfort in Computer Operators of Organized Sector: Tracing the Link with Obesity Status. International Physiology (ISSN: 2347-1505), 3, 23 – 28. doi10.21088/ip.2347.1506.3115.3.

Chatterjee, A., Chatterjee, S., Banerjee, N., Santra, T.,Mondal, P., Mukherjee, S. (2015b). Evaluation of Body Composition and Somatic Profile in Male Individuals: A Comparison between Tribal and Non Tribal Agricultural Human Resources. Proceedings of the National Conference on Agriculture and Rural Development Issues in Eastern India, 25-26.

Chatterjee, A., Chatterjee, S., Chatterjee, S., 'Santra, T., Bhattacharjee, S., Mukherjee, S. (2015c). Exposure to Heat from Natural Working Environment and Cardiovascular Strain: A Study in Male Agricultural Workers in Southern Bengal. In: Ergonomics in Caring for People: Proceedings of 'the International Conference on Humanizing Work and Work Environment (ISBN 978-93-5258-836-7) IIT Bombay, 166-171.

Chatterjee, A., Chatterjee, S., Chatterjee, S., Banerjee, N., Santra, T., Mukherjee, S. (2015d). Thermal Comfort and HSI: A Study in Bengalee Male Paddy Cultivators. Quad Scientific Reporter (ISBN 978-81-925784-4-6), 148-155.

Chatterjee, A., Banerjee, N., Chatterjee, S., Santra, T., Agrawal, K.M., Mukherjee, S. (2015e). Assessment of Physiological Strain in Male Paddy Cultivators due to Work and Exposure to Fluctuation in Thermal Conditions in Working Environments. Survey (ISSN: 0586-0008), 55: 91- 98.

Chatterjee, A., Chatterjee, S., Santra, T., Mukherjee, S. (2014). The Influence of Anthropometric Variables for Development of Musculoskeletal Discomfort among Computer Operators in Organized Sectors. In: User Centered Design and Occupational Wellbeing, McGraw Hill Education (ISBN 978 – 93- 392 – 1970 -3), 499 – 503. McGraw Hill, New Delhi.

Christensen, E. H. (1969). Man at Work-Outline of Work Physiology- Issued by the Chief Advisor of Factories, Ministry of Labour and Employment, Government of India.

Dewi, D. S., Septiana, T. (2015). Workforce 'Scheduling Considering Physical and Mental Workload: A Case Study of Domestic Freight 'Forwarding. Procedia Manufacturing.4:445-453.

Epstein, Y., Moran, D.(2006). Thermal Comfort and the Heat Stress Indices. Industrial Health. 44: 388-398.

Ghosh, S., Malik, S.L. (2010). Variations of Body Physique in Santhals: An Indian Tribe. Coll. Anthropology. 34: 467–472.

Goswami, S., Pal, A., Dhara, P.C. (2012). Evaluation of Work Related Musculoskeletal Disorder and Postural Stress among Female Cultivators Engaged in Post Harvesting tasks. Indian Journal of Biological Sciences(ISSN 0972-8503). 18: 16-25.

Groborz, A., Juliszewski, T. (2013). Comparison of Farmers Workload by Manual and Mechanical Tasks on Family Farms. Annals of Agricultural and Environmental Medicine. 20: 356-360.

Habibi, P., Dehghan, H., Haghi, A., Shakerian, M. (2015). The Relationship between Wet Bulb Globe Temperature and Physiological Strain Index in Muslim Women in Hot-Dry Condition in the Climatic Chamber. Health Scope. 4: e19349.

Heidari, H., Golbabaei, F., Shamsipour, A., Forushani, A.R., Gaeini, A. (2015). Evaluation of Heat Stress among Farmers Using Environmental and Biological Monitoring: A study in North of Iran. International Journal of Occupational Hygiene. 7: 1-9.

Hodges, A.N. H., Kennedy, M.D. (2011). Physical Exertion and Working Efficiency of Reforestation Workers.J. Occup. Med.Toxicology. 6: 1-7.

Jena, D., Mohanty, S.K. (2014). Circulo - Respiratory Efficiency of Agricultural Workers in Odisha, India. International Journal of Scientific and Technology Research. 3: 265-269.

Joshi, P., Jethi, R., Chandra, N., Roy, M.L., Kharbikar, H.B., Atheequlla, G.A. (2015). Ergonomics Assessment of Post Harvest Finger Millet Threshing for reducing Women Drudgery Ergonomics Assessment of Post Harvest Finger Millet Threshing for Reducing Women Drudgery.Indian Res. J. Ext. Education. 15: 25-30.

Joshi, P., Jethi, R., Chandra, N., Roy, M.L., Kharbikar, H.B., Atheequlla, G.A. (2015). Ergonomics Assessment of Post Harvest Finger Millet Threshing for reducing Women Drudgery Ergonomics Assessment of Post Harvest Finger Millet Threshing for Reducing Women Drudgery.Indian Res. J. Ext. Education. 15: 25-30.

Kiefer, M., Guzman, J. R., Watson, J., Joode, W. D., Mergler, D., Da Silva, A. S. (2016). Workers Health and Safety and Climate Change in Americas: Issue and Research Needs. Pan America Journal of Public Health. 40: 192-197.

Kivimäki, M., Virtanen, M., Elovainio, M., Kouvonen, A., Väänänen, A., Vahtera, J. (2006). Work Stress in the Etiology ofCoronary Heart Disease - A Meta-analysis. Scand. J. Work Environ. Health. 32: 431-442.

Kjellstrom, T., Briggs, D., Freyberg, C., Lemke, B., Otto, M., Hyatt, O. (2016). Heat, Human Performance, and Occupational Health: A Key Issue for the Assessment of Global Climate Change Impacts. *Annu. Rev. Public Health*. 37: 97-112.

Lucas, R.A. I., Epstein, Y., Kjellstrom, T. (2014). Excessive Occupational Heat Exposure: A Significant Ergonomic Challenge and Health Risk for Current and Future Workers. Extreme Physiology and Medicine. 14: 1-8.

Miller, V.S., Bates, G.P. (2007). The Thermal Work Limit is a Simple Reliable Heat Index for the Protection of Workers in Thermally Stressful Environments. Ann. Occup. Hygiene. 51: 553-561.

Mohanty, S. K., Behera, B. K., Satapathy, G. C. (2008). Ergonomics of Farm Women in Manual Paddy Threshing. Agricultural Engineering International: CIGR Journal. 10: 1-14.

Mukherjee, S. (2015). Climate Change: Implications for Human Resources in Informal Sector of Eastern India. In: Ergonomics for Rural Development (ISBN 978-93-5174-905-9), 174 - 178.

Mukherjee, S., Banerjee, N., Chatterjee, S., Chatterjee, S. (2014a). Effect of Practicing Select Indian Classical Dance Forms on Body Composition Status of Bengalee Females an Anthropometric Study. Indian Journal of Biological Sciences (ISSN 0972-8503). 18: 9-15.

Mukherjee, S., Banerjee, N., Chatterjee, S., Chatterjee, S. (2014b). Effect of Kathak Dancing on Obesity Indices in Women of Sedentary Avocations. Science and Culture (ISSN 0036 8156). 80: 279-282.

Mukherjee, S., Banerjee, N., Chatterjee, S., Chakraborti, B. (2013). Impact of Bharatnattyam Dancing Exercise on Reducing Central Obesity in Adult Bengalee Females. Science and Culture (ISSN 0036 8156). 79: 503-506.

Nag, P.K., Nag, A., (2004). Drudgery, Accidents and Injuries in Indian Agriculture. Industrial Health. 42: 149-162.

Parsons, K. (2014). Human thermal Environments. In The Effects of Hot, Moderate and Cold Temperatures on Human Health, Comfort and Performance. London: Taylor and Francis, 1–32.

Ramanathan, N.L., Dutta, S.R., Roy, B.N., Chatterjee, A., Mullick, L.N. (1967). Energy Cost of Different Muscular Tests Performed by Indian Subject. Indian Journal of Occupational Health. 10: 253-261.

Ravi Kumar, B.P., Dudala, S.R., Rao, A.R. (2013). Kuppuswamy's Socio-Economic Status Scale – A Revision of Economic Parameter for 2012.

International Journal of Research and Development of Health. 1: 2-4.

Roy, P., Kaur, M. (2015). Status and Problems of Paddy Straw Management in West Bengal. International Journal of Advances in Agricultural and Environmental Engineering. 2: 44-48.

Sabharwal, K., Kaushik, S. (2011). Inter Gender Occupational Health Problems in Paddy Cultivation. J. Dairying, Foods and Home Sci., 30: 43-47.

Santra, T., Chatterjee, A., Chatterjee, S., Chatterjee, S., Banerjee, N., Mukherjee, S. (2015). Linkage between Some Select Anthropometric Measures and Hand Grip Strength: Study on Bengalee Male Agricultural Human Resources. In: Ergonomics in Caring for People: Proceedings of 'the International Conference on Humanizing Work and Work Environment (ISBN 978-93-5258-836-7), 84-89.

Santra, T., Chatterjee, S., Banerjee, N., Mukherjee, S. (2014). Global Warming: Impact on Human Health. In: Impact of Pollution: Assessment and Awareness (ISBN 978-81-921083-8-4), 113 – 119.

Savonen, K.P., Lakka, T.A., Laukkanenm J.A., Halonenm P.M., Rauramaa, T.H., Salonen, J.T., Rauramaam R. (2006). Heart Rate Responseduring Exercise Test and Cardiovascular Mortality in Middle-Aged Men. Eur. Heart Journal. 27: 582-588.

Singh, D., Vinay, D. (2014). Ergonomics Assessment of Traditional and Improved Methods of Paddy Threshing for Drudgery Reduction of Hill Region. Journal of Food, Agriculture and Environment. 12: 244-250.

Singh, S.P. (2012). Physiological Workload of Farm Women while Evaluating Sickles for Paddy Harvesting. Agricultural Engineering Journal: CIGR Journal. 14: 82-87.

Sohar, E., Tennenbaum, D.J., Robinson, N. (1962). The Thermal Work Limit is a Simple Reliable Heat Index for the Protection of Workers in Thermally Stressful Environments Biometeorology. Tromp SW (Ed.), 395–400, Pergamon Press, Oxford.

Trites, D. G., Robinson, D. G., Banister, E. W. (1993). Cardiovascular and Muscular Strain during a Tree Planting Season among British - Columbia Silviculture Workers. Ergonomics. 36: 935.

Venugopal, V., Chinnadurai, J.S., Lucas, R.A. I., Kjellstrom, T. (2016). Occupational Heat Stress Profiles in Selected Workplace in India. Int. J. Environ. Res. Public Health. 89: 1- 13.

WHO. (2000). Obesity: Preventing and Managing the Global Epidemic, Report of a WHO Consultation on Obesity, Technical Report Series, No. 894, World Health Organization, Geneva, Switzerland, 256.

World Health Organization. (1969). Health Factors Involved in Working under Conditions of Heat Stress: Report of a WHO scientific group. WHO technical report series, 412.