



**International Journal of Biology, Pharmacy
and Allied Sciences (IJBPAS)**

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

**A STUDY TO EVALUATE CARDIAC STRAIN IN MALE AGRICULTURAL WORKERS
ENGAGED IN MANUAL PLOUGHING TASK IN HOOGHLY, WEST BENGAL**

CHATTERJEE A^{1,2}, CHATTERJEE S¹ AND MUKHERJEE S^{1,3*}

1: Human Performance Analytics and Facilitation Unit, Department of Physiology, University Colleges of Science and Technology, University of Calcutta, Rashbehari Shiksha Prangan, 92 Acharya Prafulla Chandra Road, Kolkata 700 009, India

2: Assistant Professor, Faculty of Allied Health Sciences, ICFAI University, Kamalghat, Tripura

3: Public Health Analytics Unit, Department of Food and Nutrition, West Bengal State University

***Corresponding Author: Mukherjee S: E Mail: phauhpaful@gmail.com**

Received 13th April 2020; Revised 24th May 2020; Accepted 18th June 2020; Available online 1st Feb. 2021

<https://doi.org/10.31032/IJBPAS/2021/10.2.5338>

ABSTRACT

West Bengal ranks first among all other states of India in terms of paddy cultivating area and paddy production. Agricultural workers constrained to work throughout the day irrespective of variation in working condition prevailing in the working environment. Earlier studies reports that, agricultural workers performed different tasks during the paddy cultivating time not only time immemorial but also source of drudgery for them. Hence, the assessment of cardiac strain is an important factor for the human resources occupationally engaged in open air working environment. In this backdrop, the present study has been undertaken to assess cardiac strain in 45 male agricultural workers (age range 24-36 years) involved in manual ploughing during 'Aman' type of paddy cultivation and compare it with 47 male individuals engaged in similar type of task during 'Boro' type of paddy cultivation. Results of the present study indicated that unfavorable thermal environmental condition in working environment mostly prevalent during 'Aman' type of paddy cultivation making the task strenuous for the human resources engaged in paddy cultivation.

Keywords: Paddy, thermal working environment, climate change, cardiac cost, Hooghly

INTRODUCTION

West Bengal (WB), (*'bowl of paddy'*) is the major paddy growing state in India with a production of 15023.68 thousand tones. Paddy is cultivated in WB in three different season's viz., '*Aus*' (autumn rice), '*Aman*' (winter rice) and '*Boro*' (summer rice). On the other hand so far as the occupational profile is concerned, 43.5% of male and 46.3% of the female human resources are engaged in different agricultural work in WB; among the different agricultural task paddy cultivation is the important one [1-2]. Furthermore, during the paddy cultivating time agricultural workers has to perform a variety of tasks throughout the year even in a single day [3-4]. Agriculture being an open air avocation and a large number of human resources work manually in the agricultural field for considerable period of time every day, throughout the year, irrespective of variation in thermal environmental status [5-6]. On the other hand, climate change phenomenon caused inter alia due to Global Warming, because of increased emission of GHGs, has been responsible for about 0.6°C rise in ambient temperature during the 20th century and at present the rate of increase is 0.2°C per decade. It is projected that 1.8 - 4.0 (average 3.0) °C increase will take place by 2100 AD depending on actions taken to limit

GHG emissions and future developmental scenario. Moreover rise in ambient temperature, which is taking place, in our tropical environment associated with climate change is having a profound impact on several sectors of the society including public health, especially for individuals occupationally exposed to high temperature [7-8]. It has been also reported that the work performance of the human resources also getting affected due to adverse thermal working conditions. Hence the assessment of cardiac strain is an important factor for the human resources occupationally engaged in outdoor working environment. In this backdrop the present study has been undertaken to assess the cardiac strain in terms of indicators of physiological strain in Bengalee male agricultural workers primarily engaged in manual ploughing task during the period of '*Aman*' and '*Boro*' type of paddy cultivation.

MATERIALS AND METHODS

Human resources engaged in agricultural work in Arambagh subdivision in the district Hooghly [latitude (23⁰01' N to 22⁰39' N) and longitude (88⁰30' E to 87⁰ 39' E)], were initially approached for the study. After obtaining necessary human ethical clearance, along with initial consents from the

individuals, the names of volunteers were enlisted and the procedural requirements were explained elaborately. Individuals with no known chronic disease history (self-reported) and having a minimum working experience of three years, regularly working on an average for at least a period of six to six and half hours in the agricultural field participated in the present study. The individuals who taking part in manual ploughing tasks (Ploughing is the primary tillage operation; which is performed to cut, break and invert the soil partially or completely suitable for sowing seeds) during 'Aman' (i.e. during May - middle of June) and 'Boro' (i.e. during December - middle of January) type of paddy cultivation were considered for participation in the study. Data were obtained from 37 adult Bengalee male agricultural workers (age range of 24 - 36 years) while they were taking part in manual ploughing task during 'Aman' type of paddy cultivation; it constituted the ploughing group A (PG A). Again when these individuals were participating in task during 'Boro' type of paddy cultivation, data were again collected from 39 male individuals; these data were tabulated as the data from the ploughing group B (PG B). It may be also mentioned that the data of individuals who were available for

investigation during both the paddy cultivating time were only considered for analyses. The agricultural workers of the present study usually start their work around 6.00 am and work for about three hours in the first spell. Then, they generally take a break for breakfast for about 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. They generally start their third spell work at 3 p.m. and work for about 2 hours. During the working time the agricultural workers usually put on a full sleeve cotton shirt and trouser. Information regarding their age (year), socio - economic status (SES) - assessed by using the Kuppuswamy's socioeconomic scale [9], working experience (year), and average working time (hr.day^{-1}) were recorded in a pre-designed schedule. Ambient temperature (T_a) ($^{\circ}\text{C}$), wet bulb temperature (T_{WB}) ($^{\circ}\text{C}$), globe temperature (T_g) ($^{\circ}\text{C}$) and natural wet bulb temperature (T_{nwb}) ($^{\circ}\text{C}$) were noted during the working hours in the agriculture field. The values of Wet bulb globe temperature (WBGT), corrected effective temperature (CET), and modified discomfort index (MDI) were found out. Anthropometric measurements - stature (cm) and body weight

(kg) were measured using anthropometric rod and a pre calibrated weighing scale respectively. Somatometric indicator, BMI was calculated. The pre- work heart rate ($\text{beats} \cdot \text{min}^{-1}$), pre- work systolic and diastolic blood pressure (mm Hg) were recorded in the morning hours before the individuals started working. Physiological strain indicators in terms of peak heart rate (HR_{peak}) ($\text{beats} \cdot \text{min}^{-1}$) [10], net cardiac cost (NCC) [11], estimated energy expenditure (EEE) ($\text{kcal} \cdot \text{min}^{-1}$) [12] and absolute cardiac cost (ACC) ($\text{beats} \cdot \text{min}^{-1}$) [13] were found out. The ‘heaviness’ of work has also been adjudged in terms of - HR_{peak} ($\text{beats} \cdot \text{min}^{-1}$), NCC ($\text{beats} \cdot \text{min}^{-1}$), EEE ($\text{kcal} \cdot \text{min}^{-1}$), and ACC ($\text{beats} \cdot \text{min}^{-1}$). The data collected during the period of May - middle of June (During ‘Aman’ type of paddy cultivation) and during the period of December to middle of January (During ‘Boro’ type of paddy’ cultivation). The environmental and cardiac response data were collected at regular intervals during morning [6 - 9.00 am], around noon [10.0 am-1pm] and afternoon hours [3.00 - 5 pm] respectively referred to as first to third spell [S1, S2 and S3]. Data have been presented in $\text{AM} \pm \text{SD}$ form. Obtained data were statistically analyzed. Analysis of variance (ANOVA) and correlation test was carried

out. P value lower than 0.05 ($P < 0.05$) was considered as significant.

RESULTS AND DISCUSSIONS

General characteristics including age (year), ethnic background, SES, working experience (year), average working time ($\text{hr} \cdot \text{day}^{-1}$) of the participants are presented in **Table 1**. PG A and PG B individuals do not differ significantly ($P > 0.05$), in terms of mean age (year), working experience (year) and working time ($\text{hr} \cdot \text{day}^{-1}$).

The physical and physiological profile of the study participants are presented in **Table 2**. PG A and PG B individuals do not differ significantly ($P > 0.05$) in terms of their stature, body weight, BMI, $\text{HR}_{\text{Pre work}}$, and $\text{SBP}_{\text{Pre work}}$ $\text{DBP}_{\text{Pre work}}$.

The purpose of the assessment of the indicators of the thermal working environment is that, whether the working environmental condition is acceptable and does not impair the health and performance of the human resources who are occupationally engaged in this work zone. In the present study the environmental condition in terms of three indicators of thermal environmental status- WBGT, CET, and MDI are presented in **Table 3**.

Indices of physiological strain in terms of HR_{peak} ($\text{beats} \cdot \text{min}^{-1}$) (a), NCC ($\text{beats} \cdot \text{min}^{-1}$) (b), EEE ($\text{kcal} \cdot \text{min}^{-1}$) (c) and ACC ($\text{beats} \cdot \text{min}^{-1}$)

of the study participants are presented in **Figure 1**.

The ploughing task of human resources engaged in different spells were evaluated for grading the ‘heaviness’ of the particular work

in terms of indicators of physiological strain. Heaviness of workload in terms of different indicators of physiological strain during the regular working schedule has been presented in **Table 4**.

Table 1: General Profile of the Study Participants

Variables	PG A	PG B
Age [^] (year)	22.1 ± 2.11	22.7 ± 2.71
Ethnic background	Bengalee	Bengalee
SES	Lower middle	Lower middle
Working experience [^] (year)	7.1 ± 1.11	7.3 ± 1.41
Working time [^] (hr.day ⁻¹)	6.9 ± 0.84	7.1 ± 0.55

Data were presented in AM ±SD, [^]ns

Table 2: Physical and Physiological Profile of the Study Participants

Variables	PG A	PG B
Stature [^] (cm)	153.5 ± 7.07	153.9 ± 6.81
BW [^] (kg)	53.4 ± 6.45	54.2 ± 5.31
BMI [^]	21.4 ± 3.11	21.8 ± 3.55
HR _{Pre-work} [^] (beats.min ⁻¹)	71.0 ± 4.47	70.1 ± 3.57
SBP _{Pre-work} [^] (mm Hg)	119 ± 9.41	117.8 ± 9.80
DBP _{Pre-work} [^] (mm Hg)	72.6 ± 7.11	71.4 ± 9.18

Data were presented in AM ±SD, [^]ns

Table 3: Indicators of Thermal Working Environmental Status in Three Different Spells

Indicators of thermal environmental condition	Thermal Environmental Condition for PG A			Thermal Environmental Condition for PG B		
	Spell 1	Spell 2	Spell 3	Spell 1	Spell 2	Spell 3
WBGT (°C)	28.6 ± 1.11	34.4 ± 1.35	32.0 ± 2.49	19.2 ± 0.17	23.8 ± 1.17	21.7 ± 1.18
CET (°C)	26.4 ± 1.15	31.2 ± 1.11	29.4 ± 1.75	17.6 ± 1.15	21.9 ± 1.19	21.4 ± 1.15
MDI (°C)	27.2 ± 1.12	34.1 ± 2.13	31.4 ± 1.81	18.9 ± 1.51	23.1 ± 1.31	20.2 ± 1.71

Data were presented in AM ±SD

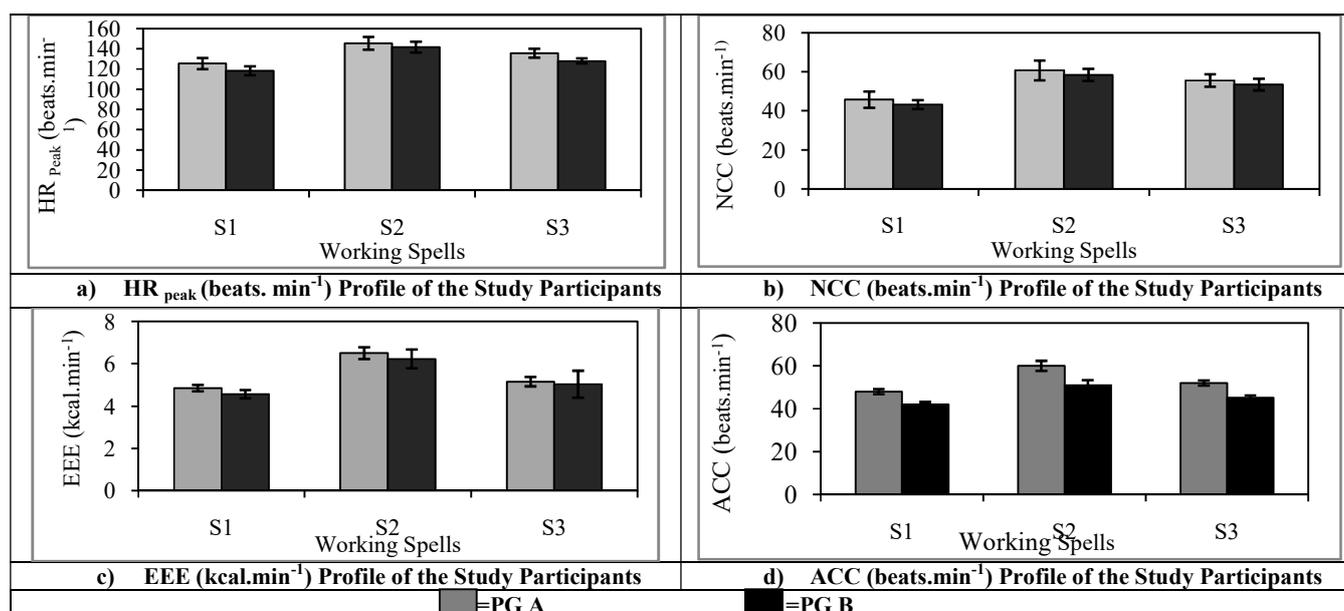


Figure 1: Indices of Physiological Strain in terms of HR_{peak} (beats.min⁻¹) (a), NCC (beats.min⁻¹) (b), EEE (kcal.min⁻¹) (c), ACC (beats.min⁻¹) (d) in three different working spells (S1, S2 and S3)

Table 4: Heaviness of Workload In Terms of Indicators of Physiological Strain

Indicators of Physiological Strain	PG A			PG B		
	Working Spell					
	S1	S2	S3	S1	S2	S3
HR _{peak} (beats. min ⁻¹)	H	VH	VH	H	VH	H
NCC (beats. min ⁻¹)	RH	H	H	RH	H	H
EEE (kcal.min ⁻¹)	H	H	H	H	H	H
ACC (beats. min ⁻¹)	H	VH	H	H	VH	H

RH-Rather, Heavy, H – Heavy, VH- Very Heavy

In the present study both the PG A and PG B individuals belonging from the Bengalee Hindu Caste Population. In terms of BMI, it may be mentioned that the human resources belonging from PG A and PG B, do not suffer from under-nutrition nor do have the risk of being over-weight. The mean BMI value of both PG A and PG B individuals indicated that, the participants were in ‘normal weight’ category as per the classification given by WHO [14]. This finding is not surprising as the human resources participating in the present study were carrying out different tasks during paddy cultivation time, as earlier studies observed that, individuals taking part regularly even in different form 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 [15-20]. Higher values of BMI have also been found to be associated with more chance of work related musculoskeletal disorder among the human resources who are engaged in different type

of sedentary type of works in their regular occupational responsibility [21-23].

In terms of the thermal working environmental condition, in the present study in case of PG A individuals, the average value of WBGT in the first, second and third spell is 28.5⁰C, 34.5⁰C and 32.2⁰C respectively. 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, each hour work is allowable. In the second spell no work is ideally allowable and in the third spell of the working hours only ‘light’ category of work can be carried out and that too with allocation of less than 25% work in work rest cycle. In case of PG B individuals, the average values of WBGT in first, second and third spell is 19.0⁰C, 23.5⁰C and 21.1⁰C respectively, there is no restriction recommended against carrying out of the work [24-25]. The average values of CET in case of PG A individuals in the first, second and third spell is 26.2⁰C, 31.1⁰C and 29.3⁰C respectively. In the first spell, there is no restriction recommended against carrying out

of the work and in the second spell only 'light' category of work is allowable and in the third spell upto 'moderate' category of work can be carried out. In case of PG B individuals, the average values of CET in the first, second and third spell is 17.1⁰C, 21.5⁰C and 21.3⁰C respectively and there is no restriction recommended against carrying out of the work [23-24]. Average values of MDI in the first, second and third spell is 27.0⁰C, 34.0⁰C and 31.5⁰C. In the first spell individuals feel hot but physical work may be performed with some difficulties whereas in the second and third spell of the working hours heat load is considered severe, and human resources engaged in physical work are at increased risk for heat illness [26]. In case of PG B individuals there is no restriction for work. On assessment of the thermal status of the work environment, it has been found that second and third spell of the working hours during the 'Aman' type of paddy cultivation i.e. work zones in case of PG A individuals are not suitable for carrying out activity, of even light intensity, in terms of ACGIH recommendation [21]. It is expectedly in consonance with the recommendation of WHO [27]. The findings of the present study in terms of thermal working environmental condition was in consonance with the finding of an earlier

study carried out among the human resources occupationally engaged in dry and wet type of ploughing task in the district of Hooghly [5]. The status of the work environmental condition also in consonance with the finding of an earlier study carried out among the human resources occupationally engaged in informal sector, which reports that, about two third of the work zones are not suitable for carrying out the task particularly in hot and humid condition [28-29]. The environmental heat load might be one of the reasons for increased physiological strain. Moreover, the global climate change is increasing average temperature are becoming more extreme. This is of great 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 and the work output of the human resources engaged in different type of outdoor occupational task [30-32]. Continuation of work for long time in such adverse environmental condition especially during the 'Aman' type of paddy cultivation especially during the second and third spell of the working hours there is a risk of suffering from developing different degree of physiological strain among the study participants.

The indices of physiological strain of human resources engaged in manual ploughing assessed in terms of HR_{Peak} (beats.min⁻¹), NCC (beats.min⁻¹), EEE (kcal.min⁻¹) and ACC (beats.min⁻¹). In the present study in case of PG A individuals the average values of HR_{Peak} denoting in the first spell ‘heavy’ degree where as in the second and third spell ‘very heavy’ degree of physiological strain. In case of PG B individuals the average values of HR_{Peak} denoting in the first and third spell ‘heavy’ degree where as in the second spell ‘very heavy’ degree of physiological strain [Figure 1 (a)]. An almost similar trend of result observed in terms of another indicator of physiological strain, NCC (beats.min⁻¹) [(Figure 1 (b)]. In case of PG A individuals in first spell average NCC values denoting ‘rather heavy’ and in the second and third spell of the working hours ‘heavy’ degree of physiological strain. In case of PG B individuals similar trend of result observed along the spells in terms of average NCC values. Another indicator of physiological strain is EEE. The average values of EEE in case of PG A individuals in the first spell indicating ‘heavy’ degree of physiological strain where as in the second and third spell average EEE values indicating ‘heavy’ degree of physiological strain. Similar trend

of physiological strain observed in case of PG B individuals [(Figure 1 (c)]. In case of ACC (beats.min⁻¹) there is absolute in agreement in terms of heaviness of workload among the PG A and PG B individuals. During ‘Aman’ type of paddy cultivation, the work heaviness in the first spell is adjudged as ‘heavy’, ‘rather heavy’, ‘very heavy’ and ‘heavy’ respectively in terms of three indicators HR_{Peak}, NCC, EEE and ACC. There is absolute agreement in so far as the degree of heaviness is concerned among all four indices of physiological strain HR_{Peak}, NCC, EEE and ACC in the first, second and third spell. In winter (i.e. during ‘Boro’ type of paddy cultivation), there is also absolute agreement in so far as the degree of heaviness is concerned among four indices of physiological strain in terms of HR_{Peak}, NCC, EEE and ACC in the first and second spells [(Figure 1 (d)]. The magnitudes of indicators of physiological strain were found to vary with the change of working spell. The environmental heat load might be one of the reasons for increased cardiovascular strain. The result of the present study shows the manual ploughing task during ‘Aman’ type of paddy cultivation is more strenuous in terms of the indicators of physiological strain. The finding of the present study in consonance with the finding of earlier studies

carried out in male human resources occupationally engaged in different types of tasks during paddy cultivation time in the district of Hooghly that reports the unfavourable thermal environmental condition in working environment i.e. above the recommended threshold values, mostly prevalent during 'Aman type of paddy' cultivation, is making the task strenuous for the human resources engaged in paddy cultivation [5-6]. Moreover, different tasks during paddy cultivating period - ploughing (dry and wet ploughing) [2, 31, 33, 34, 35] transplanting (manual) [3, 4, 36], threshing (by mechanized thresher and electrically driven paddy thresher) [5, 7, 37, 38-41] and reaping (manual) [42, 43], manual parboiling [6] was strenuous; this is affirmed by the finding of the present study for the human resources primarily engaged in manual ploughing during the 'Aman' type of paddy cultivation. Whereas in winter season during the 'Boro' type of paddy cultivation though the work zone is suitable for carrying out the work but the heaviness of the workload is absolute in agreement with the workload assessing during the 'Aman' type of paddy cultivation. Hence, ergonomic interventions, including rescheduling of the work-rest cycle, frequent fluid intake to replace the water lost due to sweating, using PPDs to

protect them from radiating heat may help reduce the heat stress of the agricultural workers.

CONCLUSION

From the present study, it may be concluded that, the agricultural work - paddy cultivation - is strenuous and has health implications for the human resources; moreover the manual ploughing task is more strenuous task; 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 arduous for the human resources primarily engaged in manual ploughing during the 'Aman' type of paddy is cultivated; whereas during the 'Boro' type of paddy cultivation, the work zone is suitable for carrying out the work.

ACKNOWLEDGEMENT

We are thankful to all volunteers for their participation.

REFERENCES

- [1] Roy P, Kaur M. Status and Problems of Paddy Straw Management in West Bengal. *International Journal of Advances in Agricultural and Environmental Engg*, 2, 2015, 44-48.
- [2] Chatterjee A, Chatterjee S, Banerjee N, Chatterjee S, Mukherjee S.

- Climate Change and Human Performance: A Study in Bengalee Male Agricultural Workers. *International Journal of Innovative Knowledge Concepts* (ISSN: 2454-2415), 7 (Special Issue 1), 2019, 72-80.
- [3] Chatterjee A, Banerjee N, Chatterjee S, Chatterjee S, Mukherjee S. A Study to Assess Cardiac Response Indices in Food Crop Cultivation Task in West Bengal. *International Journal of Innovative Knowledge Concepts* (ISSN: 2454-2415), 7, 2019, 238-243.
- [4] Chatterjee A, Banerjee N, Chatterjee S, Chatterjee S, Mukherjee S. Impact of Variation in Working Environmental Condition on Cardiac Response Profile in Bengalee Male Crop Cultivators of A Southern District of West Bengal. *Journal of Emerging Technologies and Innovative Research* (ISSN: 2349-5162), 6, 2019, 438-443. Doi <http://doi.one/10.1729/Journal.21469>.
- [5] Chatterjee A, Chatterjee S, Banerjee N, Chatterjee S, Mukherjee S. Assessment of Cardiac Strain in Male Paddy Cultivators Using two Different Type of Paddy Thresher: A Comparison. *Indian Agriculturist* (ISSN: 0019-4336), 2019, 63, 49-55.
- [6] Chatterjee A, Chatterjee S, Chatterjee S, Banerjee N, Banerjee N, Mukherjee S. Diurnal Variation in Thermal Working Environment, Workload and Physiological Strain in Women Workforces Engaged in Manual Parboiling Task. In: *Advance Technologies in Agriculture for Doubling Farmers' Income* (ISBN: 978-93-86453-61-7), New Delhi Publisher, 2018, 199-210.
- [7] Chatterjee A, Chatterjee S, Chatterjee S, Bhattacharjee S, Santra T, Banerjee N, Ghosh K, Mukherjee S. Assessment of Physiological Strain in Male Cultivators Engaged in Mechanized Threshing Task Using Two Different Types of Threshers. *Science and Culture* (ISSN 0036 8156), 84, 2018, 191-197.
- [8] Venugopal V, Chinnadurai JS, Lucas R A I, Kjellstrom T. Occupational Heat Stress Profiles in Selected Workplace in India. *Int. J. Environ. Res. Public Health*, 89, 2016, 1- 13.
- [9] Ravikumar B P, Dudala S R, Rao A R. Kuppuswamy's Socio-Economic Status Scale – A Revision of Economic Parameter for 2012.

- International Journal of Research and Development of Health, 1, 2013, 2 - 4.
- [10] Astrand PO, Rodhal K. Threshold Limit Values and Biological Exposure Indices. Text Book of Work Physiology; McGraw Hill, 1986, New York.
- [11] Chamoux A, Borel AM, Catilina P. Pour la Standardization D'unifrequence Cardiaque de Repos. Arch Mal Prof., 46, 1985, 241-250.
- [12] Ramanathan N L, Dutta SR, Roy BN, Chatterjee A, Mullick LN. Energy Cost of Different Muscular Tests Performed by Indian Subject. Indian Journal of Occupational Health, 10, 1967, 253-261.
- [13] Pancardo P, Acosta DF, Hernández-Nolasco AJ, Wister M, López-de-Ipiña D. Real-Time Personalized Monitoring to Estimate Occupational Heat Stress in Ambient Assisted Working. Sensors, 15, 2015, 16956-16980.
- [14] WHO. Obesity: Preventing and Managing the Global Epidemic, Report of a WHO Consultation on Obesity, Technical Report Series, No. 894, World Health Organization, Geneva, Switzerland, 2000, 256.
- [15] Banerjee N, Santra T, Chatterjee S, Mukherjee S. 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), 2015, 89 – 96.
- [16] Banerjee N, Chatterjee S, Chatterjee S, Ghosh K, De S, Mukherjee S. Impact of Indian Traditional Recreational Activity on Novel Anthropometric Markers of Diabetes in Bengali Females. International Physiology (ISSN: 2347-1505), 3, 2015, 11 - 15. Doi-10.21088/ip.2347.1506.3115.1.
- [17] Mukherjee S, Banerjee N, Chatterjee S, Chatterjee S. 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, 2014, 9-15.
- [18] Mukherjee S, Banerjee N, Chatterjee S, Chatterjee S. Effect of Kathak Dancing on Obesity Indices in Women of Sedentary Avocations.

- Science and Culture (ISSN 0036 8156), 80, 2014, 279-282.
- [19] Mukherjee S, Banerjee N, Chatterjee S, Chakraborti B. Impact of Bharatnattyam Dancing Exercise on Reducing Central Obesity in Adult Bengalee Females. Science and Culture (ISSN 0036 8156), 79, 2013, 503-506.
- [20] Chatterjee A, Chatterjee S, Banerjee N, Santra T, Mondal P, Mukherjee S. Evaluation of Body Composition and Somatic Profile in Male Individuals: A Comparison between Tribal and Non Tribal Agricultural Human Resources. In: Proceedings of the National Conference on Agriculture and Rural Development Issues in Eastern India, ISI Giridih, 2015, 25-26.
- [21] Chatterjee A, Chatterjee S, Santra T, Mukherjee S. 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), 2014, 499 – 503.
- [22] Chatterjee A, Chatterjee S, Chatterjee S, Santra T, Banerjee N, Mukherjee S. Musculoskeletal Discomfort in Computer Operators of Organized Sector: Tracing the Link with Obesity Status. International Physiology (ISSN: 2347-1505), 3, 2015, 23 - 28. Doi10.21088/ip.2347.1506.3115.3.
- [23] Chatterjee A, Chatterjee S, Banerjee N, Mukherjee S. A Study to Assess Relationship between Different Obesity Indices and Musculoskeletal Discomfort Score in Agricultural Workers in Southern Bengal, India. Open Access Journal of Complementary and Alternative Medicine, (ISN: 2644 1217), 4, 2020, 186-190. Doi: 32474/OAJCAM.2020.02.000142.
- [24] ACGIH, Threshold Limit Values and Biological Exposure Indices. Cincinnati, Ohio, 2008.
- [25] Miller VS, Bates GP. The Thermal Work Limit is a Simple Reliable Heat Index for the Protection of Workers in Thermally Stressful Environments. Ann. Occup. Hyg., 51, 2007, 553-561.
- [26] Brake R, Bates GP. Valid Method for Comparing Rational and

- Empirical Heat Stress Indices. *Ann Occup. Hyg.*, 46, 2002, 165-174.
- [27] World Health Organization. Health Factors Involved in Working under Conditions of Heat Stress: Report of a WHO scientific group. WHO technical report series, 412, 1969.
- [28] Epstein Y, Moran D, Thermal Comfort and the Heat Stress Indices. *Industrial Health*, 44, 2006, 388-398.
- [29] Sohar E, Tennenbaum DJ, Robinson N. The Thermal Work Limit is a Simple Reliable Heat Index for the Protection of Workers in Thermally Stressful Environments *Biometeorology*. Tromp SW (Ed.), Pergamon Press, Oxford, 1962, 395 - 400, 1962.
- [30] Mukherjee S. Climate Change: Implications for Human Resources in Informal Sector of Eastern India. In: *Ergonomics for Rural Development* (ISBN 978-93-5174-905-9), 2015, 174 -178.
- [31] Adam-Poupart A, Labreche F, Smargiassi A, et al. Climate Change and Occupational Health and Safety in a Temperate Climate: Potential Impacts and Research Priorities in Quebec, Canada. *Industrial Health*, 51, 2013, 68-78.
- [32] Parsons K. Human thermal Environments. In *The Effects of Hot, Moderate and Cold Temperatures on Human Health, Comfort and Performance*. 3rd ed, London: Taylor & Francis, 2014, 1-32.
- [33] Chatterjee A, Chatterjee S, Chatterjee S, Banerjee N, Santra T, Mukherjee S. Thermal Comfort and HSI: A Study in Bengalee Male Paddy Cultivators. In: *Quad Scientific Reporter* (ISBN 978-81-925784-4-6), 2015, 148-155.
- [34] Chatterjee A, Chatterjee S, Chatterjee S, Santra T, Bhattacharjee S, Mukherjee S. Exposure to Heat from Natural Working Environment and Cardiovascular Strain: A Study in Male Agricultural Workers in southern Bengal. *Proceeding of International Conference on Humanizing Work and Working Environment*, In: *Caring for People* (ISBN 978-93-5258-836-7), IIT Bombay, 2015, 166-171.
- [35] Chatterjee A, Banerjee N, Chatterjee S, Santra T, Agrawal KM,

- Mukherjee S. 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, 2015, 91-98.
- [36] Chatterjee A, Chatterjee S, Chatterjee S, Bhattacharjee S, Banerjee N, Mukherjee S. 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), Aaheli Publisher, Kolkata, 2017, 110-12.
- [37] Chatterjee A, Chatterjee S, Banerjee N, Chatterjee S, Santra T, Mukherjee S. 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, 2016, 8-11, 2016. Doi: 10. 11648/ j.aap. 20160101.12.
- [38] Chatterjee A, Chatterjee S, Bhattacharjee S, Santra T, Banerjee N, Mukherjee S. Assessment of Postural Discomfort in Male Paddy Cultivators in Southern Bengal. In: *Technology Enabled Workplace Design* (ISBN: 978-93-88237-27-7) (Excel India), 2018, 7.
- [39] Chatterjee A, Chatterjee S, Banerjee N, Santra T, Chatterjee S, Mukherjee S. 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), 2018, 6.
- [40] Chatterjee A, Chatterjee S, Chatterjee S, Banerjee N, Mukherjee S. 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. *Indian Journal of Biological Sciences* (ISSN 0972-8503), 24, 2018, 31 - 44.

- [41] Chatterjee A, Chatterjee S, Banerjee N, Chatterjee S, Santra T, Mukherjee S. Seasonal Distribution of Thermal Comfort: A Study to Assess Physiological Strain in Male Paddy Cultivators in Southern Bengal. In: Proceedings of the International Conference on Humanizing Work and Work Environment (ISBN: 978-93-83006-81), 2016, 157-162.
- [42] Chatterjee A, Chatterjee S, Banerjee N, Mukherjee S. A Study to Assess Cardiac Response Profile in Paddy Cultivators Engaged in Manual Paddy Transplanting Task in Hooghly, West Bengal. *NeBIO* (ISSN: 2278-2281(Online) I ISSN: 0976-3597(Print), 11 (1), 2020, 27-34.
- [43] Chatterjee A, Chatterjee S, Banerjee N, Mukherjee S. Impact of Variation in Thermal Working Environmental Condition on Cardiac Response Indices in Male Human Resources Engaged in Food Crop Cultivation Task. *Journal of Climate Change* (ISSN: (Print): 2395-7611, ISSN: (Online): 2395-7697), 6 (1), 2020, 59-66, Doi: 10.3233/JCC200007.