IMPACT OF VARIATION IN WORKING ENVIRONMENTAL CONDITION ON CARDIAC RESPONSE PROFILE IN BENGALEE MALE CROP CULTIVATORS OF A SOUTHERN DISTRICT OF WEST BENGAL

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Abstract: Rice (*Oryza sativa* L.) is a plant belonging to the family of grasses, Gramineae. During the paddy cultivating time, huge numbers of agricultural workers work manually in the agricultural field irrespective of variations in weather conditions, which may have some impact on the cardiac performance of the human resources engaged in paddy cultivation. Keeping this in view a study has been undertaken, to assess the thermal environmental conditions and impact of workplace heat exposure and workload on cardiac response profile in 39 male paddy cultivators (age range 21 - 30 years) primarily engaged in manual reaping task during 'Boro' type of paddy cultivation in the southern area of Hooghly district. Physical and physiological parameters of study participants were collected. Indicators of cardiac strain were calculated. The result of the present study indicated that there is strain in Bengalee male individuals primarily engaged in reaping task in paddy cultivation because of the nature of the work and the exposure to the thermal environment.

Keywords **-** Agriculture, PSI, thermal comfort, climate change

I. INTRODUCTION

Agriculture is the main livelihood of life for the majority of population in West Bengal (WB), where about 90 percent of the total population living in rural areas depends on agriculture for their livelihood. Besides that, more than 60 per cent of total land area of the WB has been used in different agricultural task. Paddy is the most important cereal food crops in India. And Paddy is cultivated in WB in three different seasons viz., 'Aus' (autumn rice), 'Aman' (winter rice) and 'Boro' (summer rice) [1]. Furthermore, during the paddy cultivating time agricultural workers has to execute a miscellany of tasks throughout the year even in a single day [2-4]. Agriculture being an open air task and a large number of agricultural workers work manually in the agricultural field for substantial phase of time every day, throughout the year, irrespective of variation in thermal environmental status (Chatterjee *et al*., 2018a; 2018b; 2017b; 2016b; 2015a; 2015b; 2015c). On the other hand, increase 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 (Kjellstrom *et al*., 2016; Banerjee *et al*., 2015a; 2014; Santra *et al*., 2014). And earlier studies report that physical work capacity and work-performance are getting affected due to unpleasant thermal conditions prevailing in the working environment in different occupation including agriculture (Lucas *et al*., 2014; Parson, 2014; Mukherjee, 2015; 2013a). Hence, rise in ambient temperature, a major determinant of thermal aspect of working environment, may have some impact on the physiological status on the individuals working in the open – air non-mechanized agricultural field daily for a considerable period of time. Additionally, paddy cultivation involves in various tasks - ploughing, transplanting, weeding, reaping, binding of straw, carrying of straw bundles, threshing, collection of crops and parboiling which requiring substantial physical strength mostly performed by manual efforts. Therefore, different tasks performed by agricultural workers not only demand considerable time and energy but also sources of drudgery for the agricultural workers (Chatterjee *et al*., 2019a; 2019b; 2018c; 2018d; 2018e; 2018f). In addition, manual reaping or cutting is depending on the crop's condition, and availability of labor. Moreover, manual reaping or cutting task of paddy in puddle field is a labor-intensive task, which may have some impact on the health status of the human resources. In this backdrop, the present study has been undertaken to assess the impact of workplace heat exposure on cardiac response profile in male paddy cultivators primarily engaged in manual reaping task (cutting the paddy, it is the first task in paddy harvesting) in the paddy field of the Hooghly district in West Bengal during 'Boro' (i.e. summer paddy; cultivating period December – May and reaping of the 'Boro' type of paddy usually done in April) type of paddy cultivating time.

II. METHODOLOGY

Initially the study deign was approved by the Institutional ethical committee. On obtaining the consent from the institutional ethical committee the study purpose of the study was explained to the crop cultivators. Location of the study was - villages in and around Goghat II administrative block, in Arambagh subdivision – in Hooghly district, West Bengal. Crop cultivators without any past disease history (self reported) and having a minimum working experience of three years, regularly working on an average for six to six and half hours in the agricultural field, was approached for participation in the study. On obtaining consent from the individual the study was carried out on 39 adult male agricultural workers with age range of 21 – 30 years, primarily engaged in manual reaping tasks. Basic information regarding their age (year), socio – economic status (SES) - assessed by using the modified version of Kuppuswamy's socioeconomic scale (Ravi Kumar *et al*., 2013), working experience (year), and average working time (hr.day^{-1}) were recorded in a pre-designed schedule. Ambient temperature (T_a) (ºC), wet bulb temperature (T_{WB}) (ºC), globe temperature (T_g) (ºC) and natural wet bulb temperature (T_{nwb}) (ºC) were noted during the

working hours. The values of relative humidity (RH) (%), wet bulb globe temperature (WBGT) (ºC) (Heidari *et al*., 2015), physiological strain index (PSI) (Moran *et al*., 1998), and modified discomfort index (MDI) (ºC) (Epstein and Moran, 2006) were found out. Anthropometric parameters - stature (cm), body weight (BW) (kg) – were measured using anthropometric measurement set and weighing scale respectively; and BMI was calculated. The resting heart rate (beats. min^{-1}), systolic and diastolic blood pressure (mm Hg) were recorded in the morning hours before the individuals started working schedule. Markers of physiological strain in terms of peak heart rate (HR_{peak}) ($beats.min^{-1}$) (Astrand and Rodhal, 1986), peak estimated energy expenditure (PEEE) ($kcal.min^{-1}$) (Ramanathan *et al*., 1967), relative cardiac cost (RCC) (%), and absolute cardiac cost (ACC) ($beats.min^{-1}$) (Pancardo *et al*., 2015) were found out. Markers Cardiac performance in terms of human physical drudgery index (HPDI) and drudgery index (Joshi *et al*., 2015) also calculated. The data collected during the period of March – middle of April (During 'Boro' type of paddy cultivation) in the year 2017. The environmental and cardiac response data were collected during morning hours [6.15 - 9.00 am], around noon [10.00 am-1pm] and afternoon hours [3.00 - 5 pm] referred to as first to third spell [S1, S2 and S3]. Data have been presented in AM ± SD form. Obtained data were analyzed and presented graphically. As the thermal environmental conditions were assessed in terms of several indices, the correlation between them was found out. P value lower than 0.05 ($P<0.05$) was considered significant.

III. RESULTS AND DISCUSSION

Basic characteristics including age (year), SES, working experience (year), and average working time ($hr.day^{-1}$) of 39 participating volunteers of the present study are presented in Table 1.

Table 1: Basic characteristics of the study participants

Variable	Values
Age (years)	27.8 ±1.05
SES	Lower middle
Working Experience (years)	8.3 ±1.13
Working Time ($hr.day^{-1}$)	6.8 ± 1.15

AM±SD

In the present study, the thermal environmental condition was adjudged in terms of relative humidity and three indices of thermal environmental condition–WBGT, PSI, and MDI. The thermal environmental status along the spells is presented in Figure 1.

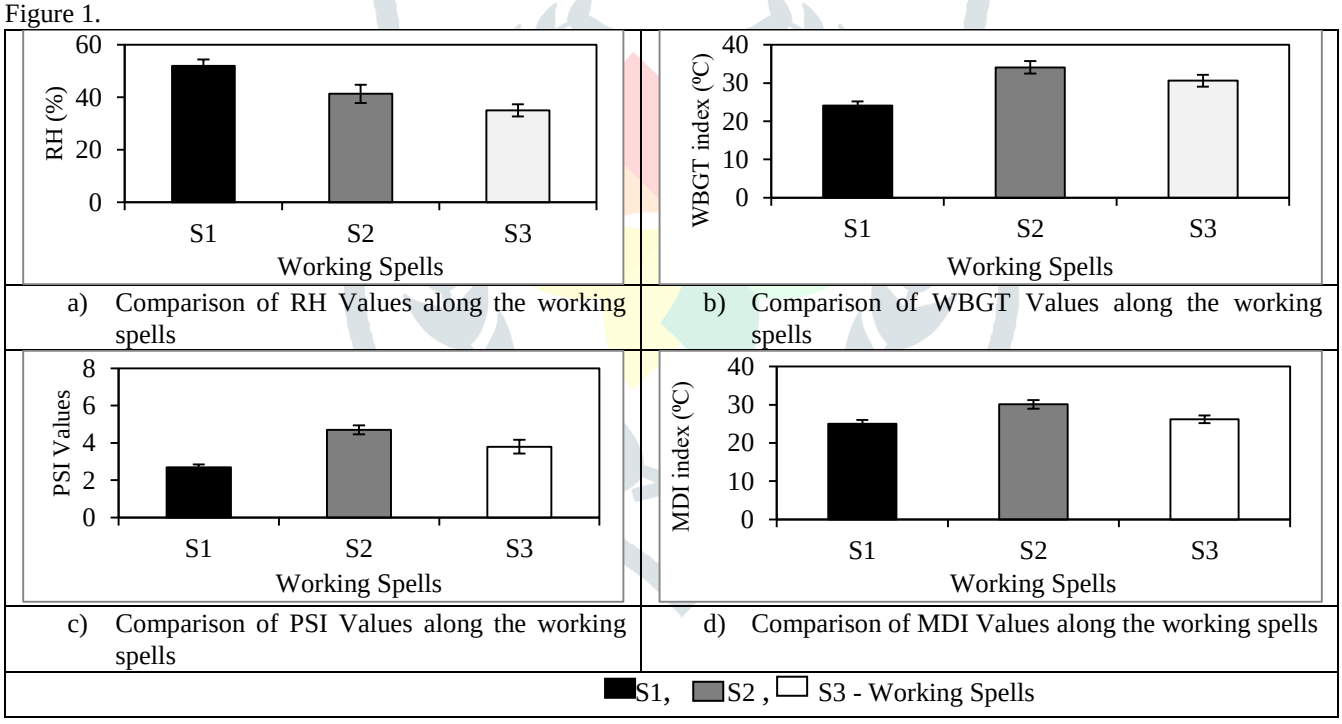


Figure 1 Indicators of Thermal Environmental Status along the Working Spells

The wet-bulb globe temperature (WBGT) is one of the most widely used heat stress indices throughout the world. In the present study, calculated WBGT value in the first spell was 24.1°C and during this spell, there is no restriction recommended against carrying out the work. At the second spell of the working hours, the calculated WBGT value was 34.1°C, during this spell no work is ideally allowable. Whereas during the third spell of the working hours, the calculated average WBGT, value was 30.6°C, during the third spell, human resources should ideally work upto 50% of the time each hour in work rest cycle and only 'light' type of work is allowable at this temperature. In addition, upto 50% 'moderate' type of work each hour in work rest cycle is allowable (ACGIH, 2008; Miller and Bates, 2007). Physiological strain index adequately depicts the combined strain reflected by the cardiovascular and thermoregulatory systems. In the present study during the first spell of the working hours, the calculated PSI value was 2.7 and at this condition, there is no restriction for carrying out any work. During the second and third spell of the working hours, the calculated PSI values were 4.7 and 3.8 respectively, i.e. during the second and third spell no work is allowable (Moran *et al*., 1998). Another indicator of thermal environmental condition was MDI. In the first spell, the calculated MDI value was 25.0°C. With this temperature, the heat load was 'moderately heavy', people feel very hot, and physical work may be performed with some difficulties. During second spell of the working hours with calculated MDI value was 30.1°C. During this spell, heat load was 'severe', and human resources engaged in physical work are at increased risk for heat illness. In the third

spell of the working hours the average calculated MDI value was 26.2°C, at this temperature; human resources feel a 'mild sensation' of heat (Sohar *et al*., 1962). However, the values of these three indices are indicating similar environmental condition. This is further affirmed by significant positive correlation among these indices. WBGT and PSI ($P < 0.05$)], [WBGT and MDI ($P<0.05$)], and [PSI and MDI ($P<0.05$)]. There is a risk of suffering from developing different degree of physiological strain among the study participants for continuation of work for long time in such adverse environmental condition.

Body composition, anthropometric dimensions, and morphological characteristics play a vital role in maintaining regular working activity (Chatterjee *et al*., 2015d). The physical and physiological characteristics of the study participants are presented in Table 2.

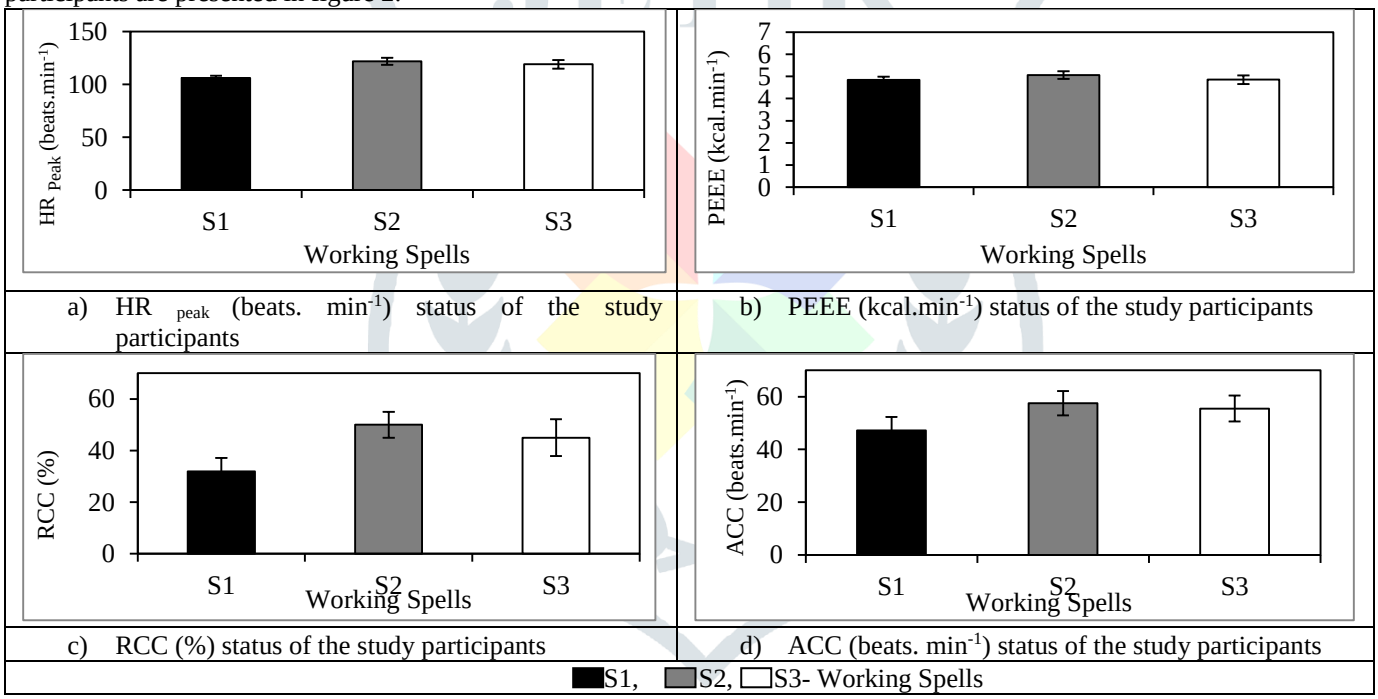
Table 2: Physical and physiological profile of the study participants

Variables	**Values**
Stature (cm)	159.5 ±5.16
BW (kg)	55.2 ± 5.11
BMI	21.5± 3.52
$HR_{Pre\text{-}work}$ (beats.min^{-1})	72.6 ± 7.21
$SBP_{Pre\text{-}work}$ (mmHg)	123.5 ± 5.21
$DBP_{Pre\text{-}work}$ (mmHg)	78.5 ± 6.01

AM± SD

The mean BMI of the participants was 21.5 kg.m^{-2}, which indicated that, all the participants were in 'normal weight' category as per the classification of WHO (WHO, 2000); the result is in agreement with earlier studies carried out on individuals regularly undertaking different forms of physical activities including recreational dance (Mukherjee *et al*., 2014a; 2014b; 2013b, Banerjee *et al*., 2015b). Earlier studies also reported that, a significant effect of BMI in increasing of work related musculoskeletal disorder among sedentary workers, regularly working in front of computer at least for a period of five to six hours in course of their regular occupational responsibility (Chatterjee *et al*., 2015e; 2014).

Indicators of cardiac strain in terms of HR_{peak} (beats. min^{-1}), PEEE (kcal.min^{-1}), RCC (%), and ACC (beats. min^{-1}) of the study participants are presented in figure 2.



a) HR_{peak} (beats. min^{-1}) status of the study participants

b) PEEE (kcal.min^{-1}) status of the study participants

c) RCC (%) status of the study participants

d) ACC (beats. min^{-1}) status of the study participants

Figure 2: Indicators of cardiac strain in terms of HR_{Peak} (beats. min^{-1}) (a), PEEE (kcal.min^{-1}) (b), RCC (%) (c) and ACC (beats. min^{-1}) (d) of the study participants

Cardiac strain of human resources engaged in manual reaping task assessed in terms of HR_{Peak} (beats.min^{-1}), PEEE (kcal.min^{-1}), RCC (%), and ACC (beats.min^{-1}). In the present study, the average values of HR_{Peak} indicated in the first spell 'moderate' degree where as in the second and third spell 'heavy' degree of physiological strain [Fig.2 (a)]. It has been observed that the acceptable workload for sustained physical activity might be estimated as 35% of the maximal aerobic power for Indian male workers, which corresponded to working HR of 110 be ats.min^{-1} (Saha *et al*., 1979). In the present study, average-working heart rate greatly exceeded this value; therefore, according to Åstrand and Rodahl, their work is heavy. As the work is heavy and stressful, it requires extreme muscle force and strength and more cardiac efficiency. Average PEEE values denoted 'heavy' degree of physiological strain throughout the working spell (Fig. 2 (b)].An almost similar trend of result was observed in terms of another indicator of physiological strain, RCC (%) [(Fig. 2(c)]. Another indicator of cardiac strain was ACC (beats.min^{-1}), according to it the heaviness of the workload in the first, second and third spell of the working hours, fell into 'heavy' category [(Fig. 2 (d)]. The magnitude of indicators of cardiac strain was found to vary with the change of working spell. The environmental heat load might be one of the reasons for increased cardiovascular strain. From the result of the present study, it was observed that human resources working in the agricultural field felt very hot and uncomfortable, especially around noon, i.e. during the second spell. This is because of as the source of the solar beam is directly overhead at 12:00 noon, with shortest ray path through the atmosphere will be shortest, resulting in the highest heat load (Khodarmi *et al*., 2013). An earlier study reported that, the WBGT level during the midday of the working spells was very high in outdoor work where sun exposure is a major contributor to high

WBGTs. The resulting work capacity during different hours for an individual who works at a heavy work intensity of 500 W is very low: on an average only 20% of work capacity remains at 12 noon. Moreover, continuation of work for long time, in such adverse environmental conditions, may force the agricultural workers to terminate their work early, resulting in decrease in work output. Earlier studies also report that, environmental condition may have some impact on the work performance of the human resources occupationally engaged in different outdoor task (Venugopal *et al*., 2016; Mohan *et al*., 2014). In order to avoid the occupational heat stress, individual may use 'siesta', or similar approaches to work primarily during less hot time of the 24-hour period. The result of the present study shows that, environmental condition adjudged by the heat stress indices are not favorable in second spell, i.e. above the recommended threshold value, making the task strenuous for the paddy cultivators engaged in manual reaping task. Earlier studies reported that, different environmental heat indices were higher than ACGIH threshold limit values in the working environment making the task stressful for the paddy cultivators involving different type of task during paddy cultivating time (Chatterjee *et al*., 2018; 2018b; 2018g; 2018h), which is further confirmed in the present study.

Cardiac performance indicators of study participants in terms of HPDI (a) and Drudgery index (b) has been presented in figure 3..

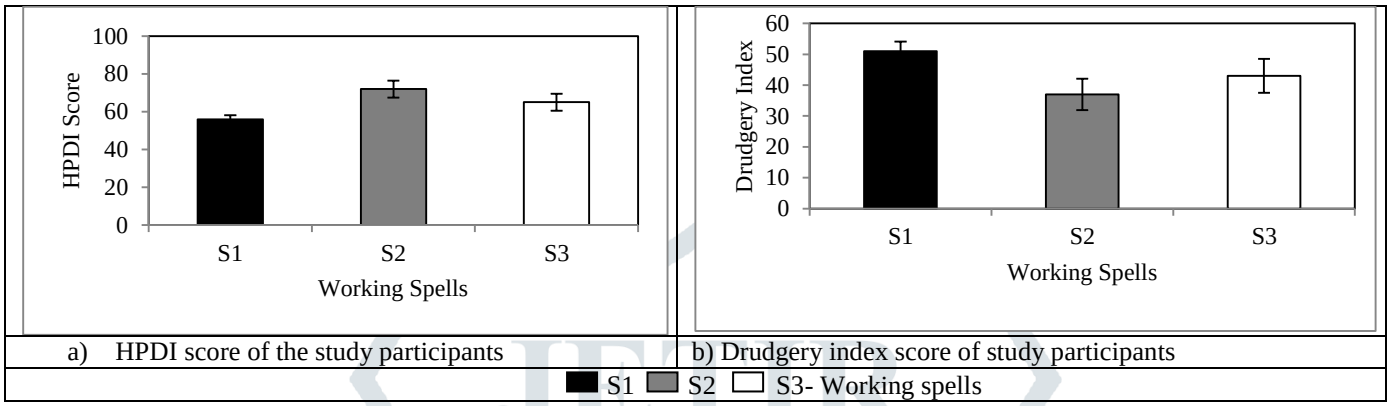


Figure 3: Cardiac performance indicators in terms of HPDI and drudgery index of the study participants

Cardiac response of the study participants was adjudged in tern s of HPDI and drudgery index. HPDI, one of the most important indicators to assess the cardiac response profile especially for the working individuals; can be calculated based on linear combination method using the scores obtained from time spend on the activity, task performance score, difficulty score of the activity, body posture adopted, frequency of postural change, load/force and postural discomfort. HPDI value was significantly higher in second spell and lower in the first spell and higher values of HPDI denoting the less working efficiency [Fig. 3(a)]. Another important indicator is the drudgery index. The values of drudgery index were significantly higher in first spell and lower in second spell. Higher values of drudgery index denoting better working efficiency [Fig. 3(b)]. In the present study HPDI score significantly higher in second spell of the working hours and drudgery index was significantly higher in first spell of the working hours. This finding was in consonance with the finding on an earlier study carried out among the Bengalee male paddy cultivators in southern area of West Bengal (Chatterjee *et al*., 2019a). The results of the present study indicated that, work in a warm humid condition is more stressful than doing the same in lower environmental temperature. Moreover, manual reaping or cutting task during 'Boro' type of paddy cultivation is more strenuous in terms of the indices of physiological strain. The finding of the present study in consonance with the finding of an earlier study conducted among the paddy cultivators occupationally engaged in reaping or cutting task during 'Aman' type of paddy cultivation (Winter paddy) that reports manual reaping task was found to be a heavier task of paddy cultivation. This is further affirmed by the finding of the present study carried out during the 'Boro' type of paddy cultivation.

IV. CONCLUSION

From the present study, it may be concluded that manual reaping or cutting the paddy in the field is a laborious task and the paddy cultivators engaged in manual reaping task experience 'moderate' to 'heavy' degree of cardiac strain, as indicated from the physiological strain indicators. This is due to the prevailing the environmental conditions existing in different spells along the day, the demand of the work, and posture that had to be adopted for carrying out the work. This may have serious implications in view of the fact that average ambient temperature is on the rise throughout the world leading to climate change and the challenges are more in tropical country like India with huge number of people being involved in open sky livelihood earning in the unorganized sector.

V. ACKNOWLEDGMENTS

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REFERENCES

[1] ACGIH. 2008. Threshold Limit Values and Biological Exposure Indices. (Cincinnati, Ohio).
[2] Adhikari, B., Bag, M. K., Bhowmick, M.K., Kundu, C. 2012. Rice in West Bengal-Rice Knowledge Management. 1- 88.
[3] Astrand, P. O., Rodhal, K. 1986.Threshold Limit Values and Biological Exposure Indices. Text Book of Work Physiology. (McGraw Hill. New York).
[4] Banerjee, N., Chatterjee, S., Chatterjee, A., Chatterjee, S., Mitra, S., Agrawal, K.M., Mukherjee, S. 2015a. Climate Change: Occupational Health and Performance Implications for Informal Sector Human Resources. In: Managing Sustainable Development: Innovations and Best Practices, Springer (India).
[5] Banerjee, N., Santra, T., Chatterjee, S., Mukherjee, S. 2015b. 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.

[6] Banerjee, N., Chatterjee, S., Santra, T., and Mukherjee, S. 2014.. Significance of Thermal Comfort Standard for Indian Urban Household: A Review. Impact of Pollution: Assessment and Awareness (ISBN 978-81-921083-8-4): 147-151.
[7] Chatterjee, A., Chatterjee, S., Banerjee, N., Chatterjee, S., Mukherjee, S. 2019a. 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): 72-80.
[8] Chatterjee, A., Banerjee, N., Chatterjee, S., Chatterjee, S., Mukherjee, S. 2019b. 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 (5): 238-243.
[9] Chatterjee, A., Chatterjee, S., Chatterjee, S., Banerjeee, N., Mukherjee, S. 2018a. 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: 199-210.
[10] Chatterjee, A., Chatterjee, S., Chatterjee, S., Bhattacharjee, S., Santra, T., Banerjee, N., Ghosh, K., Mukherjee, S. 2018b. 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), 84 (5-6): 199-205.
[11] Chatterjee, A., Chatterjee, S., Chatterjee, S., Banerjee, N., Mukherjee, S. 2018c. Assessment of Physical Performance 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, 34.
[12] Chatterjee, A., Chatterjee, S., Banerjee, N., Santra, T., Chatterjee, S., Mukherjee, S. 2018d. 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.
[13] Chatterjee, A., Chatterjee, S., Bhattacharjee, S., Santra, T., Banerjee, N., Mukherjee, S. 2018e. 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.
[14] Chatterjee, A., Chatterjee, S., Santra, T., Banerjee, N., Mukherjee, S. 2018f. 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.
[15] Chatterjee, A., Chatterjee, S., Banerjee, N., Chatterjee, S., Mukherjee, S. 2018g. 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.
[16] Chatterjee, A., Chatterjee, S., Chatterjee, S., Banerjee, N., Banerjee, N., Mukherjee, S. 2018h. Impact of Thermal Working Environmental Condition and Workload on Cardiac Response Indicators in Male Agricultural Workers. Proceedings of the National Conference on Perspectives of Human Health Microbial Biotechnology and Innovation, Vidyasagar University: 108.
[17] 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, Aaheli Publisher (ISBN: 81-89169-33-5): 110-124.
[18] Chatterjee, A., Chatterjee, S., Chatterjee, S., Santra, T., Banerjee, N., Mukherjee, S. 2017a. 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. In: Ergonomics for Improved Productivity (ISBN 978-93-86724-25-0), Excel India: 195.
[19] Chatterjee, A., Chatterjee, S., Banerjee, N., Chatterjee, S., Santra, T., Mukherjee, S. 2016a. 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 (1): 8-11. doi: 10.11648/j.aap.20160101.12.
[20] Chatterjee, A.,Chatterjee, S., Banerjee, N., Chatterjee, S., Santra, T., Mukherjee, S. 2016b. 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.
[21] Chatterjee, A., Chatterjee, S., Chatterjee, S., Santra, T., Bhattacharjee, S., Mukherjee, S. 2015a. Exposure to Heat from Natural Working Environment and Cardiovascular Strain: A Study in Male Agricultural Workers in Southern Bengal. In: Caring for People (ISBN 978-93-5258-836-7), IIT Bombay: 166-171.
[22] Chatterjee, A., Chatterjee, S., Chatterjee, S., Banerjee, N., Santra, T., Mukherjee,S. 2015b. Thermal Comfort and HSI: A Study in Bengalee Male Paddy Cultivators. Quad Scientific Reporter (ISBN 978-81-925784-4-6): 148-155.
[23] Chatterjee, A., Banerjee, N., Chatterjee, S., Santra, T., Agrawal, K. M. Mukherjee, S. 2015c: 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.
[24] Chatterjee, A., Chatterjee, S., Banerjee, N., Santra, T., Mondal, P., Mukherjee, S. 2015d. 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.
[25] Chatterjee, A., Chatterjee, S., Chatterjee, S., Santra, T., Banerjee, N., Mukherjee, S. (2015e). 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.
[26] 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.
[27] Epstein, Y., and Moran, D. 2006. Thermal Comfort and the Heat Stress Indices. Industrial Health, 44: 388-398.
[28] 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. IJOH, 7: 1-9.
[29] 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. Edu., 15: 25-30.

[30] Khodarahmi, B., Dehghan, H., Motamedzadeh, M., Zeinodini, M., Hosseini, S.M. 2013. Effect of Respiratory Protection Equipments Wear on Heart Rate in Different Workload. Int. J Environ Health Eng, 2: 1-4.
[31] Kjellstrom, T., Briggs, D., Freyberg, C., Lemke, B., Otto, M., Hyatt, O. 2016. Human Performance and Occupational Health: A Key Issue for the Assessment of Global Climate Change Impacts. Annu. Rev. Public Health, 37: 97-112.
[32] 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.
[33] 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. Hyg., 51: 553-561.
[34] Mohan, M., Gupta, A., Bhati, S. 2014. A Modified Approach to Analyze Thermal Comfort Classification. Atmospheric and Climate Sciences, 4: 7-19.
[35] Moran, D.S., Shapiro, Y., Epstein, Y., Matthew, W., Pandolf, K. B. 1998. A Modified Discomfort Index (MDI) as an Alternative to the Wet Bulb Globe Temperature (WBGT). In: Environmental Ergonomics VIII, Hodgdon JA, Heaney JH, Buono MJ (Eds.).
[36] Mukherjee, S. 2015. Climate Change: Implications for Human Resources in Informal Sector of Eastern India. Ergonomics for Rural Development (ISBN 978-93-5174-905-9: 174 -178.
[37] 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.
[38] 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.
[39] Mukherjee, S. 2013a. Occupational Health Scenario in Unorganized Sector in India: Emerging Issues. Proceedings of 100th Indian Science Congress: 123-124.
[40] Mukherjee, S., Banerjee, N., Chatterjee, S., Chakraborti, B. 2013b. Impact of Bharatnattyam Dancing Exercise on Reducing Central Obesity in Adult Bengalee Females. Science and Culture (ISSN 0036 8156), 79: 503-506.
[41] Pancardo, P., Acosta, D.F., Hernández-Nolasco, A.J., Wister, M., López-de-Ipiña, D. 2015. Real-Time Personalized Monitoring to Estimate Occupational Heat Stress in Ambient Assisted Working. Sensors, 15: 16956-16980.
[42] Parsons K 2014. Human thermal Environments. In The Effects of Hot, Moderate and Cold Temperatures on Human Health, Comfort and Performance. 3rd ed, London: Taylor and Francis: 1–32.
[43] 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.
[44] Ramanathan, N.L., Dutta, S.R., Roy, B.N., Chatterjee, A., Mullick, L.N. 1967. Energy Cost of Different Muscular Tests Performed by Indian Subjects. Indian Journal of Occupational Health, 10: 253-261.
[45] Saha, P.N., Datta, S.R., Banerjee, P.K., Narayane, G.G. 1979. An Acceptable Workload for Indian Workers. Ergonomics, 22: 1059–1071.
[46] 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: Caring for People: (ISBN 978-93-5258-836-7): 84-89.
[47] Santra, T., Chatterjee, S., Banerjee, N., Mukherjee, S. 2014. Global Warming: Impact on Human Health Impact of Pollution. Assessment and Awareness (ISBN 978-81-921083-8-4): 113 – 119.
[48] 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.), Pergamon Press, Oxford: 395–400.
[49] 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.