DOI: https://doi.org/10.36094/sc.v89.2023.Impact_of_Variation_in_Thermal_Working_Environment.Chatterjee.45

Research Communication

Sci. and Cult. 89 (1–2) : 45-51 (2023)

Impact of Variation in Thermal Working Environment on Cardiac Performance in Bengalee Male Crop Cultivators of a Southern District of West Bengal

Abstract: **During different agricultural tasks, the crop cultivators work manually in the agricultural field, 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 performance in 39 male paddy cultivators (age range 21 - 30 years) primarily engaged in manual reaping task during 'Boro' type of paddy cultivation time in the southern area of Hooghly district. Data on physical and physiological parameters of study participants were collected. Indicators of cardiac strain were calculated. The result of the present study indicated that there was strain in male crop cultivators 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, workload, paddy cultivation

Agriculture is the art or science of cultivating the ground, including management of livestock, husbandry farming including farming[1]. In many regions of the world, especially but not exclusively in the rural areas an appreciable proportion of the population is still engaged in physically demanding activities relating to agricultural tasks[2-4]. Agricultural work involving different type of tasks such as crop cultivation, sowing of seeds, uprooting, transplantation, weeding, reaping, binding of straw, carrying of straw bundles, threshing and collection of crops and straw bundles, requires substantial physical strength[5-7]. In India, agricultural work is till date significantly dependent on non-mechanized techniques. Moreover, the working conditions of agricultural workers are extremely difficult due to severe environmental conditions, long working hours, strenuous work and the use of improper equipment[8-10]. Earlier studies have reported that physical work capacity and work-performance were getting affected due to unpleasant thermal conditions prevailing in the working environment in different occupation including agriculture[11-14]. Rise in ambient temperature, a major determinant of thermal aspects of working environment, may have some impact on the cardiac performance of the male individuals working in the open – air non-mechanized agricultural field daily for a considerable period of time[15-17] as different tasks performed by agricultural workers demand considerable time and energy for the agricultural workers[18-22]. Manual reaping or cutting task of paddy in field is a labor-intensive task, and 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 and workload on cardiac performance in male paddy cultivators primarily engaged in manual reaping task (cutting the paddy which 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 is usually done in April) type of paddy cultivating time.

Methodology**:** The present study was carried out in villages in and around Goghat II administrative block, in Arambagh subdivision in Hooghly district, West Bengal. Initially human resources engaged in paddy cultivation, 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, was approached for participation in the study. On obtaining individual consent and ethical clearance, the present study was carried out on 39 adult male agricultural workers of age range of 21 – 30 years, primarily engaged in manual

The journal is in the category 'Group A' of UGC-CARE list and falls under the broad category of Multidisciplinary Sciences covering the areas Arts and Humanities, Science and Social Sciences.

reaping tasks. Information regarding their age (year), socio – economic status (SES) - assessed by using the modified version of Kuppuswamy's socioeconomic scale [23], 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 in the agriculture field. The values of relative humidity (RH) (%), wet bulb globe temperature (WBGT) (ºC) [24], physiological strain index (PSI) [25], and modified discomfort index (MDI) (ºC)[26] 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 pre work heart rate (beats. min^{-1}), systolic and diastolic blood pressure (mm Hg) were recorded in the morning hours before the individuals started working. Indicators of physiological strain in terms of peak heart rate (HR_{peak}) (beats.min^{-1})[27], peak estimated energy expenditure (PEEE) (kcal.min^{-1})[28], relative cardiac cost (RCC) (%), and absolute cardiac cost (ACC) (beats.min^{-1})[29] were found out. Cardiac performance indicators in terms of human physical drudgery index (HPDI) and drudgery index[30] of the study participants were also calculated. The data were 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 at regular intervals during morning [6.15 - 9.00 am], around noon [10.00 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 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.

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.

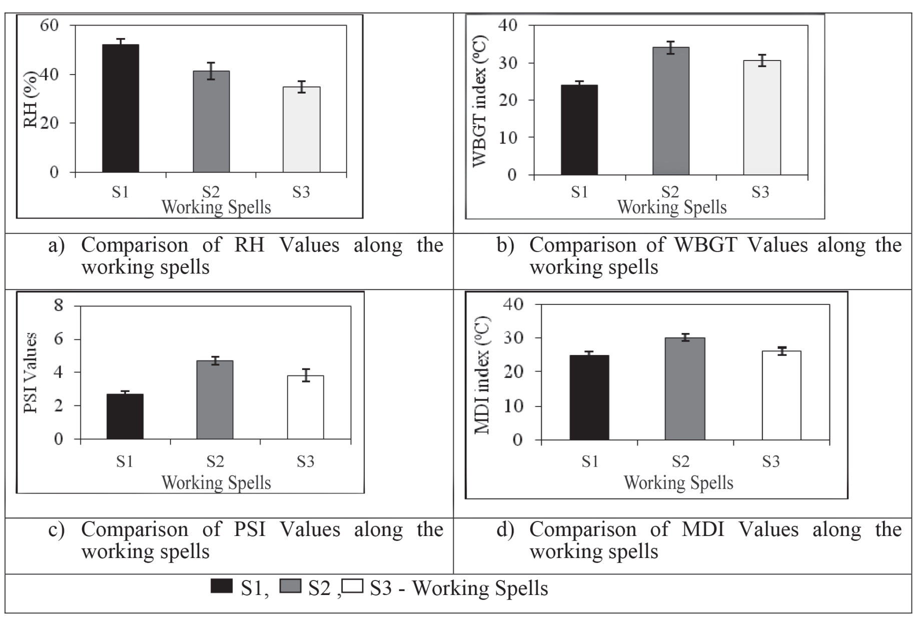
Table 1: Basic Profile of the Study Participants

Variables	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

The thermal environmental condition was adjudged in terms of relative humidity and three indicators of thermal environmental condition–WBGT, PSI, and MDI. The comparisons of the indicators of thermal environmental status along the spells are presented in Figure 1.

India is a country with varied geographical and climatic features and therefore different parts of the country experience different ranges of temperature and rainfall, even during the same month of the year or season. In addition, the extreme weather events in India have geographical heterogeneity[31]. On the other hand, despite technological improvements in protective equipment, workers are still exposed to severe environmental heat hazard, a common occupational health hazard for outdoor and indoor workers in hot environment. Therefore, the assessment of different heat stress indices was necessary. The wet-bulb globe temperature (WBGT) is one of the most widely used index of thermal environmental status 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. During the second spell of the working hours, the calculated WBGT



a) Comparison of RH Values along the working spells
b) Comparison of WBGT Values along the working spells
c) Comparison of PSI Values along the working spells
d) Comparison of MDI Values along the working spells

Fig. 1 Indicators of Thermal Environmental Status along the Working Spells value was 34.1°C, during this spell no work is ideally allowable[32]. Whereas during the third spell of the working hours, the calculated average WBGT, value was 30.6°C, 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 thermal condition. In addition, upto 50% 'moderate' type of work each hour in work rest cycle is allowable[32,33]. 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[25]. 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[34]. 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 thermal environmental condition.

Physique can be characterized by the individuals' body structure, body size and body composition. On the other hand body composition, anthropometric dimensions, and morphological characteristics play a vital role in maintaining regular working activity[35]. The physical and physiological characteristics of the study participants are presented in Table 2. The mean BMI of the participants was 21.5 kg.m^{-2}, which indicated that, all the participants were an as average in 'normal weight' category as per the classification of WHO (WHO, 2000)[36]; the result is in agreement with earlier studies carried out on individuals regularly undertaking different forms of physical activities including[37-41]recreational dance[42-49]. 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[50-51].

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

Indicators of cardiac strain[52] 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.

Cardiac strain of human resources engaged in manual reaping task assessed in terms of HR $_{Peak}$ (beats.min^{-1}),

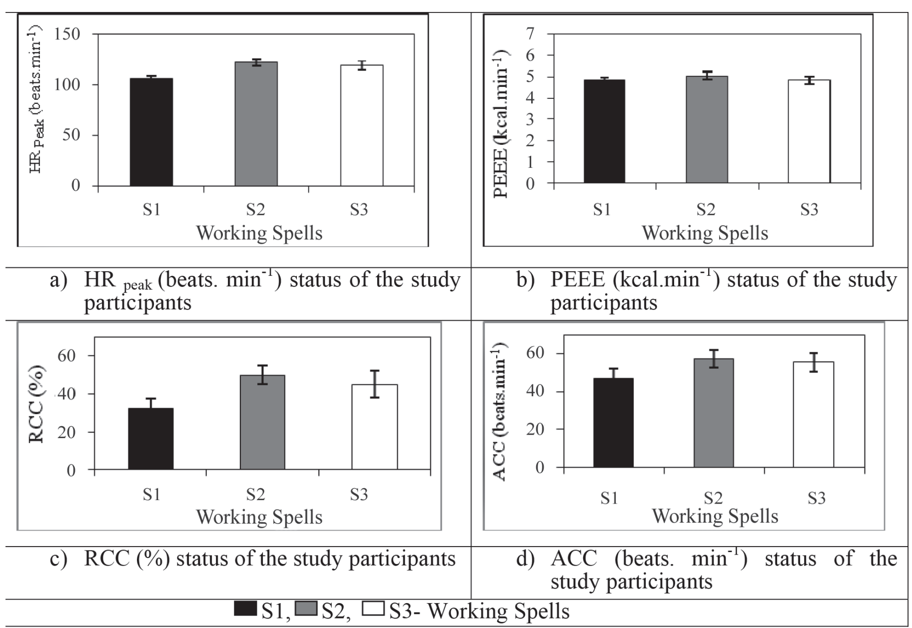


Fig. 2 Indicators of cardiac strain in terms of HR $_{Peak}$ (beats. min^{-1}) (a), PEEE (kcal.min^{-1}) (b), RCC (%) (c) and ACC (beats. min^{-1}) (d) of the study participants

PEEE (kcal.min^{-1}), RCC (%), and ACC (beats.min^{-1}). An earlier study reported that, heart rate, the principal indicator, was used to assess circulatory strain imposed by the workload of varying intensity. 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)]. An earlier study reported that, heart rate in industry should not exceed 110 beats.min^{-1}, as cumulative fatigue could ensue beyond this heart rate level[53]. 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 beats.min^{-1} [54]. In the present study, average-working heart rate greatly exceeded the threshed; therefore, the work is heavy[27]. 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[55]. 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[56]. Moreover, continuation of work for long time, in such adverse thermal environmental conditions, may force the agricultural workers to terminate their work early, resulting in decrease in work output. Earlier studies also reported that, environmental condition might have some impact on the work performance of the human resources occupationally engaged in different outdoor tasks[57-59]. 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 conditions adjudged by the indices thermal environment status 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 as WBGT index were higher than ACGIH threshold limit values in the working environment making the task stressful for the paddy cultivators involved in different type of tasks during paddy cultivating time[8, 9], which is further confirmed in the present study.

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

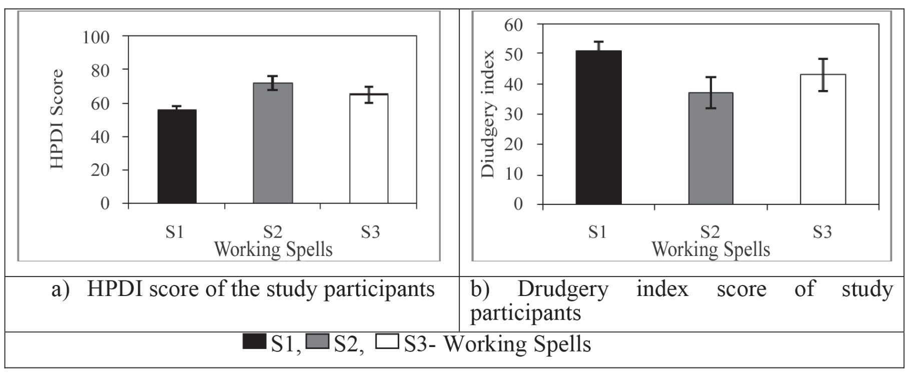


Fig. 3 Cardiac performance indicators in terms of HPDI and drudgery index of the study participants

Cardiac response of the study participants was adjudged in terns 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 spent on the activity, task performance score, difficulty score of the activity, body posture adopted, frequency of postural change, load/force and postural discomfort[60-62]. HPDI value was significantly higher in second spell and lower in the first spell and higher values of HPDI denoting the less working efficiency. 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[63]. In the present study HPDI score was 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 of earlier studies carried out among the Bengalee male paddy cultivators in southern area of West Bengal[57-59]. The results of the present study indicated that, work in a warm humid condition was 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 is 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 [8,9]. This is further affirmed by the finding of the present study carried out during the 'Boro' type of paddy cultivation. To alleviate the situation, several strategies like modification of work rest schedule, i.e. early starting of the work may be adopted and/or attempts should be made through design interventions and other means to reduce the extent of strain for ensuring better working performance.

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 thermal 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.

Acknowledgments: We are thankful to all the volunteers for their participation and cooperation during the study. ❐

AYAN CHATTERJEE,
NEEPA BANERJEE,
SANDIPAN CHATTERJEE,
SURJANI CHATTERJEE,
SHANKARASHIS MUKHERJEE*

Public Health Analytics Unit,
Department of Food and Nutrition,
West Bengal State University,
Kolkata 700 126, India
*Email: msasish@yahoo.co.in

Received: 09 December, 2019

Revised: 04 July, 2022

1. B. Adhikar, M.K. Bag, M.K. Bhowmick, C. Kundu,1-88, (2012).
2. P. Roy, M. Kaur,*International Journal of Advances in Agricultural and Environmental Engg*, **2**, 44-48 (2015).
3. T. Santra, A. Chatterjee, S. Chatterjee, S. Chatterjee, N. Banerjee, S. Mukherjee,*In*: *Caring for People*: (ISBN 978-93-5258-836-7), 84-89 (2015)..
4. A. Chatterjee, S. Chatterjee, S. Chatterjee, S. Bhattacharjee, N. Banerjee, S. Mukherjee,*In:Molecular Physiological and Nutritional Responses during Pathological Alteration of Cell Function* (ISBN: 81-89169-33-5), 110-124 (2017).
5. A. Chatterjee, S.Chatterjee, S. Chatterjee, T. Santra, N. Banerjee, S. Mukherjee, *In: Ergonomics for Improved Productivity (ISBN 978-93-86724-25-0)* (Excel India), 195 (2017).
6. A. Chatterjee, S. Chatterjee,N. Banerjee,S. Chatterjee, T. Santra, S. Mukherjee, S. *Advances in Applied Physiology (ISSN 2471-9692- Print, 2471-9714 - Online),***1**, 8-11 (2016).doi: 10.11648/j.aap.20160101.12.
7. A. Chatterjee, S. Chatterjee, N. Banerjee, S. Chatterjee, T. Santra, S. Mukherjee, *In: Proceedings of the International Conference on Humanizing Work and Work Environment (ISBN: 978-93-83006-81)*,157-162.
8. A. Chatterjee, N. Banerjee, S. Chatterjee, T. Santra, K. M. Agrawal, S. Mukherjee,*Survey (ISSN: 0586-0008)*, **55**, 91-98 (2015).
9. A, Chatterjee, S. Chatterjee, S. Chatterjee, T. Santra, S. Bhattacharjee, S. Mukherjee,*In: Caring for People: (ISBN 978-93-5258-836-7)*, 166-171 (2015).
10. A. Chatterjee, S. Chatterjee, S. Chatterjee, N. Banerjee, T, Santra, S. Mukherjee,*In: Quad Scientific Reporter (ISBN 978-81-925784-4-6)*, 148-155 (2015).
11. A. Chatterjee, S. Chatterjee, S. Chatterjee, N. Banerjeee, S. Mukherjee,*In: Advance Technologies in Agriculture for Doubling Farmers' Income (ISBN: 978-93-86453-61-7)* New Delhi Publisher, 199-210 (2018).
12. A. Chatterjee, S. Chatterjee, S. Chatterjee, S. Bhattacharjee, T. Santra, N. Banerjee, K. Ghosh, S. Mukherjee,*Science and Culture (ISSN 0036 8156)*, **84** (5-6): 199-205 (2018).
13. A. Chatterjee, S. Chatterjee, S. Chatterjee, N. Banerjee, S. Mukherjee, *Proceedings of the National Conference on Physical Education and Sports Sciences in the 21st Century*, Jadavpur University, 34 (2018).
14. A. Chatterjee, S. Chatterjee, N. Banerjee, T. Santra, S. Chatterjee, S. Mukherjee, In: Technology Enabled Workplace Design (ISBN: 978-93-88237-27-7 (Excel India), 6 (2018).
15. A. Chatterjee, S. Chatterjee, S. Bhattacharjee, T. Santra, N, Banerjee, S. Mukherjee,In: Technology Enabled Workplace Design (ISBN: 978-93-88237-27-7) *(*Excel India), 7 (2018).
16. A. Chatterjee, S. Chatterjee, N. Banerjee, S. Chatterjee, S. Mukherjee, S. Proceedings of the 3rd Regional Science and Technology Congress, 223 (2018).
17. A. Chatterjee, S.Chatterjee, S. Chatterjee, N. Banerjee, S.

Mukherjee, *Indian Journal of Biological Sciences (ISSN 0972-8503)*(2018) (in press).

18. T. Kjellstrom, D. Briggs, C. Freyberg, B. Lemke, M. Otto, O. Hyatt,*Annu. Rev. Public Health*, **37**, 97-112 (2016).
19. R. A. I Lucas, Y. Epstein, T. Kjellstrom,*Extreme Physiology and Medicine*, **14**, 1-8 (2014).
20. K. Parsons, Human thermal Environments. 3rd ed, London: Taylor and Francis, 1–32 (2014).
21. S. Mukherjee,*In: Ergonomics for Rural Development (ISBN 978-93-5174-905-9)*, 174 -178 (2015).
22. A. Adam-Poupart, F. Labreche, A. Smargiassi,*Industrial Health*, 51, 68–78 (2013).
23. B. P. Ravikumar, S. R. Dudala, A. R. Rao,*International Journal of Research and Development of Health*, **1**, 2-4 (2013).
24. H, Heidari, F, Golbabaei, A. Shamsipour, A. R. Forushani, A. Gaeini,*International Journal of Occupational Hygiene*, **7**, 1-9 (2015).
25. D. S. Moran, A. Shitzer, K. B. Pandolf,*Am J Physiol*, **275**, 129–134 (1998).
26. Y. Epstein, D. Moran,*Industrial Health*, **44**, 388-398 (2006).
27. P. O. Astrand, K. Rodhal, *In: Text Book of Work Physiology*. McGraw Hill. New York, 1986.
28. N. L. Ramanathan, S. R. Dutta, B. N. Roy, A. Chatterjee, L. N. Mullick, Indian Journal of Occupational Health, **10**, 253-261 (1967).
29. P. Pancardo, D. F. Acosta, A. J. Hernández-Nolasco, M. Wister, D. López-de-Ipiña,*Sensors*, **15**, 16956-16980 (2015).
30. P. Joshi, R. Jethi, N. Chandra, M. L. Roy, H. B. Kharbikar, G. A. Atheequlla,*Indian Res. J. Ext. Edu*., **15**, 25-30 (2015).
31. S. K. Dash, T. Kjellstrom,*Current Science*, **101**, 496-503 (20111).
32. ACGIH (2008), Threshold Limit Values and Biological Exposure Indices, Cincinnati. Ohio.
33. V. S. Miller, G. P. Bates,*Ann. Occup. Hyg*.,**51**, 553-561 (2007).
34. E. Sohar, D. J. Tennenbaum, N. Robinson, Tromp SW (Ed.), Pergamon Press, Oxford, 395–400 (1962).
35. A. Chatterjee, S. Chatterjee, N. Banerjee, T. Santra, P. Mondal, S. Mukherjee,*Proceedings of the National Conference on Agriculture and Rural Development Issues in Eastern India*, 25-26 (2015).
36. WHO. Obesity, 256 (2000).
37. S. Mukherjee, N. Banerjee, S. Chatterjee, S. Chatterjee, *Indian Journal of Biological Sciences (ISSN 0972-8503)*,**18**, 9-15 (2014).
38. S. Mukherjee, N. Banerjee, S. Chatterjee, S. Chatterjee,*Science and Culture (ISSN 0036 8156)*, **80**, 279-282 (2014).
39. S. Mukherjee, N. Banerjee, S. Chatterjee, B. Chakraborti,*Science and Culture (ISSN 0036 8156)*, **79**, 503-506 (2013).
40. N. Banerjee, T. Santra, S. Chatterjee, S. Mukherjee,*In: Ergonomics for Rural Development (ISBN 978-93-5174-905-9)*, 89 – 96 (2015).
41. N. Banerjee, S. Chatterjee, S. Chatterjee, K. Ghosh, S. De S, Mukherjee,*International Physiology (ISSN: 2347-1505)*, **3**, 11 – 15 (2015)Doi-10.21088/ip.2347.1506.3115.1.
42. S. Mukherjee, N. Banerjee, S. Chatterjee, S. Chatterjee, A. Chatterjee, T. Santra, B. Saha, *American Journal of Sports Science and Medicine*, **2**, 56-59 (2014).
43. S. Chatterjee, N. Banerjee, T. Santra, A. Chatterjee, S. Chatterjee, I. Manna, U. Banerjee, S. Mukherjee, *American Journal of Sports Science and Medicine (ISSN: 2333 4592-Print, 2333 4606 - Online)*, **2** (5A), 40 - 44, (2014) doi: 10.12691/ajssm-2-5A-9.
44. N. Banerjee, T. Santra, S. Chatterjee, A. Chatterjee, S. Chatterjee, U. Banerjee, S. Mukherjee, I. Manna, *American Journal of Sports Science and Medicine (ISSN: 2333 4592-Print, 2333 4606 - Online)*, **2**(5A), 45 - 47, (2014) doi: 10.12691/ajssm-2-5A-10.
45. N. Banerjee, S. Chatterjee, S. Chaterjee, A. Chatterjee, S. Bhattacharjee, T. Santra, B. Saha, S. Mukherjee, I. Manna, *American Journal of Sports Science (ISSN: 2330-8559 (Print); ISSN: 2330-8540 (Online)*, **2** (6 -1), 19 - 23, (2014) doi:10.11648/j.ajss.s.2014020601.14.
46. S. Chaterjee, N. Banerjee, S. Bhattacharjee, T. Santra, A. Chatterjee, S. Chatterjee, B. Saha, S. Mukherjee, I. Manna, *American Journal of Sports Science (ISSN: 2330-8559 (Print); ISSN: 2330-8540 (Online)*, **2** (6-1), 24-30, (2014) doi: 10.11648/j.ajss.s.2014020601.15.
47. S. Bhattacharjee, B. Bhattacharya, N. Banerjee, T. Santra, S. Chatterjee, A. Chatterjee, S. Chatterjee, S. Mukherjee, S. De, K. Ghosh, *International Journal ofPharmaceutical Sciences Review and Research (ISSN: 0976 – 044X)*, **41** (2), 28-33, (2016).
48. S. Bhattacharjee, N. Banerjee, S. Chatterjee, A. Chatterjee, S. De, S. Mukherjee, *International Physiology(ISSN: 2347-1505)*, **3** (1), 41 - 47, (2015) doi: ip.2347.1506.3115.6.
49. N. Banerjee, S. Chatterjeee, S. Bhattacharjee, S. Chatterjee, A. Chatterjee, T. Santra, S. De, K. Ghosh, S. Mukherjee, *InternationalJournal of Research in Medical and Basic Sciences (ISSN: 2455-2569),* **3**(6), 18-28, (2017).
50. A. Chatterjee, S. Chatterjee, S. Chatterjee, T. Santra, N. Banerjee, S. Mukherjee,*International Physiology (ISSN: 2347-1505)*, **3**, 23 – 28 (2015). doi10.21088/ ip.2347.1506.3115.3.
51. A. Chatterjee, S. Chatterjee, T. Santra, S. Mukherjee,*In: User Centered Design and Occupational Wellbeing, McGraw Hill Education (ISBN 978 – 93- 392 – 1970 -3)*, McGraw Hill, New Delhi, 499 – 503 (2014).
52. M. Motamedzade, M. R. Azari,*Pakistan J Biol, Sci.,***9**, 457-459 (2006).
53. L. Brouha, London, UK: Pergamon Press, 82–108 (1960).
54. P. N. Saha, S. R. Datta, P. K. Banerjee, G. G. Narayane, *Ergonomics*, 22, 1059–1071 (1979).
55. B. Khodarahmi, H. Dehghan, M. Motamedzadeh, M. Zeinodini, S. M. Hosseini,*Int. J Environ Health Eng,***2**, 1-4 (2013).
56. V. Venugopal, J. S. Chinnadurai, R. A. I. Lucas, T. Kjellstrom,*Int. J. Environ. Res. Public Health*, 89, 1- 13 (2016).

57. A. Chatterjee, S. Chatterjee, N. Banerjee, S. Chatterjee, S. Mukherjee, *International Journal of Innovative Knowledge Concepts (ISSN: 2454-2415),***7** (Special Issue 1): 72-80 (2019)..

58. A. Chatterjee, N. Banerjee, S. Chatterjee, S.Chatterjee, S. Mukherjee, S, *International Journal of Innovative Knowledge Concepts (ISSN: 2454-2415)*, **7**, 238-243 (2019).

59. A. Chatterjee, N, Banerjee, S, Chatterjee, S.Chatterjee, S. Mukherjee, *Journal of Emerging Technologies and Innovative Research (ISSN: 2349-5162)*, **6,** 438-443 (2019). Doi http://doi.one/10.1729/Journal.21469.

60. A. Chatterjee, S.Chatterjee, N. Banerjee, S. Chatterjee ,S. Mukherjee, *Indian Agriculturist(ISSN: 0019-4336)*, **63,** 49-55 (2019).

61. M. Mohan, A. Gupta, S. Bhati,*Atmospheric and Climate Sciences*, 4, 7-19 (2014).

62. P. P. Wankhade,D. M. Mankar,N. M. Kale, Y. B. Shambharkar,*Indian Research Journal Ext. Education*, 15, 85-90 (2015).

63. P. Parimalam, J. Meenakshi, D. S. Padmini,*International Journal of Agricultural Science and Research*, 7, 447-45 (2017).