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Effect of temperature variations in work environment on the cardiac stress in handloom weavers: implication of climate change in future

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Abstract: *Background:* Handloom industry, next to the agriculture, is providing livelihood to millions in India. This job mainly performed by the male handloom weavers is manual in nature and physically demanding. The present study was aimed to evaluate the cardiac stress in handloom weavers and additional effect of heat stress in summer season on it. *Methods:* The study was conducted on 82 handloom weavers during both summer and winter seasons. Polar heart rate monitor was used to measure resting, working and recovery heart rates and properly calibrated sphygmomanometer was used to measure working and resting blood pressure. Other cardiac stress indices were also calculated. *Results:* Different cardiac parameters, i.e. net cardiac cost (NCC), relative cardiac cost (RCC), maximum of working heart rate (WHRmax) and Brouha's index are significantly ($p<0.05$) higher in summer season than in the winter season. The percentage of recovery (PREC) and heart rate reserve (HRR) are significantly higher in winter season. *Conclusion:* The present study concludes that the work-rest cycle need to be redesigned so that the handloom weavers can work in less stressed condition especially in the summer season.

Keywords: Handloom Weavers, Cardiac Stress Indices, Seasonal Variations, Physiological Variations, Climate Change.

Introduction

India is the highest handloom producing country in the world [1]. In West Bengal, a large number of rural populations are engaged in the handloom industry. Weaving involves a number of stages, but for this study purpose weaving activity has been considered only, as, this is the major task component [2]. Workplace environment is the key factor that can have the maximum impact on the workers' health. Handloom workers mainly work indoors. There were some studies on the occupational injuries and musculoskeletal disorders in different parts of the body related to the work of handloom weaving in northern east India and other countries [3-4].

Moreover, the workers have to work in a hot and humid, congested and in poorly ventilated workplace. They are usually exposed to a high noise level due to the sound of the loom-machines which causes speech interference, annoyance and headache during working hours [5-7]. Seasonal variations are one of the important factor for their productivity as well as health. Hot working environment in the summer season increases the burden. But there is dearth of data regarding cardiac strain among them during such environmental working conditions. The climate change will cause more stress in future. The present study is aimed at comparing the cardiac strain in the summer and winter seasons of the handloom weavers.

Material and Methods

Participants: The study group consisted of eighty two (82) handloom weavers who volunteered for the study and had at least 3 years of working experience in this occupation. The weavers that are suffering from any type of chronic illnesses were excluded from the study.

Study Design: This study was done in two different seasons in West Bengal, India, viz, summer (April-June, 2017) and winter (January-February, 2018), during their first half of their work i.e., between 7:00 -14:00

hours. Firstly, they were acquainted with the study protocol and some data were collected about the job, physical profile, resting heart rate (HR), etc. along with the environmental temperatures. Next, the weavers were asked to perform the experimental task based on the standard protocol [8]. The protocol of the study was informed to all the subjects who volunteered for the study and then oral consent were taken from them. All aspects of the study were carried out according to the Ethical standards of the Departmental Research Committee of the University of Kalyani.

Physical Profile: Body height and weight were measured with a standard anthropometric rod and properly calibrated weighing machine respectively. From those data, body mass index (BMI) was calculated [9].

Cardiovascular parameters:

1. *Resting, working and recovery HR:* Heart Rate (HR) was recorded with a heart rate monitor (Polar Accurex Plus, Polar Electro Oy, S810i, Finland). The protocol of Sahu et al., [2013] [10] was followed to measure the Resting, working and recovery HR [9].
2. *Average working HR:* Average working HR was derived from the value of the fourth minute of work onwards [11].
3. *Peak HR:* It is the maximum heart rate recorded during the 30 min of work [10].
4. *Cardiac strain:* Net cardiac cost (NCC) in beats and relative cardiac cost in % (RCC) were considered as two derived indices of cardiac strain [12].
5. *Work strain or sum of recovery heartbeats (SRHB):* SRHB is a measure of work strain, calculated by Dey et al., [2007] [13].
6. *Percentage of recovery (PREC):* PREC was calculated by Pradhan et al., [2004] [14].
7. *Percentage of Resting Heart Rate (% RHR):* Percentage of RHR was calculated by the formula of Maiti, [2008] [15].
8. *Brouha's index:* Brouha's index measured from the first, second and third minute of recovery heart rate in a sitting posture [16].

Blood pressure: Resting blood pressure (RBP) was measured with the help of properly calibrated sphygmomanometer and a stethoscope by the auscultatory method after the subjects were asked to sit comfortably for about half an hour. The working blood pressures (WBP) of the subjects were measured at the 30^{th} minute of the work as per the experimental task [17].

Heat stress indices: Indoor Dry Bulb (DBT) and Wet Bulb (WBT) temperatures were noted with the help of Psling psychrometer whereas relative humidity was determined from the psychrometric chart [18]. The temperatures were measured hourly both in summer and winter seasons during the study period.

Statistical Analysis: Statistical analysis was done between different seasonal data obtained and also amongst the physiological responses of the weavers as per the experimental tasks performed [19]. Student t-test was done among two seasonal responses obtained from the handloom weavers. The level of significance was taken as $p < 0.0001$ or else otherwise stated.

Results

The physical profile of the handloom weavers shows that they have working experience of about 17 years with a normal BMI of 25 kg/m^2. Thus they primarily do not suffer from any type of nutritional disorders [20]. The mean age of the handloom weavers who participated for this study was 36 years.

Cardiac indices of the weavers in two seasons have been tabulated in Table 1.

The table 1 shows that except PREC (%) and Brouha's Index all the other parameters are significantly more in summer than in winter. The resting heart rates of the subjects are however same in both the seasons.

The resting systolic pressure and the working systolic (158±4.44 and 136±2.12 mm Hg respectively) and diastolic pressure (118±1.76 and 98±0.75 mm Hg respectively) of the weavers are significantly more in the winter than in the summer season. The working and the recovery heart rates of all the 82 weavers in both the seasons are given in figure-1.

Table-1: Comparison of cardiac indices between two seasons			
Parameters	**Summer**	**Winter**	**Significance level**
HR (Resting) (beats/min)	70.76±4.24	69.27±2.87	NS (P= 0.0678)
HR (Working) (beats/min)	97.32±3.78	91.25±2.57	S (P<0.0001)
SRHB (beats)	1872.14±15.43	1651.67±56.15	S (P<0.0001)
NCC (beats)	803.34±122.21	739±76.09	S (P = 0.0043)
RCC (%)	44.2±9.12	38.90±5.61	S (P = 0.0071)
Peak HR (beats/min)	120.29±5.26	114.1±4.16	S (P= 0.0001)
PREC (%)	89.71± 5.06	92.67±3.61	S (P= 0.0009)
BI	8.2±2.15	10.8±3.94	S (P<0.0001)
WBGT (^{0}C)	32.86±4.32	24.7±1.06	S (P= 0.0029)
HR= Heart Rate, SRHB= Sum of recovery heart beats, NCC= Net cardiac cost, RCC= Relative cardiac cost, PREC= Percentage of recovery, BI= Brouha's Index, min=Minute, NS= Non significant, S= Significant, Values: Mean ± SD.			

Fig-1: Comparison of the mean values of working and the recovery heart rates of the handloom weavers in two different seasons

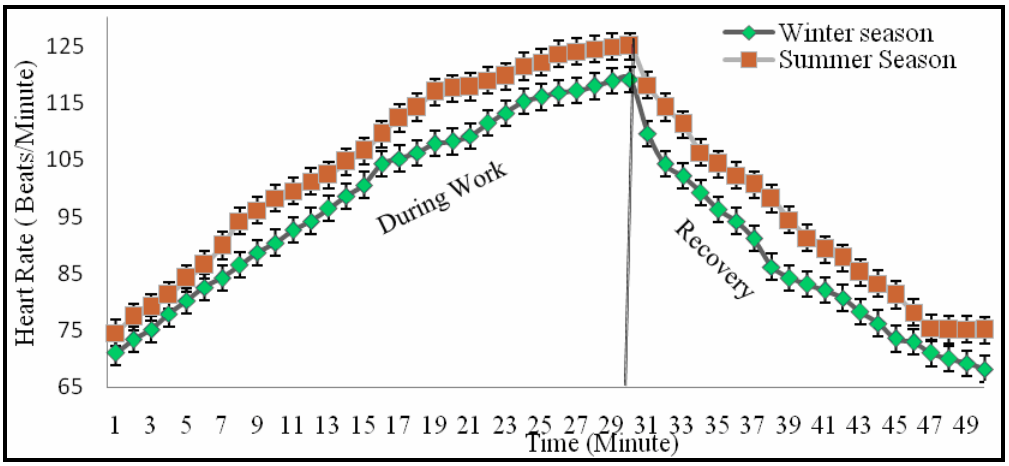
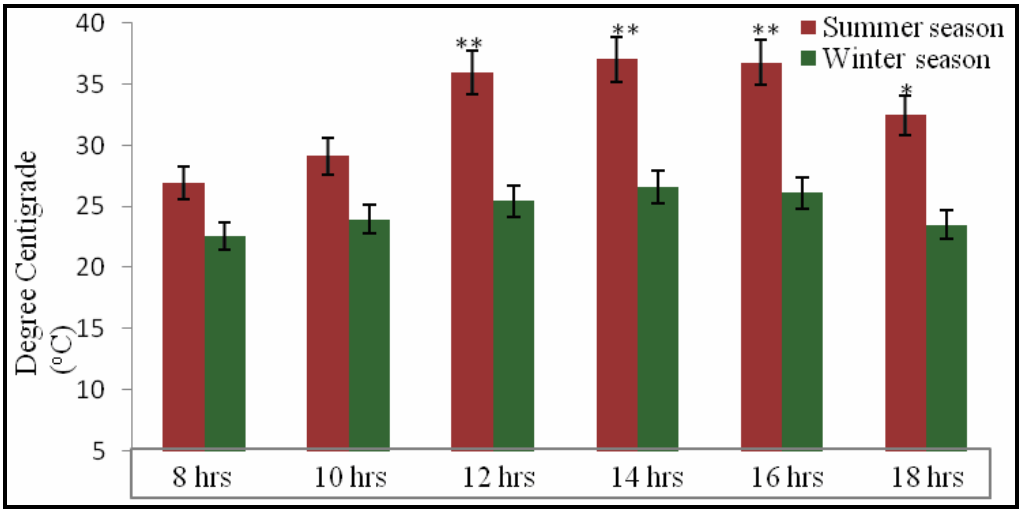


Fig-2: Indoor WBGT index of the handloom working places in two seasons



*p<0.05; **p<0.001

*

The working heart rates of the weavers are significantly more in summer ($p<0.001$) than in winter. Moreover, in summer seasons the recovery of the workers within the stipulated 20 min recovery time is partial whereas, the recovery is almost complete in the winter season. The indoor environmental temperature of the workplace is depicted in figure-2.

The WBGT index is much higher in summer seasons in the indoor work places of the handloom weavers than in the winter season. Even the relative humidity at the wee hours of their work is about 90.67% and 48.33% in the summer and in the winter seasons respectively.

Discussion

The seasonal variation in HR and BP, including SBP and DBP have been linked to the seasonal changes of outdoor temperature [21], but there is dearth of data or little research has been addressed on the potential effects of climate change on the indoor thermal environment specifically in the Indian context. The handloom weavers of West Bengal carry out their work in clumsy, ill-ventilated, ill-illuminated rooms [4].

At summer seasons working environment is very hot in West Bengal. The American Society of Heating, Refrigerating and Air conditioning engineers have showed that the thermal environmental conditions for human occupancy Standard 55-2004 characterizes the indoor summer comfort range as about 23ºC-28^{0}C and the winter comfort range as about 19ºC-26^{0}C, depending on the relative humidity [22]. From figure 2, it can be concluded that the weavers work within this comfort range during the early and late hours of the day in the summer seasons but with the passage of time the indoor air temperature rises to nearly 38^{0}C. This increase in indoor air temperature during the summer seasons increases their work load and they subsequently suffer from higher cardiac stress. Though the mean working HR values are 97.32 and 91.25 beats/min in the summer and winter seasons respectively but these handloom weavers works at a stretch and sometime works beyond 10 hours a day in such a clumsy indoor working environment. Classification of work load based on the mean HR shows that the work of the handloom weavers is light but the relative humidity of 90.67% and indoor air temperature of about 38^{0}C in the wee hours of the day in the summer months have put their physiological system at stress [23]. SRHB was significantly higher in the summer than in the winter season (1859.12 ± 82.34 and 1651.67 ± 56.15 beats/min respectively). This indicates that to recover from exhaustion after work, their heart had to beat faster. The NCC and RCC are also higher in the summer. NCC indicates that the physiological load is excessive among weavers in summer than in winter (801.56±112.41and 739±76.09 respectively).

Conclusion

From the above study it can be concluded that the cardiac stress is greater at summer seasons than in the winter seasons. Rescheduling of work-rest cycle, working at early or late hours with sufficient illumination and more fluid intake at summer season is recommended.

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