

# Critical Body Temperature Profile as Indicator of Heat Stress Vulnerability

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**Abstract:** Extreme climatic heat is a major health concern among workers in different occupational pursuits. People in the regions of western India confront frequent heat emergencies, with great risk of mortality and morbidity. Taking account of informal occupational groups (foundry and sheet metal, FSM, N=587; ceramic and pottery, CP, N=426; stone quarry, SQ, N=934) in different seasons, the study examined the body temperature profiling as indicator of vulnerability to environmental warmth. About 3/4th of 1947 workers had habitual exposure at 30.1–35.5 °C WBGT and ~10% of them were exposed to 38.2–41.6 °C WBGT. The responses of FSM, CP and SQ workers indicated prevailing high heat load during summer and post-monsoon months. Local skin temperatures ( $T_{sk}$ ) varied significantly in different seasons, with consistently high level in summer, followed by post-monsoon and winter months. The mean difference of  $T_{cr}$  and  $T_{sk}$  was ~5.2 °C up to 26.7 °C WBGT, and ~2.5 °C beyond 30 °C WBGT. Nearly 90% of the workers had  $T_{cr}$  within 38 °C, suggesting their self-adjustment strategy in pacing work and regulating  $T_{cr}$ . In extreme heat, the limit of peripheral adjustability (35–36 °C  $T_{sk}$ ) and the narrowing down of the difference between  $T_{cr}$  and  $T_{sk}$  might indicate the limit of one's ability to withstand heat exposure.

**Key words:** Foundry and sheet metal, Ceramic and pottery, Stone quarry workers, Environmental warmth, WBGT, Body temperature profile.

## Introduction

The occurrences of alarming frequency of heat waves in many regions of the Indian subcontinent are evident<sup>1</sup>. Teeming India in indoor and outdoor occupations, such as rickshaw drivers, street vendors, traffic police, construction workers, foundry, kiln, quarry workers, including urban and rural poor dwellers in slums and pavement face daunting challenge of extreme heat stress vulnerability<sup>2</sup>. Research on the community calamity as regards health impacts to extreme heat is conspicuously lacking in India. Taking account of the occurrence of heat waves for the period 1978 to 1999, De and Sinha Ray<sup>3</sup> reported heat wave

related deaths of ~1625 in the western state of Rajasthan, followed by Bihar, Uttar Pradesh and Orissa. It has been estimated that in 1998 in the eastern state of Orissa, heat wave caused 2042 deaths, when ambient temperature rose between 45 °C and 50 °C, nearly 10 °C above the normal level. From 1999–2003, a total of 3,442 heat-related deaths have been reported<sup>4</sup>.

Chaudhury *et al.*<sup>5</sup> reviewed heat wave mortality. Apart from death, hospital admission increased with people suffering from sunstroke and severe dehydration, vomiting and high fever. In 2002, the southern state of Andhra Pradesh had a toll of ~1400 lives, when ambient temperature rose to 54 °C. Prolonged heat wave over northern India in April to May took a toll of ~1000 fatalities. During 2003 pre-monsoon months (May), heat wave brought peak ambient temperatures between 45 °C and 49 °C, taking ~1500 death toll<sup>6</sup>. Varghese *et al.*<sup>7</sup> investigated predictors

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of dysfunction syndromes among heat stroke patients in southern India, and concluded that aggressive measures with supportive therapy could reduce mortality. Hajat *et al.*<sup>8)</sup> used Poisson models to compare time-series of mortality data in relation to daily ambient temperature in Delhi, Sao Paulo, and London. Patil and Deepa<sup>9)</sup> viewed the frequent weather events, and heat waves in eastern India as potential evidence of climate change. Rao *et al.*<sup>10)</sup> reported the role of Southern Tropical Indian Ocean warming on unusual central Indian drought of summer monsoon in 2008. Kovats and Akhtar<sup>11)</sup> overviewed recent extreme heat events, and discussed health impacts with reference to precipitation, rising sea-levels, retracting glaciers, vector borne diseases, and rising food insecurity, with reference to Asian cities. Akhtar<sup>12)</sup> highlighted the impact of climatic variability (rainfall, heat waves, etc.) in relation to mortality. In 2009, the state of Rajasthan and the northern state of Uttarakhand, and at least a dozen other states were hit by heat waves. Relative burden of mortality and morbidity are specific to population subgroups due to their impaired physiological and behavioral responses to extreme heat, with reference to ageing, chronic illnesses and their limited access to mitigation measures. Nag and Nag<sup>2)</sup> focused on heat vulnerability assessment, referring to occupational exposures in Western India. The study covered area environmental surveillance, and based on the environmental, physiological and biophysical data, estimated heat exchanges and determined heat susceptibility limits of workers in different informal occupations.

Epidemiological and experimental researches<sup>13–15)</sup> elucidate the challenges of thermoregulation of people in extreme hot environment<sup>16)</sup>. Essentially, the scheme of thermoregulation to prevent body core temperature ( $T_{cr}$ ) from rising into a hyperthermic range is approximated by dual inputs, as one side of the gradient for heat transfer from the body core to shell<sup>17)</sup>, as well as the independent cutaneous reflex drive for adjustment of skin blood flow<sup>18)</sup>. In the context of the direct relationship of extreme hot environment to increased mortality and morbidity, this study analyses the heat stress vulnerability with respect to body temperature profiling due to environmental warmth, in order to educating people of the approaches to mitigate heat injury.

## Materials and Methods

The study was conducted in the western states of Gujarat and Rajasthan (2010–2011). The total population of these two states is approximately 107 million. The

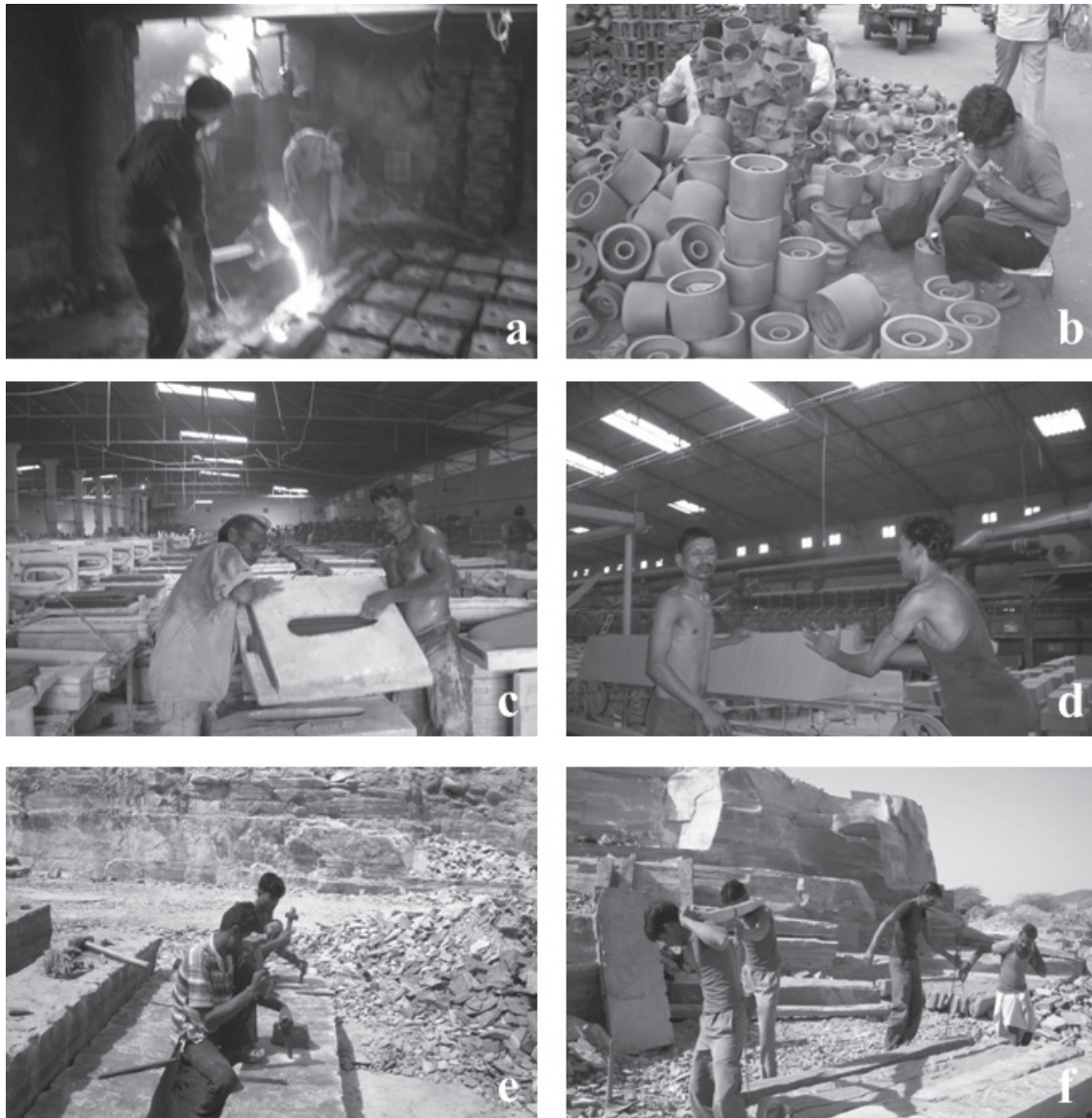
background of the study was to include active workers (N=1947) who were engaged in indoor and outdoor occupations, such as foundry and sheet metal, FSM (N=587), ceramics and pottery, CP (N=426) and stone quarry works, SQ (N=934) (Fig. 1). The participants signed the written consent, as per the Indian Council of Medical Research<sup>19)</sup> ethical guidelines. The FSM works involve handling of molten metals, cutting of iron sheets, welding, etc. The CP works include manufacturing of ceramic floor tiles, sanitary and crockery ware. The SQ works involve the excavation (digging, blasting or cutting) of rocks from open-pit mine.

The climates of the regions are predominately arid, with hot weather throughout summer and monsoon months. These states are prone to heat waves at regular frequency. For example, when the investigators were preparing the present contribution, in the month of May–June 2012, several areas of Gujarat and also Rajasthan (Bikaner, Kota, Churu, Jodhpur and Jaipur) experienced dangerously high heat, as mercury crossed beyond 45 °C. The GIS locations where the study was conducted in three broad seasons like winter (December to February), summer (April to June) and post-monsoon (July to September) are displayed in Fig. 2. The workers in the stated occupations are exposed to sources of high heat, dust and noise, in additions to their engagement in strenuous physical activity.

The thermometric parameters, such as ambient dry bulb, wet bulb and globe temperatures and WBGT index were measured by QUESTemp, Thermal Environment Monitor (USA), RH/Temp data logger (Lascar electronics, UK) for several hours during the working days and continued for a number of days at each workplace. Also, the globe temperatures using 6 inch globe thermometer and wind velocity using anemometer were recorded at frequent interval. Comparison of measurements by the Lascar and QUESTemp devices yielded that the average dry bulb temperature obtained from the Lascar data logger was ~0.2 °C higher than those of the WBGT monitor. From the observations of ambient temperature ( $T_a$ ) and globe temperature ( $T_g$ ) measurements, the following linear regression equation was derived:

$$T_g \text{ (}^\circ\text{C)} = 1.27 T_a - 5.25 \text{ (using QUESTemp); (}r=0.912, p<0.001, \text{df: 2993)}$$

The prediction equation was obtained from  $T_a$  and  $T_g$  observations in the range from 27–40°C, and 28–45°C respectively. Accordingly, the Lascar data logger measurements were used to estimate globe temperature, from which the time trend of the WBGT for the entire working



**Fig. 1. Indoor and outdoor occupations (a) Iron casting (b) edge-cutting-trimming of iron (c) ceramic sanitary works, (d) ceramic tiles work (e) breaking stone slab (f) manually lifting stone slab.**

day was obtained. The climatic parameters in case of CP and SQ were obtained from 10 AM to 6 PM, whereas in case of FSM, measurements were done from 12 AM to 6 PM, since these units operate from the mid-day. The clothing worn by the workers were at basic level, such as wearing light clothing – shorts, trouser, or dhuti (a loose fabric wrapped around at ankle length), and half-sleeve banian or t-shirt.

The infrared thermography (ThermoCAM, FLIR system, Sweden) was undertaken for body temperature profiling of the local skin areas of the entire sample population. The measurements were repeated thrice, i.e., pre-exposure and at an interval of about 2 to 3 h during work.

Temperatures of twenty six locations of the body were digitized, and grouped as skin areas ( $T_{sk}$ ) of head, trunk, back, upper arm, hand, thigh and foot. In total, over 9860 thermographic images were digitized for 1947 workers. The weighted  $T_{sk}$  was obtained from the segmental surface area and sensitivity weighting of local skin areas<sup>20</sup>, using the formula as below:

$$\text{Weighted } T_{sk} = 0.095 \text{ Head } T_{sk} + 0.255 \text{ Trunk } T_{sk} + 0.245 \text{ Back } T_{sk} + 0.125 \text{ Upper arm } T_{sk} + 0.035 \text{ Hand } T_{sk} + 0.205 \text{ Thigh } T_{sk} + 0.04 \text{ Foot } T_{sk}.$$

Different methodological options are available for measuring  $T_{cr}$ , under controlled laboratory conditions. Due to

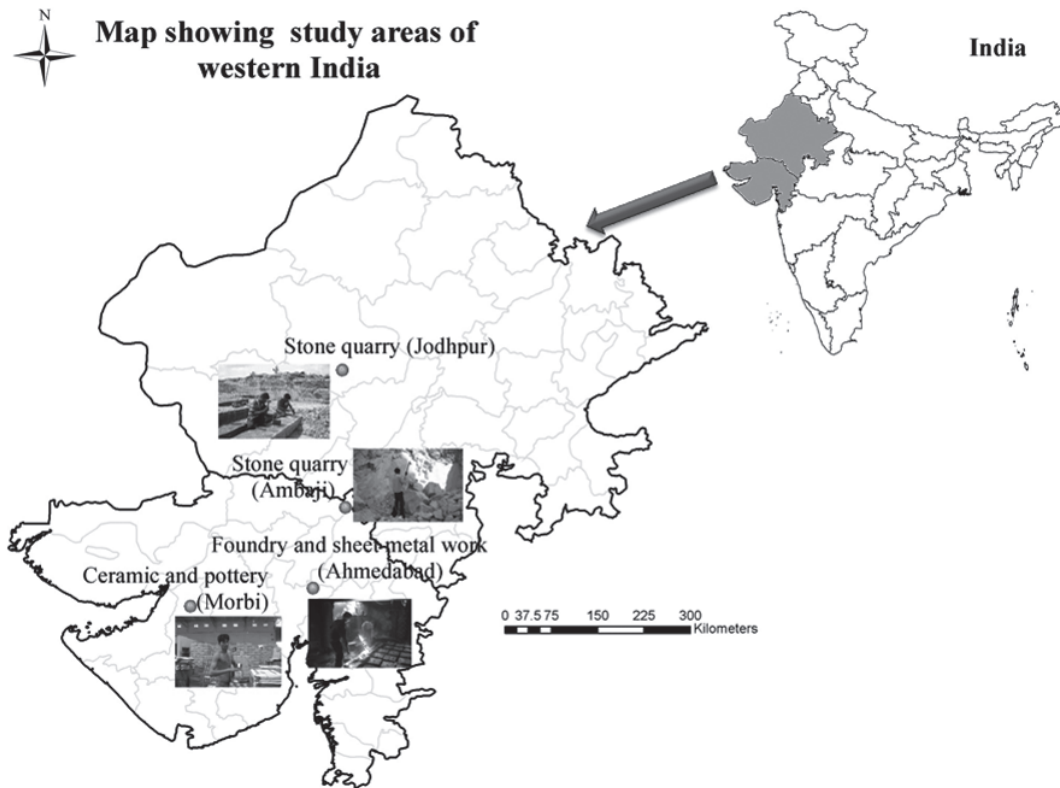


Fig. 2. Map showing study area of western India.

Table 1. Physical characteristics of the workers\*

	Foundry and sheet metal work, FSM (N=587)	Ceramic and pottery work, CP (N=426)	Stone Quarry work, SQ (N=934)
Age (years)	31.9 ± 11.0	25.5 ± 7.4	30.2 ± 9.7
Body weight (kg)	55.7 ± 11.1	51.3 ± 7.5	53.8 ± 9.0
Body height (cm)	161.9 ± 8.6	162.5 ± 8.5	164.3 ± 8.0
Body surface area (sqm)	1.6 ± 0.2	1.5 ± 0.1	1.6 ± 0.1
BMI	21.1 ± 3.9	19.5 ± 2.9	19.9 ± 3.0

\*Values are means ± SD.

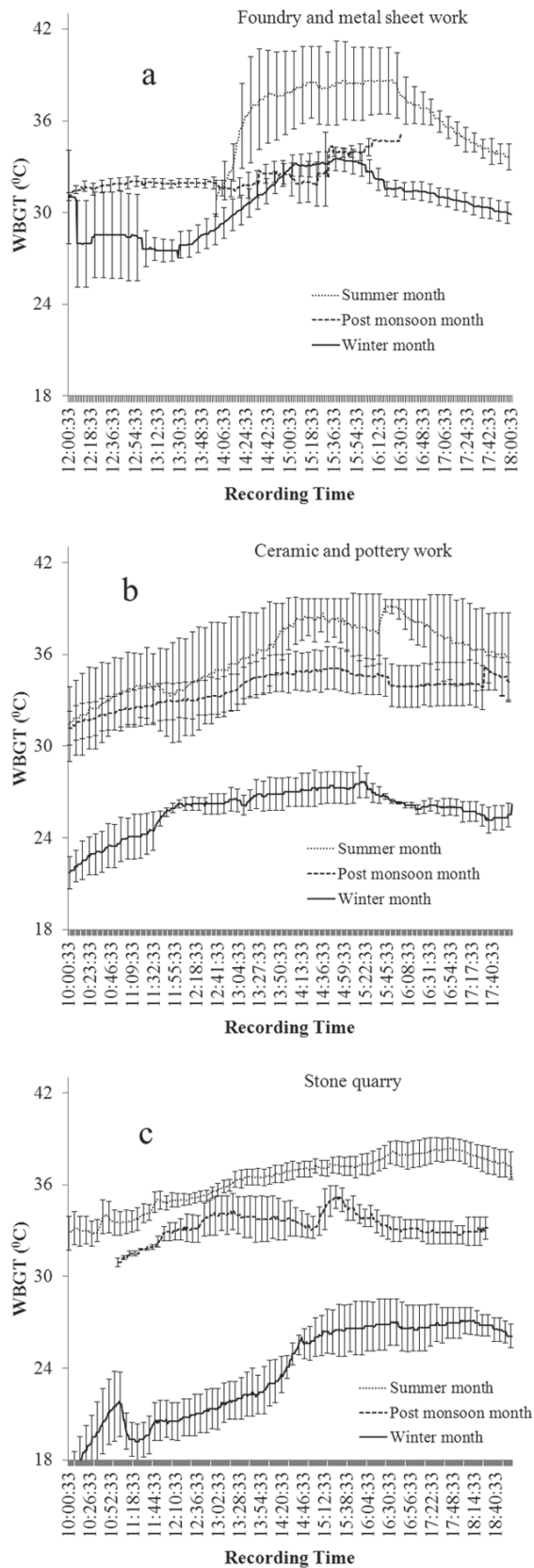
convenience of measurement of large number of workers in field situations, the oral temperature was taken as the  $T_{cr}$ . Martha *et al.*<sup>21)</sup> reviewed the normal range of oral, rectal, tympanic and axillary temperatures of men and women and found large deviation in oral temperatures, as compared to rectal and tympanic membrane. O'Grady *et al.*<sup>22)</sup> noted that the temperature of tympanic membrane reflects the temperature of the hypothalamus and thus the core body temperature. The data analysis, using SPSS 16.0, included systematic screening and treatment of data for descriptive statistics and one-way ANOVA to compare environmental warmth and body temperature responses.

## Results

The workers of different occupational groups had similar anthropometric dimensions, as given in Table 1. The CP workers were relatively younger, and others were in the range of 30+ years of age. The average body weight of the workers ranged from 51.3±7.5 kg (CP) to 55.7±11.1 kg (FSM) and body height 161.9±8.6 cm (FSM) to 164.3±8.0 cm (SQ).

The time trends of WBGT values vary distinctively by occupational activity and seasons. As mentioned that the operations of FSM starts from midday, the buildup of the WBGT was significant by 2:30 PM and tended to decline





**Fig. 3.** Time trend of WBGT during the working day in indoor and outdoor occupations; (a) Foundry and sheet metal (FSM), (b) Ceramic pottery (CP) and (c) stone quarry (SQ) works.

from 4:30 PM, highest temperature being recorded during the summer month as  $38.6 \pm 2.2$  °C WBGT at around 4 PM (Fig. 3a). The work processes of CP make the working environment very hot. In case of CP work, the WBGT increase was gradual in all three defined seasons (Fig. 3b), highest WBGT being recorded as  $38.6 \pm 1.0$  °C at 4 PM in summer month. The SQ workers are exposed to direct sun, all day long. The WBGT in summer and winter months had upward trend from morning to afternoon, whereas in post-monsoon the WBGT maintained consistently at a level, as shown in Fig. 3c. In summer months, the mean levels of WBGT maintained at a narrow level between  $36.6 \pm 0.5$  °C at 2 PM to  $37.4 \pm 0.7$  °C at 4 PM respectively.

High ambient load prevailed in all occupational groups during summer. As given in Table 2, in general, the mean WBGT levels in post monsoon days at 2 and 4 PM were about 3 to 4 °C lower as compared to those observed during the summer days. The WBGT levels during the working day in winter months were about 7 to 8 °C lower as compared to levels recorded during post monsoon months. One-way ANOVA yielded significant seasonal difference in environmental warmth ( $p < 0.001$ ) in different occupational groups. However, post hoc multiple comparisons using Tukey's test showed no significant difference in environmental warmth during summer and post-monsoon within each occupational group, however, the warmth in SQ works during summer was significantly higher ( $p < 0.001$ ), as compared to other occupational groups.

About 94% of workers of FSM, 70% of CP and 67% of SQ were exposed at environmental warmth in the mean range from 30.1 to 35.5 °C WBGT respectively. About 14% of the CP and SQ workers were exposed to 38.2 to 41.6 °C WBGT. Nearly 20% of SQ workers were exposed in the range of 20.9 to 26.5 °C WBGT. Also in winter, the environmental warmth of FSM workers was high ( $32.6 \pm 2.3$  °C WBGT at 4 PM) due to the work processes generating localized heat.

The magnitudes of weighted  $T_{sk}$  changes varied largely in different working seasons, with consistently higher level in summer, followed by post-monsoon and winter months (Table 3), however, in each of the seasons there was a narrow difference in weighted  $T_{sk}$  in different occupational groups. Accordingly, the  $T_{sk}$  of the local areas as well as weighted  $T_{sk}$  were pooled together and arranged according to the range of WBGT values (Fig. 4), showing that the local  $T_{sk}$  response showed characteristic trend with the increasing WBGT. The large spread ( $27.7$  to  $32.2$  °C) of local  $T_{sk}$  at WBGT of  $20.9 \pm 0.6$  °C gradually converged to  $\sim 35$  °C  $T_{sk}$ , at corresponding WBGT of  $30.1 \pm 1.2$  °C,

**Table 2. WBGT levels in different working seasons\***

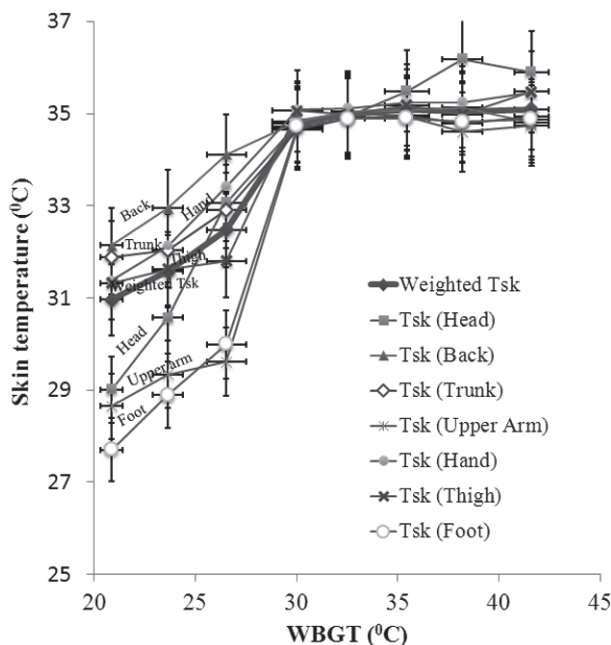
		Summer (April - June)	Post-monsoon (July-September)	Winter (December -February)
Foundry and sheet metal work, FSM				
DB temp (°C)	2.30 PM	39.6 ± 6.7	32.3 ± 1.7	32.4 ± 3.9
	4:00 PM	41.7 ± 4.6	35.1 ± 1.8	34.6 ± 1.0
WBGT (°C)	2.30 PM	37.3 ± 4.7	32.3 ± 2.0	31.1 ± 2.8
	4:00 PM	38.6 ± 3.1	34.4 ± 2.5	32.6 ± 2.3
Ceramic and pottery work, CP				
DB temp (°C)	2:00 PM	41.4 ± 1.8	35.9 ± 4.3	27.7 ± 2.1
	4:00 PM	42.5 ± 0.7	35.1 ± 4.2	26.7 ± 0.6
WBGT (°C)	2:00 PM	38.1 ± 2.2	34.8 ± 3.1	27.0 ± 1.6
	4:00 PM	38.6 ± 1.6	33.9 ± 3.0	26.2 ± 0.3
Stone quarry work, SQ				
DB temp (°C)	2:00 PM	39.0 ± 2.3	34.4 ± 3.4	22.7 ± 0.1
	4:00 PM	40.7 ± 3.2	34.6 ± 1.3	27.3 ± 3.3
WBGT (°C)	2:00 PM	36.6 ± 1.4	33.8 ± 2.6	22.9 ± 2.6
	4:00 PM	37.4 ± 2.0	33.9 ± 1.2	26.7 ± 2.8

\*Values are means ± SD.

**Table 3. Weighted skin temperatures of workers in different seasons\***

	Summer (April- June)	Post-monsoon (July-September)	Winter (December-February)	F values
Foundry and sheet metal work, FSM (N=587) (°C)	35.8 ± 0.8 (287)	34.8 ± 0.7 (104)	34.0 ± 1.0 (196)	223.1 (p<0.001)
Ceramic and pottery work, CP (N=426) (°C)	35.6 ± 1.0 (193)	35.1 ± 1.0 (166)	31.8 ± 1.3 (67)	339.8 (p<0.001)
Stone quarry work, SQ (N=934) (°C)	35.3 ± 1.3 (521)	35.0 ± 1.0 (214)	31.1 ± 4.1 (199)	264.4 (p<0.001)

\*Values are means ± SD (N), N= number of workers.



**Fig. 4. Spread of local T<sub>sk</sub> in relation to environmental warmth.**

with a relative difference of ~5 °C between local T<sub>sk</sub> and WBGT. At higher environmental warmth, the convergence of T<sub>sk</sub> prevailed, excepting that the head T<sub>sk</sub> increased to ~36 °C. Relative comparison indicated that the upper arm and foot were on the lower side of the weighted T<sub>sk</sub>. Others stayed above the weighted T<sub>sk</sub>, till convergence, and the back T<sub>sk</sub> stayed above all.

The difference of T<sub>cr</sub> and weighted T<sub>sk</sub> in relation to WBGT (Fig. 5) ranged from 2.1 to 5.8 °C, the differences being narrow at higher environmental warmth. Further, the delta changes of T<sub>cr</sub> and T<sub>sk</sub> with respect to the buildup of T<sub>cr</sub> are presented in Fig. 6. The mean difference ranged between 2.1 to 2.5 °C, up to the level of 38 °C T<sub>cr</sub> and about 3 °C, between 38.1 to 39 °C T<sub>cr</sub>. The difference was 4.1 °C beyond 39 °C T<sub>cr</sub>, in which head and back T<sub>sk</sub> to T<sub>cr</sub> were exceedingly higher, as 4.3 °C and 4.8 °C respectively. Essentially, the delta T<sub>cr</sub>-T<sub>sk</sub> for the weighted T<sub>sk</sub> line had upward trend and the values were marked influenced by the T<sub>sk</sub> of head and back, as observed beyond 39 °C. It was noted that nearly 90% of the workers recorded T<sub>cr</sub> below the level of 38 °C during work, and about 4% of the workers had T<sub>cr</sub> beyond 39 °C.

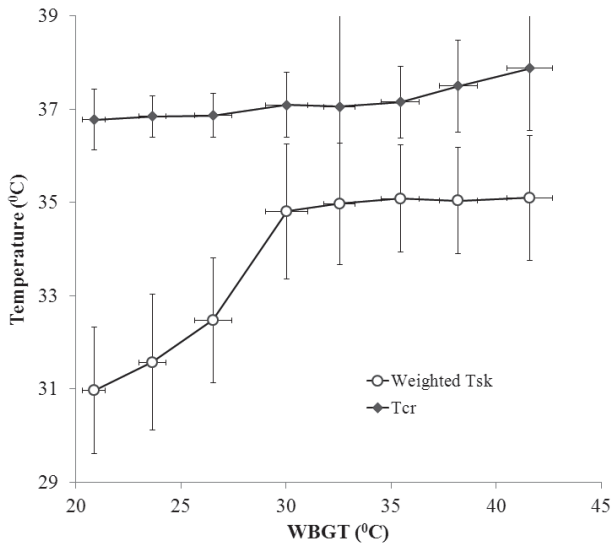


Fig. 5. The weighted mean  $T_{sk}$  and  $T_{cr}$  in relation to environmental warmth.

## Discussion

The climate change impact on occupational health is sparsely explored in the vast Indian subcontinent<sup>2, 23</sup>. There is a perceived realization that the climatic variability with respect to extreme heat potentially causes direct and indirect health effects, and loss of productivity of people in different occupational settings<sup>24, 25</sup>. The annual mean temperature across the country has been generally above normal, since 1990, with anomalies ranging from 0.1 °C in 1990 to nearly 0.9 °C by 2009<sup>26</sup>. While the trend of warming and extreme conditions varies in different geographical regions, the impacts may be more pronounced in low-income sectors and among workers in strenuous physical activity<sup>27</sup>. The people of the states of western India regularly confronts with extreme heat emergencies in different compelling vocations<sup>28</sup>. Analysis of heat stress vulnerability is useful to ascertain the exposure of the targeted population to the changing climate, their resilience and adaptive ability to combat heat stress<sup>2</sup>. It bears significance to preserve physiological functions critical for life, and enable people to continue a level of work safely. Since the profiling of body temperature manifests thermogenesis as well as heat dissipation from the body as an essential physiological control, the present study examined the body temperature changes as indicator of vulnerability of workers with respect to levels of environmental warmth. The study focus was placed on selected informal indoor (FSM and CP) and outdoor (SQ) occupational groups.

The physical severity of work of the occupations could

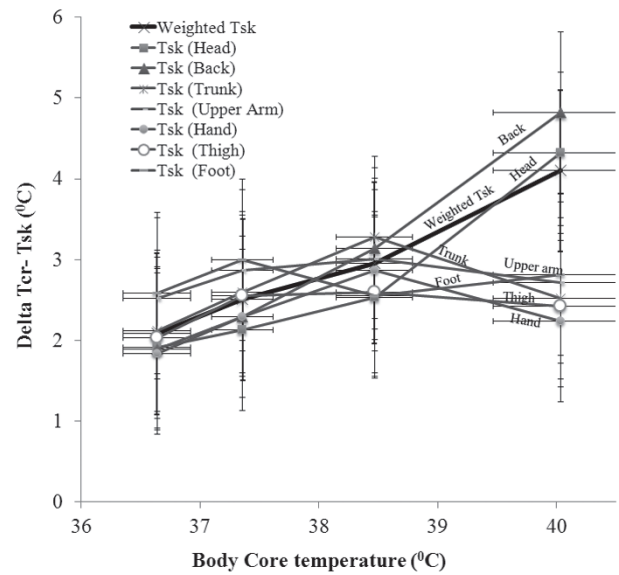


Fig. 6. The gradient of  $T_{cr}$  to local  $T_{sk}$  in relation to  $T_{cr}$ .

not be equated, nor could the same work group be studied in different seasons. It was noted that 76% of the total 1947 workers had habitual mean exposure at 30.1 to 35.5 °C WBGT. The majority of the workers (e.g., 95% of FSM, 84% of CP and 81% of SQ) had high ambient heat load between 30.1 to 41.6 °C WBGT. The SQ workers had higher stress, as compared to other occupations. The CP workers had higher heat stress, as compared to FSM and the stress levels of the indoor workers were similar during the summer and post-monsoon months. With reference to the level of 28 °C WBGT as the suggested permissible exposures for acclimatized men in tropical heat<sup>29, 30</sup>, it was noted that high ambient heat load prevailed in all occupational groups during summer and post-monsoon.

It is understood that thermoregulation is achieved by the pre-optic nucleus of the anterior hypothalamus, which receives and integrates afferent information from the thermo-receptive sites<sup>31, 32</sup> and relays efferent impulses to the thermoregulatory effectors<sup>33, 34</sup> to stimulate cutaneous vasodilatation and sweating<sup>35</sup>. In the present analysis, it was evident that towards body's thermoregulatory efforts, the local  $T_{sk}$  responses showed increasing trend with the increasing thermal stress. The environmental warmth dominantly influenced the local  $T_{sk}$ . The large spread of local  $T_{sk}$  at lower environmental warmth (~21 °C WBGT) gradually converged upwards at ~35 °C (~30 °C WBGT). At higher environmental warmth (highest range being 41.6±0.8 °C WBGT), the local  $T_{sk}$  prevailed at ~35 °C, however, the head  $T_{sk}$  tended to increase by a degree to ~36 °C, indicating the limit of peripheral adjustability.



Fig. 7. Make-shift shelter of stone quarry workers.

In the present study, the overall difference of  $T_{cr}$  and  $T_{sk}$  narrowed down from 5.8 to 2.1 °C at higher WBGT. This narrowing might indicate reduction in heat dissipation and consequent cardiovascular drift, limiting one's ability to withstand exposure in extremely hot situations. Stephan *et al.*<sup>36)</sup> observed significant correlation between  $T_{cr}$  and ambient temperature among 2003 France heat wave affected critically ill patients and, the regression line was steeper among the infected patients than in non-infected patients. The investigators noted that during the heat wave, the mean  $T_{cr}$  of infected patients was always above 38.5 °C and was above 39 °C for 5 consecutive days, despite intervention of external cooling and prescription of paracetamol.

Based on analysis of the responses of FSM, CP and SQ workers, the study affirmed that high ambient heat load prevailed in all occupational groups during summer and post-monsoon months. The physiological mechanism of heat susceptibility was critically related to the gradient of local  $T_{sk}$  and  $T_{cr}$  over a range of environmental warmth, exceeding beyond 28 °C WBGT. The overall mean difference of  $T_{cr}$  and  $T_{sk}$  was about 5.2 °C at environmental warmth up to 26.7 °C WBGT, whereas the mean difference was about 2.5 °C beyond 30 °C WBGT. The  $T_{sk}$  of local areas and  $T_{cr}$  maintained dynamic equilibrium for heat transfer to the periphery as well as cutaneous reflex to control skin blood flow. The resultant is the combined effect of work and heat stress<sup>37)</sup>, with the dominant effect reflected in the responses. The risk of hyperthermia ensues when excessive environmental warmth overwhelms the thermoregulatory mechanism and/or, there is impairment in heat dissipation<sup>38)</sup>. Data indicated that only 4% of the

present habitual workers manifested  $T_{cr}$  exceeding 39 °C. The vast majority (90%) had  $T_{cr}$  within 38 °C, suggesting that the workers might have adopted self-adjustment strategy in the pace of work and regulating  $T_{cr}$ . Within the scope of the present study, the  $T_{cr}$  and  $T_{sk}$  recordings of the volunteers were taken at an interval of ~2 h. In order to explore individual susceptibility to high heat, the follow up study of  $T_{cr}$  and  $T_{sk}$  measurements at shorter interval would probably elucidate individual differences whose  $T_{cr}$  stayed relatively low and for those  $T_{cr}$  went beyond 39 °C. However, the limit of peripheral adjustability appeared to be at about 35 to 36 °C  $T_{sk}$ . The significant narrowing down of the difference between  $T_{cr}$  and  $T_{sk}$ , as shown in Fig. 5, might indicate the limit of one's ability to withstand heat exposure.

Studies have indicated that by self-regulating the pace of work the workers could maintain a useful level of workload even under thermally stressful conditions<sup>39, 40)</sup>. To what extent this work behavior is spontaneous and to what extent it can be learned and communicated require understanding, with respect to the physiological control mechanism. The work processes of the presently selected FSM and CP (indoor) and SQ (outdoor) are not paced by itself. The workers had options of self-pacing their rate of work, as a protective thermoregulatory behavior, and sustaining a level of work in severe hot conditions in summer and post-monsoon months. Besides, the SQ workers took tea/lunch breaks under the stone covered shelters (Fig. 7), in order to avoid high heat load. The FSM and CP workers tended to cool themselves by sprinkling cool water and wiping body parts, and taking rest breaks while remained in the work area. The workers engaged in line operations in CP had to maintain work rate, corresponding to the speed of the conveyer.

Increasing incidences of extreme heat in many parts of Western India are evident and vast numbers of people are exposed to extreme heat in diverse informal occupational settings. The present data are evident that the habitual workers had individual strategies in minimizing the potential risk of heat injury. The study provided an understanding of the peripheral thermoregulatory adjustability that limits the ability of a worker to withstand heat exposure in indoor and outdoor work environment. In order to bring in proactive response in the event of extreme heat, therefore, the limit of peripheral thermoregulatory adjustability may be considered beneficial to devise actionable public health interventions, in order that the vulnerable groups can be taken away from the fury of high heat.



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