Physiological and perceptual heat strain responses in Iranian Veiled women under laboratory thermal Conditions

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ABSTRACT

Heat stress risk assessment, as a harmful agent at workplace, is essential for controlling heat strain. The purpose of this study was relation between physiological and perceptual heat strain responses in Iranian veiled women under laboratory thermal conditions.

This experimental study was carried out on 36 healthy females (age 22.3 ± 2.0 yr., height 162.76±5. 57cm, weight 55.82 ± 9.27kg) in sitting state under thermal conditions (27 - 38° C) in the hot-dry climatic condition for 120 min. In order to calculate the physiological strain index (PSI), oral temperature and heart rate were measured every 5 min. Physiological factors, and Heat Strain Score Index (HSSI) questionnaires are simultaneous measurements taken at any 5 min during the exposure and physiological factors, and Heat Strain Score Index (HSSI) questionnaires are the initial measurements.

The data were analyzed using correlation and line regression by test spss16.

The results showed that the average heart rate and oral temperature at resting and sitting were between 83.06 ±9.41bpm, 87.91 ±7.87 bpm and 36.7° C, 37. 1°C respectively. Also, the results have revealed a direct and significant and direct correlation among HSSI with WBGT (R^2 = 0.97, P≤ 0.001), PSI (R^2 = 0.96, P≤ 0.001), oral temperature (R^2 = 0.96, P≤ 0.001) and heart rate (R^2 = 0.62, P≤ 0.01) indices.

The results have shown that simultaneously with the increase in valid indices of heat stress evaluation such as WBGT and PSI indices, the amount of HSSI index has also increased with high power. Therefore, it can be conclude that when there is no access to a reliable heat stress method such as WBGT or PSI indices, HSSI index, an objective and subjective heat strain method, can be used as a simple, fast and inexpensive method for evaluating the heat strain in women.

Keywords: Heat Stress, Heat Strain Score Index, Physiological Strain Index, Wet Bulb Globe Temperature, Veiled Women.

INTRODUCTION

Heat stress indices are effective techniques that predicted severity heat stress in workers population [1].In some workplaces, employees are exposed to heat, which may deteriorate work efficiency, safety and productivity. Additionally, the risk of heat-induced illnesses such as heat cramps, heat stroke increases with additional heat stress [2, 3]. Heat stress evaluation is needed in order to heat stress measures control. These heat stress indices should be noticed based on parameters such as capability of applying a wide range of metabolic rate and environmental conditions, taking into account important factors related to heat stress (ambient temperature, clothing, etc.), measuring the amount of heat exposure without interfering the activity workers. Heat exposure limits should be reflected by physiologic and psychological responses reflecting increased hazard and safety in employees [3].

Due to the importance of healthy human workforce in productivity and the importance of heat as a harmful factor, it is necessary that heat exposure to be evaluated for having an effective heat stress control. Therefore heat strain indices have been developed. These indices are able to predicate effective techniques in estimating heat strain level in the workers population.

Each of the heat stress indices has limitations for example wet bulb globe temperature index, (WBGT), that its used to evaluate the heat stress in worldwide [4], prolonged the time of globe temperature measuring [5] or physiological strain index (PSI) was developed to evaluate physiological strain which considers the load into the cardiovascular system and regulation of body

temperature [6] On the limitation of PSI index, it was illustrated that middle-aged relatively responded better than younger's. Whereas another researcher reported the heat stress tolerance in middle-aged population was smaller comparing to the younger. The PSI index may not be possible in the field because its evaluation requires the core body temperature measurement, which is not practically possible [7].

In a study conducted by Dehghan *et al*., on reliability and validation of the heat strain score index (HSSI) in women population in the climatic conditions of Iran, results showed that the HSSI scale is a reliable method for screening heat stress on Iranian women workers [8]. The HSSI scale includes 17 items, observation and subjective questions, relating to heat stress such as thermal and humidity sensation [9], Intensity of sweating [10], Intensity of fatigue [11], Intensity of thirst and other probable effective factors onset heat strain [10].

The question arose whether in women exposed to warm conditions range; HSSI is able to show the heat strain? It is well established that women generally have a higher percentage of body fat than men, which acts as insulation and increases the thermal store; they have a good system of temperature regulating and lower aerobic capacity resulting in increase in the relative workload of a provided task [8].

How variations of HSSI in comparison with valid heat stress indices stress changes? So this study is mainly concerned with the relationship between physiological and perceptual heat strain responses in Iranian veiled women under laboratory thermal conditions.

MATERIALS AND METHODS

Thirty six healthy young female students volunteered to participate in the study.

The physical characteristics of the subjects were as follows (Mean± Standard Deviation): age 22.3 ± 2.0 yr.; height 162.76±5. 57 cm; Weight 55.82 ± 9.27 kg.

Subjects were informed as to the nature of the study and potential risks of exposure to exercise in a hot climate chamber. All subjects signed a consent form.

This study was conducted in a climatic chamber (length 4.5 m, width 3.5 m and height 3 m). None of the participants had a history of medical disorders for at least 6 months before the study. Subjects refrained from exercise, coffee, and over-the-counter medication for 24 hours and from caffeine for 12 hours prior to each test period and outside of the ovulation and menstrual cycle.

The subjects wore the same Muslim clothing (uniform, pants, scarf and socks) and performed the exercise in an environmental chamber (temperature 27 ○C- 38 ○C) for 120 min. To avoid interfering factors, the participants clothing was provided by the researchers from the same model and materials. The details related to the materials used in the Iranian female clothing including the weights of individual garments and ensembles, fabric composition and body surface area coverage are presented in table 1.

Furthermore, in order to determine the intrinsic clothing insulation, ICL was used in this study that is referring to, the intrinsic or basic clothing insulation and can be defined as the insulation from the skin surface to the clothing surface.

Table 1: Characteristics of various Iranian female clothing materials used

Ensemble type	**Clothing ensembles**	**Body surface area Covered (%)**	**Weight gr/m^2**	**The density of warp yarns cm^{-1}**	**The density of weft yarns cm^{-1}**	**ICL**		**Fibre/ content**
						Clo	**M^2°CW^{-1}**	
Islamic clothing—summer	pants	45	253.46	34	24	0.80	0.123	13.7% Viscose,86.3%
	uniform	61						
	scarf	12						
	socks	7						

After 15 min of resting on the bed outside the chamber, the subjects began light activity in the chamber. Termination at any time was according to the attending physician's decision.

During the rests and heat exposure, heart rate and oral temperature were continuously monitored and recorded at 5-min intervals. For simultaneous measurement of physiological parameters, a questionnaire, including 17 items, was asked to be filled out in the resting and working states(Light activity) every 5 min for 120 min. Heart beats were monitored and recorded online through bipolar chest leads using polar belt electrodes (Polar Electro RS100, Finland).

Oral temperature was measured by a digital medical thermometer (Digital Thermometer; Omron).

In this study, oral temperature was calculated for core temperature because rectal temperature measurement was not possible. PSI was calculated using the following equation [8].

$$PSI = 5(T_{ret} - T_{re0})\ (39.5 - T_{re0})^{-1} + 5(HR_t - HR_0) \times (180 - HR_0)^{-1}$$

Where Core temperature (Tre0) and heart rate (HR0) are the initial Tre and HR, respectively, and Tret and HRt are simultaneous measurements taken at any time.

The data were analyzed using correlation and line regression by test spss16. All statistical contrasts were accepted at the P≤ 0.05 level of significance.

It should be noted that there was no heat radiation in the climatic chamber. This study was performed after getting permission from the Ethic Committee in Medicine.

RESULTS

This study was carried out on 36 healthy females' students. Table 2 indicates the physiological parameters in subjects.

Table 2: Physiological characteristics of subjects (n=36)

Variable	Mean± SD
heart rate(Resting)	83.06 ±9.41bpm
heart rate(Light activity)	87.91 ±7.87 bpm
oral temperature(Resting)	36.10 ±0.35° C
oral temperature(Light activity)	36.89 ±0.22° C

Figure 1.Shows a relationship between HSSI index and WBGT index in light activity within 2 hr. The results showed a direct and significant relationship between the HSSI index and WBGT index (P≤0.001).

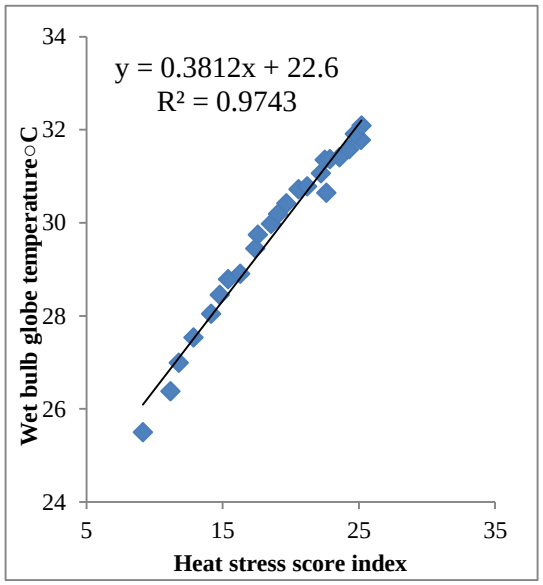

Fig. 1: The scatter plot between HSSI index and WBGT index

Figure 2.Shows a scatter plot between the HSSI index and heart rate in light activity within 2 hrs. The results showed a direct and significant relationship between HSSI index and heart rate (P≤ 0.01).

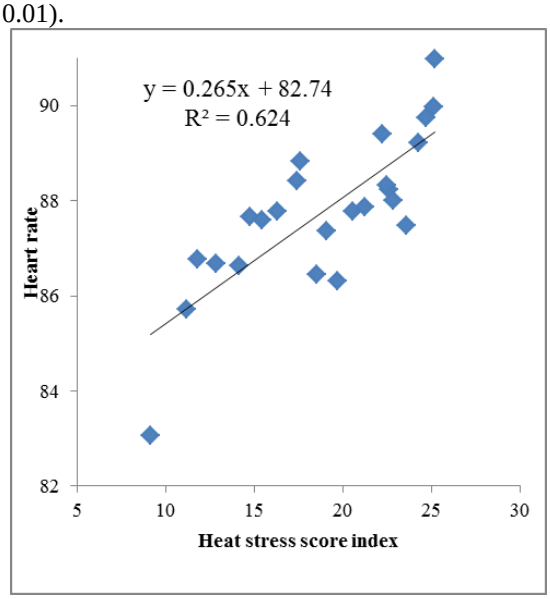

Fig. 2: The scatter plot between HSSI index and heart rate

Figure 3.Shows a scatter plot between the HSSI index and PSI index in light activity within 2 hr. The results showed a direct and significant relationship between the HSSI index and PSI index (P≤ 0.01).

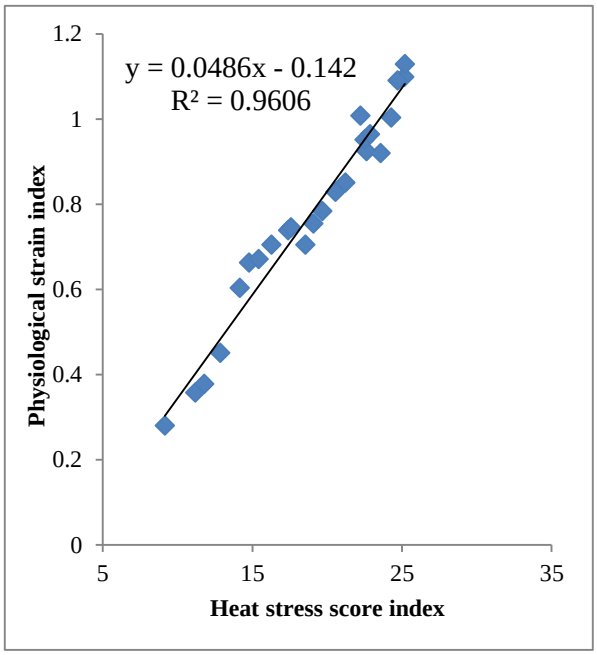

Fig. 3: The scatter plot between HSSI index and PSI index

Figure 4.Shows a scatter plot between the HSSI index and oral temperature in light activity within 2 hr. The results showed a direct and significant relationship between the HSSI index and oral temperature ($P \leq 0.001$).

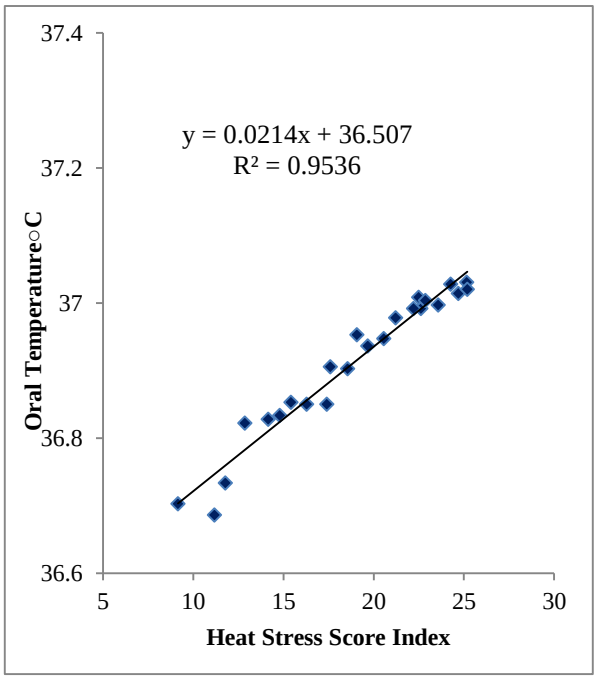

Fig. 4: The scatter plot between HSSI index and oral temperature

DISCUSSION

Occupational exposure to heat and hot environment can be expected to result in heat strain, which can cause mental or physical problems. In addition to physiological problems in human, the heat also effects in different issues inducing productivity and economical operations, so, controlling this physical factor not only prevents the health problems, but also does it increase work efficiency of people [12]. Future climate change will cause the situation even more difficult for millions or even billions of workers [13].Several indices are applied for the heat stress on individuals [12, 14]. Among heat stress indices, physiological strain (PSI) and the wet bulb globe temperature index (WBGT) are noticeable [14]. However, due to inherent and applied limitations of each index, they are not suitable to be used in small and medium workplaces, observational- perceptual techniques are others indices used for evaluating risk factors in recent years. Observational- perceptual methods are used widely, because of their simplicity, inexpensiveness, high speed, and applicability in the workplace without work force interference [9]. So, this study is concerned with physiological and perceptual responses to heat stress in Iranian veiled women under thermal conditions.

In a study conducted by Bourbonnais on identification of workers exposed to heat stress, environmental parameters including air temperature, air humidity, air velocity, surrounding surfaces temperature (heat radiation) and parameters related to clothing and energy consumption (working metabolism) were mentioned [15].In our study, the first four variables were evaluated through a HSSI questionnaire, as well as clothing parameters which considered being identical for all the subjects.

In a study by Takamata *et al*, on the effect of increasing the body core temperature on thirsty response, results showed that the intensity of subjective thirsty and received water was higher in hot conditions compared to neutral temperatures [16]. The feeling of thirst is one of the variables in HSSI index.

In a study conducted by Lee *et al*, results showed wetness of perceived skin is in a significant relation with body core temperature, skin temperature, and heart rate also thermal comfort indices and humidity perception in order to determine the quantity of skin wetness based on the subjective perception [17]. The sweats intensity variable, showed a direct and significant correlation simultaneously with environmental and physiological parameters according to the HSSI questionnaire.

In a study by Hostler *et al*, on the effect of hyper hydration on physiological and perceived strain during treadmill exercise, results showed that inequality levels between perceptual and physiological heat stain indices in the same condition of thermal load lead to this suggestion that possible factors, such as perception of physical efforts in a subjective manner interferes with perceptual indices of heat strain such as heat feeling under hot environmental conditions [18]. In this study, simultaneously with recording

environmental and physiological parameters, subjective indices of heat strain were used too.

All variables of HSSI index which included main heat stress parameters have significant correlation with physiological and environmental parameters. Also results of this study showed that the HSSI index could be in high correlation with PSI index (R^2 = 0.960). Moreover, HSSI index showed a direct and significant relationship with the main environmental variables which is calculated in the WBGT index (R^2 = 0.974).

Conclusions: The results showed that there is a direct and significant relationship between the HSSI index and physiological variables such as heart rate, oral temperature and also PSI and WBGT indices. So simultaneous with the increase in valid heat stress indices such as WBGT and PSI indices, the amount of HSSI index has also increased with high power. Therefore, it is concluded that when there is no access to reliable heat stress method such as WBGT or PSI indices, HSSI index, an objective and subjective heat strain method, can be used as a simple, fast and inexpensive one for evaluating the heat strain in women.

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