Oral Temperature Changes among Overweight and Normal-Weight Subjects during Exercise under Hot Climatic Conditions

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ABSTRACT
The overweight and obesity are considered as a risk factor for the heat strain. This study was planned to assess the oral temperature changes among overweight and normal-weight subjects during light and moderate exercises under exposure to hot and very hot conditions. An experimental study was conducted on 35 subjects with normal-weight and 35 subjects who had overweight. The subjects rested for 30 minutes. Then, each subject performed a light exercise (2.8 kilometers per hour on the treadmill) under exposure to very hot and moderately humid conditions for 60 minutes. In the next phase, subjects performed a moderate exercise (4.8 kmph on the treadmill) under exposure to hot and moderately humid conditions for 60 minutes after 30 minutes of rest. The oral temperature was measured every 4 minutes. The rest oral temperature of overweight subjects with body mass index more than 27kg/m^2 was significantly higher than that of normal-weight subjects in both conditions (P<0.015). While the exercise oral temperature of overweight subjects with body mass index more than 27kg/m^2 compared to that of normal-weight subjects was significantly higher only in the moderate exercise under exposure to hot conditions (P=0.001). The rest and exercise oral temperature of overweight subjects with body mass index more than 27kg/m^2 was higher than that of normal-weight subjects when they performed a moderate exercise under exposure to hot conditions.
Key words: Body temperature, Overweight, Hot temperature, Exercise

INTRODUCTION
Obesity is increasing in most countries [1]. Reports indicate that 35 percent of men and 36 percent of women in the United States, 26 percent of men and women in the United Kingdom, 24 percent of men and 35 percent of women in Mexico, 9 percent of men and 27 percent of women in South Africa are obese [2, 3]. The prevalence of overweight and obesity among Iranian people have increased from 13.6 and 32.2 percent in 1999 to 22.3 and 36.3 percent in 2007 [4]. Overweight and obesity have resulted in a significant increase in the prevalence of diseases such as cardiovascular disease, diabetes, stroke, osteoarthritis, and cancer [5]. Therefore, increased obesity and body mass index (BMI) is one of the main risk factors for health in the world [6].

Heat stress causes diseases such as heat syncope, heat exhaustion, heat cramps, heat shock, confusion, poor concentration, and fatigue [7, 8]. The overweight and obesity are considered as a risk factor for the heat strain. Results of a study on workers in the southern area of Iran demonstrated that the heart rate, as a physiological heat strain index, among subjects with overweight and obesity is higher than that among subjects with normal-weight [9]. The body temperature is also another indicator for the heat strain assessment. Resulted by Jerry *et al.*, there is a good correlation between body temperature and heart rate [10]. Some studies indicate an inverse relationship between obesity and oral temperature [11-13] and some others show a direct relationship [14, 15]. The difference in these results may be due to the different climatic conditions and exercise intensity. Therefore, this study was planned to assess the oral temperature changes among overweight and normal-weight subjects during light and moderate exercises under exposure to hot and very hot conditions.

MATERIALS and METHODS
An experimental study was conducted on 70 male students of the Medical University of Isfahan in 2014, in a climatic chamber located in the School of Public Health. Subjects were divided into two groups including 35 subjects with normal-weight (18< BMI <25kg/m^2) and 35 subjects with overweight (BMI > 25kg/m^2) [16]. Subjects were selected based on the

body mass index and non-probabilistic sampling method.

Inclusion criteria for participating in this study included the absence of cardiovascular disease, respiratory disease, neuromuscular disease, musculoskeletal disease, epilepsy, seizures, and diabetes. All subjects were asked to avoid consuming drugs and medicines affecting the heart rate and blood pressure and from drinking coffee, caffeine, and alcohol for at least 12 hours before the exercise. Exclusion criteria were: an increased heart rate over 180 beats per minute (bpm), an oral temperature over 38.5°C and extreme fatigue. All subjects were screened by a physician based on the criteria. Steps of the study were also explained to subjects and they signed the consent form developed by the medical ethics committee of the medical university of Isfahan. The tools used in this study included an oral thermometer (Amron model with an accuracy of 0.1$^{\circ C}$), digital scale (Hamilton model with an accuracy of 0.1kg), tape meter, and treadmill (Ketler model).

Prior to beginning the test, the age and physical activity (the time of the sporty activity during the week) of subjects were recorded and their height and weight measured. All subjects were then asked to wear similar types of clothes (30% polyester, 70% cotton). Fig. 1 illustrates the steps of the test. In the first phase of the test, each subject was asked to rest on a bed for 30 minutes and his oral temperature was measured every five minutes. Each subject then performed a light exercise (speed of 2.8 kilometers per hour (kph) on the treadmill) under exposure to very hot and moderately humid conditions (WBGT = 30° C, Ta = 37 ° C and RH = 50%) for 60 minutes. In the next phase, each subject rested on a bed for 30 minutes and his oral temperature was recorded every five minutes. Each subject then performed a moderate exercise (speed of 4.8 kph on the treadmill) under exposure to hot and moderately humid conditions (WBGT = 27.5$^{\circ C}$, Ta=32° C and RH=50%) for 60 minutes. While subjects were exercising, their oral temperature was measured every four minutes. The exercise level on the treadmill was determined based on metabolism [17]. For measuring the oral temperature under the reliable conditions, the digital thermometer was correctly placed under the tongue, subjects did not drink hot and cold beverages for at least 15 minutes before the test and the thermometer also was kept in an ice container [18].

Body mass index (BMI) was also calculated based on the following equation:

$$\textbf{BMI = weight (kg) / (Height (m))}^{2}$$

Data were analyzed using descriptive statistics, One-way ANOVA and Mann Whitney U test in the statistical package for the social sciences (SPSS) version 16. The significance level was 0.05.

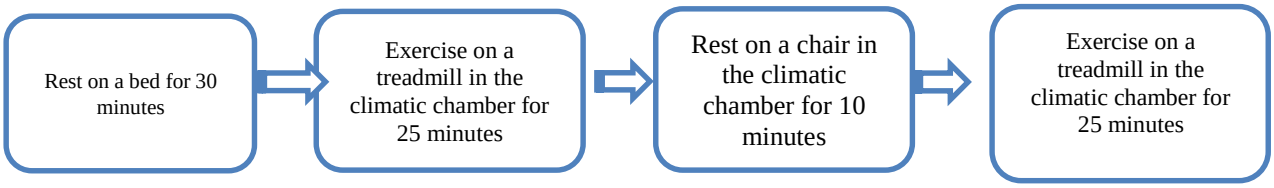

Fig. 1: the steps of the test

RESULTS

Table 1 describes the demographic characteristics and physiological parameters in three groups of subjects (18< BMI< 25kg/m^2, BMI 25 - 26.9kg/m^2 and BMI > 27kg/m^2). The mean values of the age and height showed no significant difference among the three groups of subjects. While the mean values of the weight and physical activity were significantly different among the three groups (P< 0.001). As well as, results of the one-way ANOVA test demonstrated that the rest oral temperature of overweight subjects with BMI > 27kg/m^2 was significantly higher than that of normal-weight subjects with BMI < 25kg/m^2 before the light (P=0.015) and moderate (P=0.006) exercises. In contrast, the rest oral temperature of overweight subjects with BMI 25 – 26.9kg/m^2 compared to that of normal-weight subjects with BMI < 25kg/m^2 had no significant difference before the light (P=0.093) and moderate (P=0.792) exercises. Based on the results, the exercise oral temperature of overweight subjects with BMI > 27kg/m^2 was significantly higher than that of normal-weight subjects with BMI < 25kg/m^2 while subjects were performing a moderate exercise under exposure to the hot climatic conditions (P=0.001). However, this difference among overweight subjects with a BMI 25–26.9kg/m^2 compared to normal-weight subjects with a BMI < 25kg/m^2 was not significant (P=0.122). The exercise oral temperature of overweight subjects with BMI 25 –26.9kg/m^2 was significantly lower than that of normal-weight subjects with BMI < 25kg/m^2 while subjects were performing a light exercise under exposure to the very hot climatic

conditions (P<0.001). However, the exercise oral temperature of overweight subjects with BMI > 27kg/m^2 compared to that of normal-weight subjects with BMI < 25kg/m^2 had no significant difference (P=0.0.308).

Fig. 2 depicts the mean values of the measured oral temperature every 4 minutes from the 2nd minute to the 60th minute for three groups of subjects (18< BMI< 25 kg/m^2, BMI 25 - 26.9kg/m^2 and BMI > 27kg/m^2) in the light exercise under exposure to very hot conditions.

Fig. 3 indicates the mean values of the measured oral temperature every 4 minutes from the 2nd minute to the 60th minute for three groups of subjects in the moderate exercise under exposure to hot conditions.

Table1: the demographic characteristics and physiological parameters in three groups of subjects

Parameter		Subjects with normal-weight		Subjects with Overweight				P value
		18< BMI< 25kg/m^2		25< BMI< 26.9kg/m^2		BMI > 27kg/m^2		
		Range	Mean (±SD)	Range	Mean (±SD)	Range	Mean (±SD)	
Age (year)		21-27	22.72 (1.73)	21-27	23.23 (2.09)	21-35	24.00 (3.38)	0.176
Height (meter)		1.65-1.89	1.76 (0.59)	1.69-1.82	1.75 (0.44)	1.65-1.98	1.77 (0.07)	0.631
Weight (kg)		57-80.10	68.72 (7.21)	73.00-86.00	79.33 (4.01)	79.10-111.00	89.60 (7.90)	<0.001
Physical activity (hour per week)		0-16	5.40 (3.90)	1-6	2.46 (1.27)	0-9	1.95 (1.70)	<0.001
Hot and moderate humid conditions	Rest oral temperature (°C)	35.47-36.8	36.36 (0.32)	35.67-36.63	36.34 (0.25)	35.90-37.03	36.59 (0.27)	0.011
	Exercise oral temperature (°C)	36.19-37.19	36.73 (0.26)	36.39-36.85	36.60 (0.15)	36.35-37.19	36.95 (0.23)	<0.001
Very hot and moderate humid conditions	Rest oral temperature (°C)	36-36.7	36.46 (0.18)	36.10-36.63	36.37 (0.17)	36.23-36.83	36.58 (0.16)	0.002
	Exercise oral temperature (°C)	36.71-37.10	36.93 (0.10)	36.55-36.83	36.74 (0.08)	36.71-37.11	36.96 (0.12)	<0.001

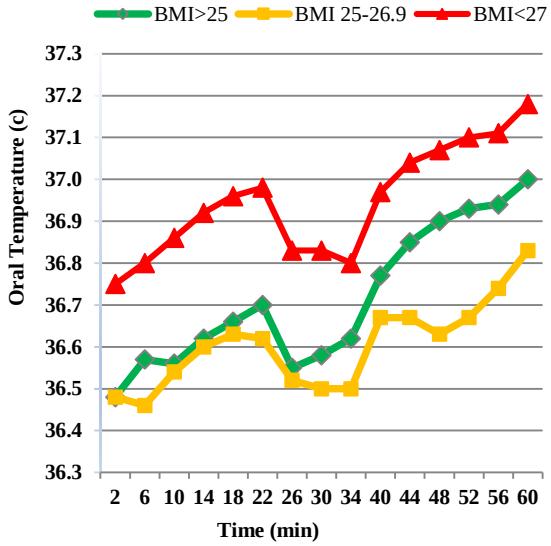

Fig. 2: the mean values of the oral temperature every 4 minutes from the 2nd minute to the 60th minute for three groups of subjects in the light exercise under exposure to very hot conditions.

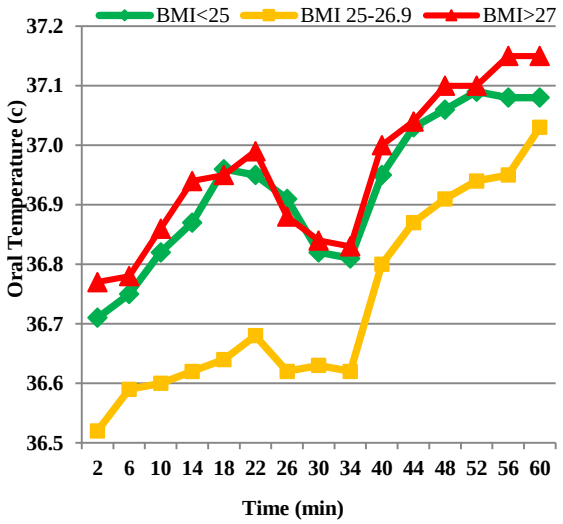

Fig. 3: the mean values of the oral temperature every 4 minutes from the 2nd minute to the 60th minute for three groups of subjects in the moderate exercise under exposure to hot conditions.

In both hot and very hot conditions, the values of WBGT did not significantly differ between the three groups.

DISCUSSION

Based on the results, the rest oral temperature of overweight subjects with BMI > 27kg/m^2 was significantly higher than that of normal-weight subjects with a BMI < 25 kg/m^2. However, this difference among overweight subjects with a BMI 25–26.9kg/m^2 compared to normal-weight subjects with BMI < 25kg/m^2 was not significant. The overweight and obesity are defined as the growth of the white adipose tissue. The increased white adipose tissue needs a higher metabolism that generates higher heat [19]. Hence, the rest oral temperature of overweight subjects with BMI > 27kg/m^2 was significantly higher. In addition, results of the present study showed that the exercise oral temperature of overweight subjects with body mass index more than 27kg/m^2 compared to that of normal-weight subjects was significantly higher only in the moderate exercise under exposure to hot conditions. The adipose tissue as heat insulation decreases the body thermal conductivity [20]. Therefore, the heat produced by moderate exercise is accumulated in central parts of the body. There are studies that show a direct relationship between overweight and body temperature. Eriksson *et al*. measured the body temperature in men every morning during 14 months and the results indicated that the body temperature has an inverse relationship with the height and a positive relationship with the body fat. As well as, this study demonstrated that more physical activity and sensitivity were associated with a higher mean body temperature [15]. Results of another study also showed a direct relationship between obesity and body temperature [14]. On the other hand, the results of the present study revealed that the exercise oral temperature of overweight subjects with BMI 25 – 26.9 kg/m^2 was significantly lower than that of normal-weight subjects with BMI<25kg/m^2 only in the light exercise under exposure to very hot conditions. Subjects with BMI 25 – 26.9kg/m^2 compared to those with BMI > 27 kg/m^2 have a lower adipose tissue and compared to those with BMI > 25kg/m^2 have a higher adipose tissue. Hence, their metabolism is lower than subjects with BMI > 27kg/m^2 and their heat insulation is higher than subjects with BMI>25kg/m^2. Therefore, when the subject with BMI 25 – 26.9kg/m^2 performs a light exercise under exposure to the very hot conditions, lower heat is produced and accumulated in central parts of the body and lower heat is also entered into the body from the environment. There are studies that show an inverse relationship between obesity and body temperature. Results of a study on 42 women and 18 men revealed that the oral temperature has an inverse relationship with the body weight in all groups [12]. Kim *et al*. also stated an inverse relationship between overweight and body temperature [13]. As well as, there are studies that found no significant relationship between obesity and body temperature. Resulted by Savastano *et al.*, the core temperature between obese and normal-weight subjects did not significantly differ [21]. In addition, Heikens *et al.* reported that the mean daily core body temperature was not significantly different between the non-obese and obese subjects [22]. Perhaps, the difference in the results of these studies is due to this fact that the effects of the climatic conditions and physical activity have not been considered. Moreover, the results of the current study showed that the difference between the oral temperature of subjects with overweight and normal-weight in the first physical activity was higher than that in the second physical activity of each phase. This may be due to the physiological adaptation to the environment and physical activity.

In both conditions, the values of WBGT did not significantly differ between groups. Therefore, it can be concluded that climatic parameters were the same. The limitation of the current study was the loss of cooperation by some overweight and obese subjects. The information on these subjects was excluded from the study.

CONCLUSION

The rest and exercise oral temperature of overweight subjects with BMI > 27 kg/m^2 was significantly higher than that of normal-weight subjects with BMI < 25kg/m^2 only in the moderate exercise under exposure to hot conditions. Hence, it is recommended that subjects with overweight and obesity avoid intense activity in hot and very hot environments. Otherwise, high oral temperature causes heat strain.

ETHICAL ISSUES

The authors have completely observed ethical issues including plagiarism, informed consent, misconduct, falsification, and double publication.

CONFLICT OF INTEREST

There are no conflicts of interest to declare.

AUTHORS' CONTRIBUTION

Saeid Yazdanirad: acquisition of data, analysis and interpretation of data, drafting of the manuscript, and critical reversion of manuscript for important intellectual content. Amir Hossein Khoshakhlagh: interpretation of data and drafting of the manuscript. Habibollah Dehghan: study concept and design, administrative, technical and support, study

supervision, and analysis and interpretation of data, and critical reversion of manuscript for important intellectual content. Vali Sarsangi: acquisition of data and statistical analysis.

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