

Evaluation of Heat Stress in Dry Cleaner Units: A Case Study in Qom, Iran

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Background & Aims of the Study: Nowadays, heat stress is one of the most harmful physical agents in workplaces. According to the consequences of heat stress and have no information about it in Qom dry cleaner units, Iran, this study have been designed to evaluate the heat stress among workers of dry cleaner units in Qom province of Iran, in Jul-Aug 2011.

Materials & Methods: This cross-sectional study was conducted in 113 units of active dry cleaner units. WBGT (Wet Bulb Globe Temperature) index was selected for heat stress evaluation. In order to measure the requisite parameters, WBGT meter made of Casella Company had been used according to ISO 7243. Data had been analyzed according to Occupational Exposure Limits (OELs) with SPSS V.16, using analysis of variance, independent T and LSD tests.

Results: The average of WBGT index in Qom dry cleaner units of Iran were 28.98 ± 1.64 °C. The average of WBGT index in 66.4% of units was up to 28°C. The average of relative humidity was 42.86%, the average of wet bulb temperature and globe temperature were 25.56°C and 36.72°C, respectively. The findings showed a significant correlation between the average of WBGT index and the standard recommendation level ($p < 0.0001$). In dry cleaner units with less than 10 m² area, heat stress was higher than other units significantly ($p < 0.05$).

Conclusions: Heat stress in many dry cleaner units in Qom, Iran, was more than recommended OELs. Because of wet bulb and globe temperature in units were high value, the most important measures to heat controls, are technical engineering controls such as radiation shield, insulation on boilers and modify the cooling systems.

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Background

Working in warm environments causes the heat stress in workers and besides reducing the ability can lead to various diseases (1). The ability of working and activity in a high temperature directly depends on the amount of the heat stress (2). The most important implications derived from working in warm

environments are heat exhaustion, heat cramp, dehydration of body, heat rash, reduction of sweating and heatstroke (3). Heat also is considered as a risk factor in cardiovascular diseases; also it can be an effective factor in work related accidents (1). However, there is heat stress in some workplaces; industries like textile, casting, iron melting and jobs such as bakery and dry cleaner units related to these

places. So far, various studies have been done which were related to the evaluation of the heat stress in different industries and jobs around the world and Iran; industries like construction, steel, glasswork, Aluminum, painting and kitchens are the examples of them (1,4-10). Based on the review of literature, it was clear that a few studies have been done about the heat stress evaluation in dry cleaner units, and the only relative research was studied about the heat stress evaluation in dry cleaner, in which three dry cleaner units were evaluated by WBGT index in Malaysia. According to the results, it revealed that, the heat stress in 33% of units was higher than recommended standard limits (10).

The WBGT index has been used in this study to evaluate the heat conditions. The WBGT index was introduced by Yaglou and Minard at first(1957), for the study of the environmental heat conditions and the probability of its dangers during the navy drillings on American Army's desert operations (3,11). So far, various studies recommended, using WBGT (8,9,12-14). This index was also selected by the American Conference of Governmental Industrial Hygienists (ACGIH), as an index in studying the rate of workers who faced with the heat at workplaces (10). The National Institute for Occupational Safety and Health (NIOSH), also the International Standardization Organization (ISO) have recommended this index to evaluate the heat conditions (10,15,16).

Qom province, Iran, was selected for this research. The climate of it, in the classification of country's climate is considered as a semi-desert one. Since it is located in the center of Iran, between 34 degree orbit and 15 minutes, to 35 degree and 15 minutes of southern width than equator, and 50 degree and 30 minutes to 51 degrees and 30 minutes of northern length than Greenwich (Fig.1), it seems that many workers in dry cleaner units are exposed to various heat sources; also in hot summers, they are exposed to the high heat stress.



Figure 1) Geographical location of Qom province, Iran

Aims of the study:

Hence, considering the lack of information about heat stress evaluation in dry cleaner units of Qom province of Iran, this study was designed to evaluate the heat stress among workers of dry cleaner units in Qom province, Iran.

Materials & Methods

In this cross sectional study which have been done in Jul-Aug 2011, according to the information of Qom dry cleaners' tradeunion of Iran, 113 units were active during the study and it was done in all units. Considering the clarification of the pilot study, it revealed that, the place involved highly in heat exposure during a day in dry cleaner units, near the iron systems. As a result, it was selected as a place of measurements. According to the ISO 7243, this study was done during the warmest days of the year, between 11 to 13.30 o'clock (16). The calibrated WBGT meter which is made by Casella Company was used to evaluate the heat stress in this study, according to NIOSH standard and equipped with the exact determination tools of natural wet bulb, dry and globe temperatures (17). This device has been used with different studies so far (8,17). The WBGT index (in an indoor working place) is calculated in accordance with the following equation:

$$WBGT_{indoor} = 0.7t_{nw} + 0.3t_g \quad (1)$$

Where t_{nw} is the natural wet bulb temperature and t_g is the globe temperature (°C). The WBGT meter was adjusted on three locations with three different heights; near to the head (1.7m height), the abdomen was 1.1m and ankles of worker was 0.1m. After measuring the considered parameters for 3 times in each height, the average WBGT rate was calculated in accordance to the following equation:

$$WBGT = \frac{(WBGT_{head} + 2 \times WBGT_{abdomen} + WBGT_{ankles})}{4} \quad (2)$$

To obtain the heat balance of the globe thermometer with its surrounding environment, 20 minutes is considered to these measurements. Since the room dimension is the most important factor of heat stress in dry cleaner units (18), the length and the width of units were measured by tape meters.

One ways to estimate the metabolism rate is measuring an individual's total metabolism in

special activities (3). The ISO 8996 tables were used to estimate the metabolism rate of workers' activities in dry cleaner units (19). The energy consumption tables were presented based on the body posture, type of work and the speed of performance. In this study, considering the work analysis of individuals with standing posture and the total gesture of body, referring to the energy consumption tables in different activities, the amount of metabolism was determined. Final amount of metabolism was specified after the collection of worker's metabolism values.

In accordance with the recommendations of ISO 7243 (Table 1) (16), the standard value for the WBGT index was recommended to 28°C in adapted individuals (individuals who work more than one week in a certain place) and in average class, considering the energy consumption during the work (15). Considering all individuals, according to the energy consumption, were part of the adapted group and in average level, the obtained amounts were compared with 28°C standard rate.

Table 1) ISO 7243: WBGT reference values

WBGT reference value				Metabolic rate (w)	
Not acclimatized (°C)		Acclimatized (°C)		Base of Average area of skin	Calories consumption
	32		33	M<117	Rest (0)
	29		30	117<M<234	1
	26		28	234<M<360	2
No sensible air movement	No sensible air movement	No sensible air movement	No sensible air movement		
23	22	26	25	360<M<468	3
20	18	25	23	M>468	4

The obtained values were recorded in designed sheet based on the individual's adaptation and type of the work, and entered into SPSS 16, to carry out data analysis. The T-test was used to analyze and compare the results with standard, the independent T-tests and one-sided variance analysis used for comparison between groups, the chi-square tests used for comparing the heat stress ratio among individuals, and the procedure of the variance of analysis and LSD

test were used to compare the total average WBGT among dry cleaner units.

Results

The average areas of dry cleaner units calculated $17.23 \pm 2.1 \text{ m}^2$. All dry cleaner units staffs worked continuously more than a month. As before mentioned, according to the job analysis of individuals with a standing posture

and physically full-active, in accordance with ISO 8996, the workers have been categorized in group 2 ($234 < M < 360$ w/1.8m²) by calorie consumption classification.

The average of WBGT index in dry cleaner units was determined $28.98 \pm 1.64^\circ\text{C}$. The obtained results of this study indicate that the WBGT index in 66.4% of units are higher than

28°C ; therefore, 33.6% are smaller or equals to the standard. Data related to measuring parameters such as relative humidity, dry temperature, natural wet bulb temperature, globe temperature and also working times were given in details in Table 2.

Table 2) Results of measured parameters

Variables	Average	Max	Min	SD
Hours in a day	10	15	4	2.27
Ironing average hours in one day	6.98	14	2	2.31
Relative humidity (percent)	42.86	62.1	26.7	6.39
Dry temperature ($^\circ\text{C}$)	35.73	40.2	30.5	2.21
Wet bulb temperature ($^\circ\text{C}$)	25.56	29.7	22.1	1.61
Globe temperature ($^\circ\text{C}$)	36.72	41.7	32	2.46
WBGT Index	28.98	32.2	25.2	1.64

Based on the results of T-test, we observed a significant difference between the heat stress average of Qom dry cleaner units and standard rate (28°C) statistically ($P < 0.0001$). The results of the analysis showed that there was a significant difference between the average of WBGT index in units above 10 m² area than those which were in lower areas statistically ($P < 0.05$).

Discussion

Based on the results of this study, the average of WBGT index in dry cleaner units was determined $28.98 \pm 1.64^\circ\text{C}$. According to the the WBGT index limits of ISO 7243, there was a significant difference between the average heat stress of Qom dry cleaner units and standard rate statistically ($P < 0.0001$). Also, this study showed that 66.4% of dry cleaner units in this study had improper heat stress situations. The reason for higher WBGT index in these places can be investigated in working environments of dry cleaner units like boiler systems (insulation and distance to operator), the confined space, and the kind of cooling system and also the weather conditions of Qom province, Iran. In a similar research, Jalil et al, carried out on three

units of dry cleaners in Malaysia, found that in one of the three units of research, the heat stress (about 33%) was higher than recommended standard limits (10).

Because the main heat distribution source of these shops was related to the boiler systems, thus the first and main step in heat engineering control in workplaces was to eliminate or control of the heat production source. The isolation approach, reduction of emission, insulation, radiation shield, local exhaust ventilation or combinational can be used (3,4). Based on this fact that the average radiant temperature measured in those units was 36.72°C , it seems that using suitable heat insulations and radiation shield made of bright aluminum material or polished tin with high radiation reaction can have an effective role to control the heat radiation in dry cleaner units (20).

Also, the results of the analysis showed that there was a significant difference between the average of WBGT index in units above 10m² than those with lower areas statistically ($P < 0.05$) which is a reason for higher heat stress in dry cleaner units with small physical areas. These results are in accordance with the results of other studies based on the introduction of room dimensions as the most

important factor in heat stress in dry cleaner units, especially in ironing task (18).

Application of improper cooling systems is an example of other reasons for heat stress in dry cleaner units. The water coolers are used in some units due to the economic purposes. The appearance of water vapor resulted in ironing and air moist by water coolers in some units, leads to feel more heat in workers. The technical and engineering controls can be done in different ways such as heat source control, separating the ironing task from other activities, local cooling in work station, general ventilation, fans and humidity control (3). It is recommended that gas coolers be used in those areas; otherwise, using proper ventilations is the second choice (10). Also, similar to other jobs such as bakery (21) and steel industries, (22) selection of administrative controls like doing ironing tasks before noon, also resting in cool areas and drinking with suitable temperature can be effective to reduce the severe results of these stress (3,10).

Among the limitations of this research, the shortage of similar studies can be pointed to compare the results. At the end, it is recommended that the evaluation of heat effects on workers in dry cleaner units to be considered in next researches.

Conclusion

Among all results of this study, it can be understood that the heat condition in some dry cleaner units of Qom province, Iran, is higher than recommended standard limits. Considering the high wet bulb and globe temperatures in dry cleaner units, the most important action to heat control, besides recommendation for using of areas with large dimensions, selection of technical and engineering controls such cooling systems improvement in units, use of shields and insulations in boiler systems can be mentioned.

Footnotes

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