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Research paper

The relation between heat strain and hydration status in the food industry employees in Mashhad, 2014

Somayeh Bolghanabadi[1], *Aliakbar Mohammadi*[2], *Baharam Kohnavard*[3], *Mohamadbagher Delkhosh*[1]

[1] *Department of Occupational Health Engineering, Neyshabur University of Medical Sciences, Neyshabur, Iran*
[2] *Department of Environmental Health Engineering, School of Public Health, Neyshabur University of Medical Sciences, Neyshabur, Iran*
[3] *Department of Occupational Health, Shahid Sadoughi University of Medical Sciences,Yazd, Iran*

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Abstract

Introduction: During physical activity in hot environments, sweating along with evaporation is increased, as the most important physiological response, which can lead to dehydration. Especially those who participate in physical activity in warm environments.

Aim: The aim of this study was the determination of heat stress and its risk assessment and investigates in dehydration conditions of workers in hot workplaces.

Material and methods: This cross-sectional study was done on 90 workers in the food industry. Heart rate and oral temperature were respectively measured using a heart rate meter and an oral thermometer. The WBGT index was recorded and the HSSI questionnaire was completed simultaneously, in order to assess the dehydration level was measured of refract meter. Data obtained from this study were analyzed using compare means and *t*-test, paired *t*-test tests with SPSS 20 software.

Results and discussion: Heat stress exceeded the national and international recommended limits based on the WBGT index in 44% of cases of workstations. According to this study, 8.5% of our population had some degree of dehydration; 63.4% of them were significantly dehydrated (urine SG > 1020) and 28% of them were severely dehydrated (urine SG>1030). The correlations between heat strains, urine density and heat stress, including oral temperature, heart rate were significant ($P < 0.05$).

Conclusions: High percentage of our population was dehydrated. On the basis of results of this study, heat stress condition was worrying. It seems that planning in order to control of heat stresses by replacing drinking is necessary.

Corresponding author: Somayeh Bolghanabadi, Department of Occupational Health Engineering, Neyshabur University of Medical Sciences, Neyshabur, Iran.
E-mail address: bolghanabadis1@nums.ac.ir.

1. INTRODUCTION

According to geographical location of Iran (short distance to the equator) has a dry climate[1,2] and considering that the majority of industrial and non-industrial post heat are faced with heat, and heat from is added to the reason and problems caused by the heat intensifies, and the use of personal protective clothing and equipment according to the type of industry (dust, toxins, microorganisms, ionizing and non-ionizing, etc.), their metabolic heat combined with, and the level of body and environment heat exchange limits and ambient temperature and body temperature dropped out, subsequently, deep body temperature exceeds the normal physiological levels and ultimately to prepare for the detection of heat strain.[3]

Other aggravating factors for heat-related disorders can be cited such as obesity and overweight, the risk of some chronic diseases, use of certain drugs, failure to comply with heat, low-salt diet, inappropriate work dress.[4]

Chronic exposure to hot temperatures caused physiological disorders,[5] reduced physical and mental performance with an increase in neurological and psychiatric disorders,[6] fatigue and dehydration[7] and ultimately reduced productivity,[8] an increased incidence risk of accidents[9,10] and decreased immunity in the work.[11]

Since harmful effects of working in a hot environment on human health and safety have been demonstrated,[12] that if heat stress not controlled, a wide range of symptoms and diseases may be fatal such as mild abnormalities such as burning conditions.[13] Kovat et al. In a study review conducted in 2008, mentioned the heat as a major cause of death and morbidity among individuals and have suggested that further studies be done to protect people against heat stress in order to reduce the harmful effects of heat.[14]

The human body responds to various physiological responses to heat stress shows that include increased skin temperature, sweating, increased heart rate and increased body depth temperature.[15] When working in a warm environment, sweating and evaporation in the body are increased that, if continued, dehydration occurs,[1] and with increased dehydration, urine is concentrated that we can use it as an indicator of dehydration. According to the conducted studies, lack of water and salts lost from the body due to the heat is the main cause of heat-related disorders that if replace water and salts lost, 90% of these disorders can be prevented.[16]

The results of research on dehydration have shown that mild dehydration can be considered a risk factor for lung disease,[17] other problems caused by dehydration can be noted constipation,[18] increased dryness of the skin,[19] increased risk of cancer, cardiovascular disease, and diabetes.[20]

Research has shown that dehydration also increases the risk of high blood pressure in childhood in old age.[21] Among other problems is the risk of kidney stones and urinary tract infections.[22]

Although yet full studies have not been done about the cause of kidney stones in jobs, people who have inactive jobs are at risk to have more urinary problems.[23] Several factors increase the risk of kidney stones, which can be cited genetics, age, gender, geography, diet, occupation, seasonal factors. The first observations showed the risk of kidney stones among American troops that were working in the desert and in hot weather conditions.[24]

Another study that examined the relationship between thermal stress caused by job and kidney disease, was in Thailand that between 37 816 workers who were exposed to heat stress, concluded that the risk of kidney stones is more common in men than in women and significant relationship between heat stress and the incidence of kidney disease was found in men and the risk of chronic kidney disease among workers who were exposed to heat was higher.[25]

In another study, which examines the state of dehydration and heat strain in fire workers in an open-pit mine, the mean radiant temperature measured 37.5°C and the average volume of urine obtained 1.024 according to the results, 73% of workers have been at least one of the symptoms of heat-related illnesses in shift works.[26]

2. AIM

According to conducted investigations, few studies about the assessment of state of dehydration in hot industry, especially in food production factories is done in the country, so the aim of this study was to investigate heat strain and dehydration in a sugar factory workers to identify at an early stage of jobs at risk of dehydration and eventually offered preventive approach.

3. MATERIAL AND METHODS

This cross-sectional study was conducted on 90 workers of the sugar factory in winter 2014. Samples were selected from people who were working as hot work without cardiovascular disease, respiratory, infectious diseases, diabetes and hyperthyroid, according to medical records, people who used cardiovascular drugs, beta blockers, diuretics, antihistamines, were not excluded. Before the study, the consent of all persons to participate in this research was drawn and the workers were assured that the information will remain confidential. The questionnaire containing demographic information including age, height, weight, work experience, education, smoking was completed. The normal body temperature was measured by a mercury thermometer. Heart rate was measured using radial pulse counting. Heat stress in the industry was evaluated for each workstation, for each of the individuals were enrolled in the study. To measure WBGT was used Casella model of digital WBGT. Also the HSSI questionnaire was used to assess the validity and reliability of heat strain that reviewed and approved by Mortazavi et al.[27] The questionnaire contains 18 questions where variable temperatures, humidity, air movement, intense sweating, intense thirst, fatigue, sadness, clinical signs, levels temperature, ventilation, type of work wear, work wear color, type of protective equipment, workload, body position, dimensions of work space and loca-

tion of doing tasks has been studied that score obtained from this questionnaire will be considered as an indicator of heat strain. The first 12 questions were asked from respondents while the last 5 questions were completed after observation of the workers, scores for each item were multiplied by the effect coefficient of each question. Finally, the scores of the items were summed to yield total score. This index has three levels of risk with numbers less than 13.5 (without strain), numbers 13.6–18.0 (containing strain) and numbers over 18.1 (certainly containing strain). To check the status of dehydration, urine density was measured by Automatic Device Model G.WON 201U (made in Korea) at the appointed hour (9.00 to 11.00). According to studies conducted in this case, individual's hydration status based on the specific weight of urine was divided into four groups with normal hydration status (specific weight less than 1.009), mild dehydration (1.010–1.019), moderate dehydration (1.020–1.029), severe dehydration (specific weight over 1.029).[28,29] The urine color was examined using an urine 8 color chart. As well as from the medical records in the health unit, people who had kidney stones, were identified.

The collected data were analyzed by SPSS software v. 20. In the descriptive analysis, the quantitative variables, mean, standard deviation and range were determined. To investigate the relationship between variables, the test of means comparison, including *t*-test and paired *t*-test and χ^2 test were used.

4. RESULTS

The studied population was 90 employees in the sugar factory that 82 completed questionnaires. According to the results, the average age was 36.42 ± 7.46 years and the meaning of an individual's body mass index was 27.36 ± 3.69 kg/m^2 which 60% were overweight. 39% of individuals were smoking.

Average thermal strains between the individuals that were assessed by questionnaire HSSI, was 19.71 ± 7.69 which are on the 3rd level of division and certainly have the strain. The obtained mean temperature of WBGT is 28.2°C more WBGT is obtained. Information related to different levels of heat strain are shown in Table 1.

Obtained results (Table 1) determined that 54.8% of individuals have heat strain and 17% without heat strain. Also, 8.5% of them had degrees of dehydration, approximately 63.4% completely dehydrated and 28% of individuals had suffered severe dehydration and among the workers who certainly were experiencing extreme heat strain, 27% had severe dehydration. In Table 2, according to obtained results, the frequency of heat strain index, the average of measured specific urine weight in individuals was 1025.52 (4.33).

In Table 3, correlation of study indexes (HSSI, WBGT index, dehydration) with the physiological parameters is given. According to the results, the highest correlation coefficient is between WBGT index with physiological parameter which the heartbeat with the highest correlation is 0.58.

Pearson correlation results showed that there is a high correlation between the amount of heat strain score index with WBGT temperature index used as an indicator of global standards in the workplace ($r = 0.79$). Linear regression analysis was also examined that scattering diagram and regression line of Heat Strain Score Index based on the WBGT temperature index was shown in Figure 1.

Among the subjects, 32% had kidney stones, the χ^2 test showed that there is a significant relationship, between the kidney stones in individuals and smoking, urine color, GFR ($P < 0.001$), as well as a significant relationship was found between the WBGT temperature index and kidney stones and urine color ($P < 0.05$), but there was no significant relationship between kidney stones and urine color with heat strain index.

Table 1. Different levels of heat strain on hydration status at the sugar factory workers.

Dehydration Frequency	Mild dehydration	Moderate dehydration	Severe dehydration	Mean frequency *n*(%)
HSSI<13.5 (without strain)	4	9	4	17(20.73)
13.6 – 18 (containing strain)	0	13	7	20(24.4)
HSSI>18.1 (certainly containing strain)	3	30	12	45(54.87)
Mean frequency (Percent)	7(8.54)	52(63.41)	23(28.05)	82(100)

Table 2. Rate of heat strain score index (HSSI) and classification parameters according to HSSI.

Parameter		Minimum	Maximum	Mean (SD)
Without strain	Oral temperature, °C	35	37	36.15(0.41)
	Heart beat, bpm	50	110	81.4(12.5)
	BMI	21.67	34.72	27.85(3.21)
Containing strain	Oral temperature, °C	34	38	36.67(1.01)
	Heart beat, bpm	60	100	80.05(11.5)
	BMI	19.49	34.89	27.29(4.26)
Certainly containing strain	Oral temperature, °C	35	36.6	36.92(0.6)
	Heart beat, bpm	53	115	78.48(12.17)
	BMI	18.73	40.46	26.67(3.7)

Table 3. Correlation among the HSSI scores and WBGT index and dehydration with physiological parameters.

Parameter	HSSI Index	WBGT	Dehydration
Oral temperature	0.44*	0.25*	–0.116*
Heart beat	0.126*	0.58*	–0.098
Systolic	0.026	0.124	–0.055
Diastolic	0.124	0.105	0.088
PH urine	0.184*	0.232*	0.495*
Urine Creatinine	0.242*	0.204*	0.151*
BMI	0.10*	0.157*	–0.246*

5. DISCUSSION

Food production factories due to the type of measure of cooking process and volume of works which workers are doing, in different seasons, especially in hot seasons, and in hot and dry areas of the country will be exposed to heat strain that these factors will increase heat-related illness. This study aimed to investigate the relationship between strain on the work environment and their effects on physiological parameters and to check the status of dehydration and increasing of kidney stones in workers.

According to heat strain score index, the 20.7% of individuals without heat strain, 24.4% of them have likely heat strain and 54.8% of them have heat strain. In this study, individuals with respect to working conditions were forced to use steel-toed shoes and helmet and due to the high level of dust particles of powdered sugar and sugar, have to use masks for face and voice of the industry require the use of protective devices that these factors can be added to the amount of heat strain in the warm seasons in the employees who they work in high-temperature conditions.

In many industrial and mining environments to assess the environmental heat stress use Bulb Globe temperature index as a standard index due to limitations such as being expensive and method's time consuming.[30] In this study, the measured amount of heat stress index as the indicator of WBGT was obtained 28.2°C that compared with the standard amount of booklet occupational exposure approximate of Iran in 2016, 27.5°C, and show that individuals are exposed to high heat stress. Also, because measurement took place during the cold season (January and February), the high results of this indicator shows that this index will be growth with warming weather and in the summer. In the present study, correlation tests showed that there is a direct and positive significant relation between WBGT index with the most physiological parameters, so the parameter increases with increasing temperature, that there was a significant relation between deep body temperature and heart rate and WBGT index in the study of Dehghan et al.[31]

In another study by Haji Zade et al. On the subject to evaluate statues of heat stress in brick workshop was conducted in Qom 2013, blood pressure as an appropriate scale for assessing the physiological heat exposure was not detected[32] that there is also the lack of relation between blood pressure and thermal stress in this study that there is not a significant correlation between systolic, diastolic and WBGT index.

heat strain scoring index (HSSI) that has been introduced as a primary screening tool, as well as showed significant correlation with oral temperature and heart rate ($P < 0.05$) and also tables (see Table 1) where the mean oral temperature and the rate of hydration is expressed in three levels of HSSI risk, shows that the oral temperature changes are increasing, for example, people who were at level 3 of risk, oral temperature was the highest amount and people who were at level 1 of risk had the lowest oral temperature.

Gage et al. in a study aimed at investigating the individuals feeling of warmth with physiological responses, found that individuals who feel comfortable thermal skin temperature and heart rate are better than others.[33] In the present study, there was a significant relationship between the thermal strain index and heart rate and oral temperature that data indicates people who had heat strain in terms of heart rate and body temperature are not normal. In a study conducted by Dehghan et al. to assess heat strain, results showed that there was a relationship between heart rate and oral temperature and heat strain index.[34]

Negahban et al. in a study that conducted on Tehran casting staff, results showed that there is a correlation between heat strain of heart rate number and amount of recovery heart rate and environmental heat stress.[35]

In a study by Stephen and McQueen in 2012 to evaluate heat stress by measuring body temperature, heart rate, body weight loss was conducted on farm workers, the re-

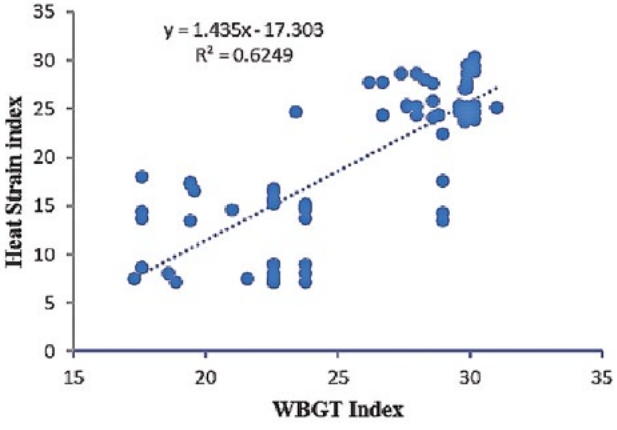

Figure 1. Scatter plot of heat strain index and WBGT index.

sults found that one-third of workers have had weight loss of 1.5%, which was a sign of dehydration and heart rate were significantly associated with WBGT index that is consistent with this study and people who were exposed to heat stress, body temperature, and weight was respectively high and less than those who were exposed to less thermal stress. Also study the people who had severely dehydrated showed people with less weight, are in this group which is consistent with the study's McQueen.[36]

According to the results obtained from the present study, individual's urinary density was obtained 1.025 show that the people in the environment are exposed to excessive heat stress which shows people being more dehydrated. More than 62% of people in this study had a higher density of 1.020. Deep temperature rising of worker's body in the face of the heat will be caused to activate the sweating mechanism to overcome this situation. But because workers are usually due to lack of planned hygienic proceedings compared to the amount of water lost from the body do not drink fluids, it causes dehydration during the work shift and thus increases the density of urine in them and it would also be caused a change in urine color and also increase the risk for kidney stones. In studies conducted in this case also have been reported increases the amount of urine density with increasing duration of exposure to heat stress environment which is consistent with our study,[37–38] as well as a strong significant correlation was found between dehydration and smoking, kidney stones, urine color and GFR which Hamanov et al. in a study conducted on the effects of kidney stones on coronary artery disease, one of the results showed that there is a significant relationship between smoking and obesity and kidney stones.[39]

In a study conducted on heat stress and the occurrence of kidney stones on 37816 workers in Thailand, indicated that there is a significant relationship between heat strain of work environment and workers kidney disease that was required appropriate occupational health interventions for preventing the occurrence of kidney stones.[25] According to the results obtained from this study, the state of dehydration of individuals can be used as an appropriate indicator of individuals heat strain. The limitations of this study can be mentioned such as the lack of review of individuals nutrition, daily exercise and be using some medications, but factors such as smoking, drinking, and some diseases present in the study were considered. It also needs to study are examined in the greater range of people working in hot environments (indoor and outdoor environment) to obtain more accurate results. Due to the high status of heat strain and heat stress and dehydration and the number of people are involved, can be mentioned the appropriate hygiene measures for the industry which could include personnel training in a hot environment to use more fluids during work time and it can also help with continues monitoring of urine color status to avoid dehydration.

6. CONCLUSIONS

Based on the results of this study, heat stress and heat strain is high and worrying that caused an increase of 90% dehydration in employment in this industry that the continuation of this situation could cause irreparable damage to the physical and mental health of workers in the industry and operational efficiency decrease of individuals. Therefore revised policy is clear in this hot industry and similar industries till with proper planning in order to control heat stresses and health measures and workers training in field of the importance of body water supply in a hot environment and the availability of sufficient quantities of cooling water preventing from detection of heat stress and then from other mental and physical illnesses, so efficiency is not reduced.

Conflict of interest

None declared.

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