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Determination of Work-Rest Schedules Based on Physical Workload Among Bakers in Ahvaz, Iran

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Abstract

Background: Bakery workers due to exposure to radiant heat and doing manual labor are at risk of heat-related illnesses and musculoskeletal disorders

Objectives: The current study aimed to determine the appropriate work-rest time interval using two indexes of wet bulb globe temperature (WBGT) and relative heart rate (RHR).

Methods: It was an analytical and descriptive research. Heart rate of workers was continuously recorded to achieve the physiological monitoring and the obtained information was used to determine the work difficulty and physical workload. The ratio of heat stress and RHR was measured using the WBGT and polar team pro device, respectively. Work-rest schedules were detected through the heart rate reserve and heat stress indexes. The level of significance was $\alpha = 0.05$.

Results: Physical workload based on heart rate was estimated light to moderate in bakery workers. Suitable work-rest schedule for all bakery workers according to WBGT index was 25% work-75% rest and based on heart rate reserve index in half of the workers was 50% work-50% rest, and in the other half of the bakery workers was continuous work without rest. According to Kappa test, there was no agreement between the two methods of heat stress index and heart rate reserve to determine the work-rest schedules of workers ($P < 0.001$).

Conclusions: Physical workloads on the basis of heart rate were light for all workers except the workers of *Tanoury* who had moderate workload. Meanwhile, determining the work-rest schedule was different using the two indexes. The heart rate reserve index represents the physiological status of individual during the work and states the ratio of physical workload more precisely.

Keywords: Work-Rest Schedule, Workload, Bakery

1. Background

Heat is one of the triggers of stress in the workplace, which is of the most common occupational health problems in the workplace (1, 2). Disorders in disposal of heat resulting from body metabolism by rising the ambient temperature are great physiological challenges and life-threatening for workers, leading to physiological responses such as increased sweating, increased heart rate, increased skin temperature and in case the heat stress is close to the threshold of human tolerance, it increases the risk of heat-related diseases (3, 4). Working in a hot environment, in addition to creating stress in workers, reduces the working efficiency of employees and causes multiple diseases; predisposing factors for these diseases include increasing the wet bulb globe temperature (WBGT) and individual factors such as heat intolerance, fatigue, intense activity and increased heart rate (5). Work-related fatigue is one of the important physiological factors in the workplace, which develops for major reasons including lack of sleep and rest, working for long periods of time, monotonous and repetitive task and its rate (6, 7) is determined by measuring physiological indicators of heart rate, since increased fatigue and workload alter the physiological indicators of heart rate. Fatigue interferes in physical, mental and emotional performance of workers and reduces the efficiency of workers in jobs with high workload and poor work-rest schedules (8-10). Bakery is one of the warmest workplaces, which is done manually and physically. Statistics show that about 10%-20% of workers in industrialized countries are doing jobs with physical work, while in the developing countries such as Iran, all types of physical works are common (11). Bakery workers, due to working near the furnace and exposure to radiant heat, are at risk of heat-related illnesses and because of doing physical work are exposed to important factors of musculoskeletal disorders such as accepting and maintaining extreme working postures, high speed, direct mechanical

pressure on certain parts of the body, excessive force, static work and prolonged stress (12). According to the grain research center of the Ministry of Industry and Mines of Iran in 2011, about 62,980 bakeries are active in the country and 100,000 people are employed in these bakeries (13). Workload and task content in the bakery profession expose the workers to numerous harmful agents. It is important to mention that since workers employed in this occupation should endure hard conditions and based on the classification of hard and detrimental jobs performed by the office of Iran's work, bakery workers are implicated to the law of hard and detrimental jobs. In general, bakery workers are exposed to many different kinds of diseases resulting from their job such as: 1, Respiratory disease (cough), rhinitis (runny nose) and a rare but serious one such as occupational asthma and short of breath; 2, Muscular-skeletal disorder and; 3, Occupational dermatitis (14, 15). Based on statistics, musculoskeletal disorders are the leading causes for the disability of workers, and constitute 7% of the total population disease and 14% of patients referred to physicians and 19% of admissions to hospitals. In America and Canada, the number of deaths from heat stress in the workplace is 220 cases per year. Toronto public health agency of Canada predicted that deaths from heat in the working environment in this state increases from 20 cases in 2001 to 300 cases in 2020 (16, 17). Appropriate work-rest schedules in the workplace should be implemented to reduce the peak of physiological strains, prevent the fatigue, musculoskeletal disorders and diseases caused by heat (18). Work-rest schedules are defined as the frequency of resting, duration of resting and interval between rest times. Desirable work-rest schedule allows workers to fully return from fatigue to initial state and return from loss performance levels (19). Duration of resting should be enough to reduce the heart rate less than 100 beats per minute, and the duration can be determined by equations and due to physiological assessments and timing. In this regard, major constraints include lack of accuracy in predicting the work-rest schedules and the lack of correct detection of rest time during the shift (20). Work-rest time interval can be determined using objective techniques such as WBGT, qualitative or subjective estimation of the metabolic rate of heat, direct measurement of the heart rate indicator during work (the most common indicator to determine the workload and estimate the work-rest pattern) and the equivalents.

Since working in the bakeries requires a lot of physical activities, in addition to exposure high heat stress, workers may get the disease and serious injuries due to the lack of engineering controls and management; and since very few studies are conducted so far in these workplaces, especially in very hot weather conditions, to determine the physical workload and the timing of work-rest, the current study had two main objectives including: 1, determining the physical workload and the appropriate work-rest time interval using two indexes of WBGT and relative heart rate (RHR); 2, comparing appropriate work-rest time interval using the WBGT and RHR indexes in bakers.

2. Objectives

The current study aimed to determine the appropriate work-rest time interval using two indexes of WBGT and relative heart rate (RHR) among bakery workers of Ahvaz, Iran.

3. Methods

3.1. Study Design

This analytical and descriptive research was conducted in the summer 2015 in Ahvaz. Generally, four types of traditional bakeries were investigated in the study including Tafton, Sangak, Lavash and Tanouri. The current study randomly monitored physiological and thermal stresses in 20 bakers (workers who were working near the furnace); five traditional bakeries were selected from each of the four listed types. Sample size was estimated by assuming 80% power to detect a significant difference of 3.0 points between groups with the standard deviation of 1.5, and a significance level of $\alpha = 0.05$. By assuming a 10% loss to follow-up rate, it was necessary to randomly select 20 participants. The questionnaire included demographic characteristics recorded for each of the subjects through verbal interview. Then, WBGT and RHR were used to calculate the physical workload and work-rest schedule.

The inclusion criteria for this study were as follows: right-hand dominant, age > 19 years, weight less than 100 kg, height lower than 185 cm and work experience more than 2 years. The exclusion criteria were previous heart surgery, blood pressure, respiratory disorders and cardiovascular disease. After meeting the criteria, the study goals were explained and workers provided informed consent.

3.2. Study Tools

The equipment used to determine the workload according to heart rate was Polar Team Pro device, made in Finland, used in several studies including base station, transmitter charger, 10 transmitters and strap. First, the transmitter was installed on the area under sternum by the belt. After installing the belt, heart rate at rest (HR_{rest}) was measured for two minutes in an environment with a temperature of 25°C in a resting position. Then the subjects were asked to perform their duties normally. Sensor of transmitter started to record the heart rate of subjects

during work (HR_{work}). The data obtained during a shift was transmitted through a cable to a computer and analyzed using the Polar Team Pro device software. The collected data were employed to estimate the difficulty of work and the heart rate reserve to determine work-rest schedules. Work-rest schedule was determined based on WBGT and physiological indicators of heart rate reserve (21) (Table 1); 1, The wet bulb globe temperature (WBGT): natural wet-bulb temperature (tn_w) and bulb globe temperature (t_g) are required to measure the WBGT of internal environment. The standard of occupational exposure limit of Iran was used to determine the allowed values of heat stress in workplace to determine heart rate for a period of three hours through Table 1 based on the amount of heat stress using WBGT and workload, and finally work-rest schedule was estimated (20) (Table 2).

Equation 1. Measurement of Indoors WBGT

WBGT = 0.7 tnw + 0.3 tg

2, Physiological indicators of heart rate reserve: work-rest schedule for workers was estimated based on the continuous monitoring of heart rate and the ratio of heart rate (RHR) according to Equation 2 the tabulation presented to work schedule (22).

Equation 2. Measurement of Relative Heart Rate

$$RHR = \frac{HRwork - HRrest}{(HRmax - HRrest) \times 100} \quad (1)$$

RHR, relative heart rate; HR work, average heart rate during work; HR rest, resting heart rate level.

Table 1. Classification of Work (Performed Over an Entire Work Shift) From Light to Extremely Heavy According to Heart Rate

Classification	Heart Rate, Beats/min
Light work	90 or less
Medium work	100
Heavy work	120
Very heavy work	140
Extremely heavy work	160 or more

4. Results

The study participants were 20 workers from four types of traditional bakeries (Tafton, Sangak, Lavash and Tanouri). Demographic characteristics of the study based on the type of breads are presented in Table 4. Kruskal-Wallis test showed that four bakery types were matched in terms of age, height, weight and experience of backers and there was no significant difference among groups of bakeries ($P > 0.05$).

Table 2. Recommended Maximum WBGT (°C) Exposure Levels at Different Work Intensities and Rest/Work Ratios

Hourly Work/Rest Ratio	Intensity of Work		
	Light	Moderate	Heavy
Continuous work	30°C	26.7°C	25°C
75% work, 25% rest	30.6°C	28°C	25.9°C
50% work, 50% rest	31.4°C	29.4°C	27.9°C
25% work, 75% rest	32.2°C	31.1°C	30°C

Table 3. Workload Limits for 12, 10, 8, and 4 Hours of Work

Work Time, h	RHR, %
12	16
10	20
8	24.5
4	39

Determination of work-rest schedule for bakery workers on the basis of general fatigue techniques (RHR) showed that 50% of workers needed the work-rest schedule of 50% work and 50% rest, 50% of workers could continuously rest, but based on WBGT technique all workers need the work-rest schedule of 25% work and 75% rest; Kappa test demonstrated that there was no agreement between the two methods of heat stress and general fatigue to determine work-rest schedule of workers ($P < 0.001$). Physical workload of workers based on heart rate reserve showed that the bakery workers of Tafton, Sangak, and Lavash had light workload and only workers of Tanouri bakery had moderate workload; in fact, 75% of all traditional bakery workers were with light workloads and 25% of workers were with moderate workloads (Table 5).

5. Discussion

There are four types of traditional bakeries (Tafton, Sangak, Lavash and Tanouri) with manually cooking style in Ahvaz, Iran. The current study was conducted given the importance of biomechanical and physiological risk factors in this profession and also that the bakery is almost forgotten and it is placed in low priority to establish the improving programs. The results showed that all bakery workers were under stress compared with occupational exposure limit of Iran, which was consistent with those of several studies conducted earlier on bakery workers (23-25). The results of the study showed that Tanouri bakery workers were more exposed to workload and considering that,

Table 4. Demographic Characteristics of Workers

Indicators	Lavash (n = 5)		Tafton (n = 5)		Tanouri (n = 5)		Sangak (n = 5)		Total Bakeries	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age, y	34.4	12.11	33	10	37	9.13	29.6	8.17	33.5	9.54
Length, cm	172	4.33	176	4.18	175	5.36	175.4	5.94	174	4.81
Weight, kg	76	14	67.2	1.92	68.2	14	74.2	3.19	71.4	10.12
Work experience	13.4	9.76	12	8.13	18.6	5	8.6	5.17	13.15	7.7
BMI	21.75	0.63	24.6	5.07	24.72	2.7	21.76	7.52	23.20	9.13

Table 5. Physical Workload of Workers Based on Heart Rate Reserve and WBGT Index

Bakeries	Work Load	Rest-Time		P Value
		WBGT	RHR%	
Lavash	Light	6 hour	4 hour/No rest	< 0.001
Tanouri	Medium	6 hour	4 hour	
Sangak	Light	6 hour	4 hour/No rest	
Tafton	Light	6 hour	No rest	

physical factors and workplace stress were the most important ergonomic parameters to create a high workload; it can be due to the chimney technique, resulting in more exposure of workers to radiant heat as well as more physical and repetitive works in these workers; the findings were consistent with those of the study by Aliabad et al., on bakeries of Arak, Iran (25). Also, studies on the bakery workers show that standing for long periods of time and heat have great impacts on chronic venous diseases in them. It is shown that bakery workers due to repetitive movements and standing for long periods are at risk of musculoskeletal disorders in the knee, back, shoulder and varicose veins (26-30). According to various diseases due to heat stress and awkward postures and standing for long periods of time in working shift (75% work, 25% rest) of bakers, work-rest schedule is needed to prevent fatigue and work-related diseases that endanger the bakery workers' health in the long term. Results of the study showed that suitable work-rest schedules for the traditional bakery workers based on WBGT index was 25% work-75% rest and based on heart rate reserve index in half of the workers was 50% work-50% rest, and in the other half was determined as continuous work without rest.

The cause of differences in determining the work-rest schedules based on two indexes is probably that WBGT index is calculated as environmental parameters such as radiant heat, drying temperature, humidity and air velocity and non-environmental factors such as age, body adaptation to a hot environment, activity levels and body mass index or physical factors such as noise and vibration that affect heart rate are not considered. These results showed that the work pattern of bakery workers should be changed, since according to previous studies doing physical work in hot working environment makes heat exhaustion (31) increases accident risk (32) and diminishes physical work capacity (33, 34).

5.1. Conclusion

Results of the current study showed that physical workloads on the basis of heart rate were light for all workers except the workers of *Tanoury* bakeries who had moderate workload. Meanwhile, the two indexes led to different work-rest schedules. The heart rate reserve index represents the physiological status of individuals during the work and more precisely states the ratio of physical workload. The WBGT index is based on the effect of atmospheric conditions in workplace on the body; therefore, it seems that the heart rate reserve index is more appropriate to determine the work-rest schedule.

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Footnotes

Authors' Contribution: Study concept and design, Davood Afshari and Leila Jodakinia; acquisition of data,

Leila Jodakinia and Abdolhosein Bigdeli; analysis and interpretation of data, Leila Jodakinia; drafting of the manuscript, Leila Jodakinia and Hamid Saednia; statistical analysis, Leila Jodakini and Amal Saki; study supervision, Davood Afshari

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