

## The Effects of Heat Stress on Haematological Parameters in Production Department of Food Industry Employees

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### Abstract

**Objective:** To investigate the effects of heat stress on some haematological parameters among food industry employees working in the production department.

**Method:** The ambispective, single-centre, case-control study was conducted from December 1, 2016, to June 6, 2018, at Istanbul Gedik University and the Okan University, Istanbul, which is part of the Marmara region of Turkey. The study comprised subjects of either gender aged 22-57 years. Those working in the food industry were the cases in group A, while healthy controls formed group B. Within group A, subjects who were office workers formed subgroup A1, while those in the production department working in the heat treatment areas exposed to high temperatures formed subgroup A2. Heat stress in the environment was evaluated using the Wet Bulb Globe Temperature index. Peripheral blood haemoglobin and platelet levels, neutrophil-lymphocyte ratio and platelet-lymphocyte ratio were compared between the cases and the controls. Data was analysed using SPSS 22.

**Results:** Of the 257 subjects, 139(54.1%) were women and 118 (45.9%) were men. The overall mean age was 35.07±7.32 years. There were 143(55.6%) subjects in group A and 114(44.4%) in group B. Within group A, 19(13.3%) subjects were in subgroup A1 and 124(86.7%) in subgroup A2. The mean working duration for group A was 9.95±4.37 years (range 5-24 years). Haemoglobin and platelet levels were significantly lower and the neutrophil-lymphocyte ratio was significantly higher in subgroup A2 compared to those in subgroup A1 and group B ( $p<0.05$ ). There was no significant difference in terms of platelet-lymphocyte ratio ( $p=0.486$ ).

**Conclusion:** Differences in haematological parameters were significantly different in individuals who worked in the production department and were exposed to heat stress compared to those who did not.

**Keywords:** Haematological parameters, Heat stress, Food industry, Production department, Occupational health.

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### Introduction

Heat stress is a term which means perceived uneasiness and physiological strain related to exposure to a hot environment, mainly during physical work. The cellular and systemic reactions to heat stress contain thermoregulation with acclimatisation and an acute-phase response.<sup>1</sup> Acclimatisation allows an individual to work safely at levels of heat that were formerly unacceptable. The process of acclimatisation is a result of various adaptive responses and lasts for weeks.<sup>2</sup> Heat stress may also cause an inflammatory acute-phase response. Acute phase cytokine response can progress into a pro-inflammatory state.<sup>3</sup> This is a coordinated reaction that keeps against tissue injury and supports repair.<sup>4</sup>

Heat stress is the most discussed topic in occupational health. The temperatures between 23-27°C and 20-25°C in summer and winter, respectively, are ideal values for

human health.<sup>5</sup> Heat stress in many industries is a major problem. Employees who have been working in high ambient temperature and low moisture environments for a long time fail to decrease their body temperature through heat exchange and fall into heat stress.<sup>6</sup> Heat stress may give rise to various physiological changes in human beings, which are defined as heat strain.<sup>7</sup> The alternation in haematological parameters could be used to determine the heat strain resulting from exposure to heat stress.<sup>8</sup>

The chief regulatory component reimbursing for alternations in ambient temperature is the respiratory protein haemoglobin (Hb). Also, platelets are important mediators of the inflammation. There are many studies evaluating changes of Hb and platelets among animals and humans exposed to heat stress.<sup>9</sup> Although different results have been reported by these studies, the effect of heat stress to Hb and platelets is a known fact. The NLR and PLR, which can be obtained with ease by complete blood count (CBC) measurements, have been studied as a different expression of the inflammatory biomarkers in a variety of diseases that are known as systemic inflammatory response (SIR) markers. In line with this, recent studies have

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revealed that elevated levels of neutrophil-lymphocyte ratio (NLR) and platelet-lymphocyte ratio (PLR) are related with severity of many diseases, such as atherosclerosis, psoriasis, pancreatitis and cancer.<sup>10</sup>

The current study was planned to investigate the effects of heat stress on some haematological parameters among food industry employees working in the production department.<sup>2</sup> Cohorts of workers (a heat-exposed group and a group not exposed to heat) and completely healthy control group outside the food industry sector were compared. Therefore, our objective was to determine the effects of heat stress on the haematological parameters among food industry employees in a single-center study in 2 cohorts (workers exposed / production department and not exposed to / office workers high temperatures).

### Subjects and Methods

The ambispective, single-centre, case-control study was conducted from December 1, 2016, to June 6, 2018, at Istanbul Gedik University and the Okan University, Istanbul, which is part of the Marmara region which is known in Turkey the largest food industry cluster. After approval from the ethics review committee of the Istanbul Gedik University, the sample was raised from among subjects of either gender aged 22-57 years. This was a cross-sectional study. All subjects provided written informed consent. Those working in the food industry were the cases in group A, while healthy controls formed group B. Within group A, subjects who were office workers formed subgroup A1, while those in the production department working in the heat treatment areas exposed to high temperatures formed subgroup A2. The healthy controls in group B were matched for age, gender and body mass index (BMI), and were selected from within the same city belonging to several occupational health services, and were not exposed to any heat stress and worked in appropriate environmental conditions.

Heat stress in the environment was evaluated using the Wet Bulb Globe Temperature (WBGT) index.<sup>11</sup>

A routine occupational check-up, which included a health examination, and additional tests, like CBC, biochemical tests, spirometry test, tonal audiogram, urinary test and electrocardiogram, was administered by an occupational physician who was blinded to prevent bias. This data was retrospectively obtained from the medical records as the entire study population was recruited during their bi-annual routine medical visit which is obligatory for all employees. To assess demographic details, occupational history and current health status, a prospective questionnaire and physical examination were applied to all cases and controls. Questionnaires with missing data were

excluded from analyses. The study was conducted using an interviewer-administered health questionnaire. Occupational physicians completed the same questionnaire in both the groups. The questionnaire included information about age, gender, height, weight, BMI, marital status, education, lifestyle/personal habits (sleeping hours, smoking habits), past and present occupational history, health status (medication use, history of hypertension, diabetes, and kidney disease), heat illness symptoms within the preceding 1 month. The answers were checked by the occupational physician. Patients with chronic inflammatory diseases (e.g overt infections, cardiovascular disorders, chronic liver or kidney diseases, haematological diseases, and autoimmune disorders), patients taking anti-hypertensive drugs and statins, those with smoking history and alcohol abuse as well as those who were pregnant or breastfeeding were excluded.

Samples from venous blood from the antecubital vein were obtained and, using an automated blood cell counter, CBC measurements were made within 1h of venipuncture. Levels of neutrophils, lymphocytes, platelets and Hb were measured. The NLR and PLR were then calculated.

Data was analysed using SPSS 22. Normal distribution of data was evaluated using Shapiro Wilks test. One-way analysis of variance (ANOVA) was used for comparison of the parameters. Descriptive statistics, included mean, standard deviation, frequencies and percentages. Tukey's honestly significant difference (HSD) test was used to determine the difference between the groups. Chi-square test was used to compare qualitative data. The relations between the parameters were examined using Pearson's correlation analysis. A post hoc power calculation was performed, which demonstrated a power of 0.94 for the interaction effect between heat stress and haematological parameters. Post hoc analysis was conducted with Holm-Sidak methodology. The level of statistical significance was set at  $p < 0.05$ .

### Results

Of the 368 individuals approached, 257(%) formed the study sample (Figure). Among them, 139(54.1%) were women and 118 (45.9%) were men. The overall mean age was  $35.07 \pm 7.32$ . There were 143(55.6%) subjects in group A and 114(44.4%) in group B. Within group A, 19(13.3%) subjects were in subgroup A1 and 124(86.7%) in subgroup A2. There were significant differences between the groups in terms of age, gender, marital status and educational status (Table 1).

The mean working duration for group A was  $9.95 \pm 4.37$  years (range: 5-24 years with). Hb and platelet levels were significantly lower and NLR was significantly higher in

**Table-1:** Demographic characteristics (n=257).

	Office workers (n=19)	Production Department (n=124)	Control (n=114)	p-value
Mean Age (years) <sub>ort±SS</sub>	35.63±6.04	37.73±7.40	32.07±6.26	<sup>1</sup> <0.001*
MeanBMI <sub>ort±SS</sub>	26.15±4.80	24.98±3.73	24.27±4.26	10.121
Gender [n (%)]				<sup>2</sup> 0.011*
	Female	8 (42.1)	79 (63.7)	
	Male	11 (57.9)	45 (36.3)	
Marital status [n (%)]				<sup>2</sup> 0.039*
	Single	3 (15.8)	20 (16.1)	
	Married	14 (73.7)	101 (81.5)	
	Divorced	2 (10.5)	3 (2.4)	
Education [n (%)]				<sup>2</sup> <0.001*
	Primary school / illiterate	4 (21.1)	55 (44.4)	
	Elementary school	5 (26.3)	62 (50)	
	Two year graduate	4 (21.1)	5 (4)	
	Graduate / Postgraduate	6 (31.6)	2 (1.6)	

<sup>1</sup>Oneway analysis of variance (ANOVA) Test; <sup>2</sup>Chi-square test; \*p<0.05; BMI: Body Mass Index.

**Table-2:** Haematological parameters.

	Office workers (n=19)	Production department (n=124)	Control (n=114)	p-value
WBC	7±1.51	7.46±1.97	7.06±1.72	0.200
RBC	4.94±0.35	4.73±0.51	4.69±0.41	0.086
HGB	14.11±1.26	12.83±1.83	13.71±1.71	<0.001*
PLT	262.53±52.64	241.85±59.45	262.91±63.79	0.024*
LYM	2.13±0.45	2.18±0.59	2.34±0.66	0.092
NEU	4.32±1.2	4.23±1.41	3.95±1.21	0.210
NLR	1.92±0.46	2.02±0.72	1.77±0.62	0.021*
PLR	126.31±30.19	117.22±37.41	120.65±44.24	0.596

Oneway analysis of variance (ANOVA) Test <sup>0</sup>\*p<0.05; WBC: White blood cell, RBC: Red blood cell, HGB: Haemoglobin, PLT: Platelet, LYM: Lymphocyte, NEU: Neutrophil, NLR: Neutrophil-lymphocyte ratio, PLR: Platelet-lymphocyte ratio.

**Table-3:** Evaluation of the relationship between PLR and NLR with working period in the food industry.

		Working period in the food industry	
		Office workers (n=9)	Production department (n=124)
NLR	r-value	-0.025	0.106
	p-value	0.920	0.239
PLR	r-value	-0.004	-0.069
	p-value	0.987	0.445

Pearson correlation analysis; PLR: Platelet-lymphocyte ratio, NLR: Neutrophil-lymphocyte ratio.

subgroup A2 compared to those in subgroup A1 and group B (p<0.05). There was no significant difference in terms of PLR (p=0.486) (Table 2).

There was no significant difference in NLR and PLR levels with respect to the duration of working in the food industry between subgroups A1 and A2 (p>0.05) (Table 3).

**Discussion**

To the best of our knowledge, the current study is the first to have investigated the effects of long-term heat stress on haematological parameters in the food industry.

The molecular and cellular alternations in heat stress are complicated. At first, heat stress encourages an acute phase response that safeguards and repairs tissues. However, if heat stress persists, these changes can progress to being proinflammatory when severe.<sup>1</sup> Thus, heat stress raises both the plasma levels of inflammatory and anti-inflammatory cytokines. Some studies showed that heat directly stimulates tissue damage. The intensity of the tissue injury depends on the duration and grade of exposure to heat.<sup>13</sup> As a consequence of these processes, changes occur in many haematological parameters.

In an animal study, heat-exposed animals showed a significant increase in Hb levels compared to the control group.<sup>14</sup> Heat stress also caused an elevation in packed cell volume (PCV) in buffaloes.<sup>15</sup> This change was attributed to the loss of water due to dehydration and haemoconcentration, suggesting that high PCV values may be due to an increase in red blood cell (RBC) and Hb concentrations.<sup>15</sup> Choi et al. evaluated the effects of high temperature on haematological parameters of human blood after exposure to varying degrees of temperature. Blood specimens were treated at 50°C for 5min. However, there was no significant difference in Hb concentrations before and after heat exposure.<sup>8</sup>

Changes in resting haematological variables in runners during a multi-stage ultra-marathon competition in the heat were examined by Rama et al. The competition was managed over 5 sequential days in hot ambient circumstances (32-40°C). Hb and haematocrit showed linear declines along the multi-stage ultra-marathon.<sup>16</sup> In another study, seasonal effects on Hb levels and deferral rates in whole-blood and plasma donors were examined. Hb levels reduced with growing daily temperature. The highest deferral rates were seen during summer months.<sup>17</sup> These findings indicate that Hb levels vary depending on the ambient temperature. Particularly in humans, long-term high-temperature exposure lead to a decrease in Hb levels. The findings of the current study are in line with such conclusions.

Anaemia describes the condition in which the number of red blood cells and Hb levels in the blood is low. Anaemia of inflammation is a common form of anaemia that arises from an underlying inflammatory process. Chronic inflammation shortens erythrocyte survival, suppresses erythropoiesis by direct impact of cytokines on the marrow, and impacts the erythropoietin production and renal

excretion of hepcidin.<sup>18</sup> Acute-phase cytokine response may progress into a pro-inflammatory state in chronic exposure.<sup>3</sup> Therefore, it is speculated that exposure to high temperature and heat stress for a long period of time in food industry may cause a decrease in Hb levels.

In response to hyperthermic environmental conditions, subjects in different studies have displayed increased levels in platelets.<sup>8,19</sup>

In a case presented by Lohiya et al. a previously healthy car wash attendant had mild thrombocytopenia related to heat exhaustion. Heat exhaustion is described as mild-to-moderate illness because of water or salt depletion that results from exposure to high environmental heat or vigorous physical exercise. But the platelet count became normal within 4-20 days in this case<sup>1,20</sup> In addition, thrombocytopenia is an initial laboratory finding in acute kidney injury related with heat stroke. In one study, approximately half of the patients had severe thrombocytopenia related with heat stroke, but platelet counts normalised within  $10 \pm 3$  days<sup>21</sup> In another study, there were considerable changes in the number of platelets and Hb levels of acclimated workers after short-term exposure to heat.<sup>22</sup>

In the current study, platelets of employees in the production department exposed to heat stress were statistically significantly lower ( $p < 0.05$ ) than office workers and controls. Studies have shown elevated inflammatory cytokines in humans and rodents exposed to heat stroke.<sup>1,23</sup> Thrombocytopenia in individuals exposed to long-term heat stress in food industry may be associated with increased inflammatory cytokines.

Recent studies have shown a positive relation involving NLR, PLR and commonly used inflammatory markers. NLR and PLR can be useful markers of subclinical systemic inflammation.<sup>24</sup> Also, NLR and PLR have usually been investigated as predictors of prognosis of several cancers, metabolic, inflammatory and cardiovascular diseases, and as a marker of infectious pathologies and postoperative complications.<sup>25</sup> In addition, studies have established that low-grade chronic inflammation has links with risk factors like insulin resistance, metabolic syndrome (MetS), nonalcoholic fatty liver disease, hypertension, diabetes mellitus, dyslipidaemia and psychiatric disorders.<sup>26</sup>

The current study demonstrated a statistically significant difference between groups with regard to NLR ( $p < 0.05$ ), and we speculate that chronic inflammation related with heat stress may cause an increase in NLR. Between 1979 and 2003, heat exposure caused more than 175 deaths per year in the labour force in the United States.<sup>27</sup>

In contrast to many studies, PLR did not differ between the groups in the current study ( $p > 0.05$ ).<sup>28,29</sup> Long exposure to heat stress in the current study could be the key factor behind this difference in results.

The present study has several limitations. The present study was an ambispective single-centre study lacking longitudinal observation. In addition, there was a small sample that had 114 production department employees compared to 19 office workers. The working hours in Turkey are 45 per week at the most. Unless otherwise agreed, the hours are divided over the working days equally. In the current study, food industry employees' average daily working time was 8 hours, within a 24-hour operation having 3 shifts. There may have been employees with more or less working hours, and, if so, this may create a bias in the results. Also, concurrent inflammatory markers were not evaluated which is the most important limitation of the current study.

Prospective multi-centre studies are needed to better reveal the association between heat stress and chronic inflammation in food industry workers.

## Conclusion

Differences in haematological parameters were significantly different in individuals working in the production department who were exposed to heat stress compared to those who were not.

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**Conflict of Interest:** None.

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