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INVESTIGATION OF THE RELATIONSHIP BETWEEN ERGONOMIC RISK PERCEPTIONS AND PHYSICAL DISCOMFORT OF EMPLOYEES IN A FOUNDRY FACTORY

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Abstract: Employees in foundry factory are exposed to many ergonomic and environmental risk factors. Both working in postures that are not suitable for the human body and lifting loads, as well as noise, vibration and chemicals in the production environment force employees in many ways. This situation causes various physical discomfort or disorders, especially musculoskeletal disorders, in the long-term workers in the casting industry. In this study, it was aimed to evaluate the relationship between ergonomic risk perceptions and physical discomfort levels in employees working in various parts of a foundry factory. For this purpose, a survey study was conducted with the participation of all workers working in different departments in a foundry factory operating in Türkiye and the obtained data were evaluated statistically. In the study, it was determined that the workers mostly experienced musculoskeletal pain (lower back, upper back, shoulder pain, etc.), especially in the upper extremities, which can be seen as a result of unsuitable, repetitive working styles and lifting loads. In addition, the noise, vibration, and the gases and chemicals that the workers are exposed to during melting have been identified as important risk factors.

Keywords: *Ergonomics, Ergonomic risk perception, Physical discomfort, Casting process.*

1. Introduction

Risk is the danger of being harmed or the possibility of being harmed. According to the Occupational Health and Safety Law No. 6331, risk is defined as “the potential for loss, injury or other harmful consequences arising from danger” (Turkish Official Gazette, 2012). Ergonomic risk factors are generally associated with Musculoskeletal Disorders, which are also seen with the effect of bad posture in continuously repetitive studies (Aksüt et al., 2020). When the "Workplace Hazard Classes List" in the ANNEX-1 file of the "Communiqué on Workplace Hazard Classes on Occupational Health and Safety" published in the Official Gazette dated 26.12.2012 and numbered 28509 in Türkiye is examined, It is classified as “dangerous” work. (Turkish Official Gazette, 2012). For this reason, it is of great importance to carry out ergonomic risk analyzes and assessments in terms of occupational health and safety of employees in casting production. At the same time, it is necessary to determine the ergonomic risk perceptions of the employees in this sector, to increase the awareness levels of both

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employers and employees and to take adequate precautions. Today, with the effect of Industry 4.0 and digital transformation in some sectors, the rate of injury from human power has begun to decrease both physically and mentally. However, many sectors and companies in our country are still not at the Industry 4.0 level and there are many labor-intensive jobs based on manpower. In the study conducted by TÜBİTAK with 1000 private sector organizations in 2016, it was stated that the digital maturity level of the industry in Türkiye is between Industry 2.0 and Industry 3.0 (Ünlü ve Atik, 2019; Deste vd., 2020). This situation reveals the importance of ergonomics and the necessity of harmony between work and people. Postures that are not suitable for work and human body in employees cause occupational musculoskeletal disorders, which are generally classified as upper extremity and low back diseases, especially in repetitive and continuous work. These disorders negatively affect the occupational health and safety of the employees, causing work accidents and a decrease in the quality of life and work efficiency of the employees.

Some of the studies in the literature on ergonomic risk factors that threaten employees in the workplace and musculoskeletal disorders seen in employees are as follows:

Björkstén et al. (2001) studied how exposure to physical and psychosocial factors at work and at home affects musculoskeletal problems, especially in regions such as the neck and shoulders. For this purpose, 173 women working in the food and metal sector were examined and it was stated that monotonously working in fixed positions without support triggered musculoskeletal disorders. Vandergrift et al. (2012) aimed to examine the relationship between low back pain experienced by workers working in automobile production and physical and psychosocial ergonomic risk factors. Psychosocial workplace interventions for LBP indicated that jobs with high physical and ergonomic exposures should be given priority. Chiasson et al. (2015) aimed to measure the effect of musculoskeletal pain on employees' evaluation of workstations. In the study, it was revealed that the musculoskeletal pain of the workers can negatively affect the perception of the workers. Nordlöf et al. (2015) aimed to explain the safety culture and risk taking, workers' experiences and perceptions of safety and risk in a steel manufacturing company in Sweden. Uskun et al. (2015) aimed to examine the risks in the working environment and its relationship with the quality of life of employees in small-scale workplaces located in an industrial site. It has been stated that exposure to at least one risk group in the workplace negatively affects the quality of life parameters of the employees. Sağıroğlu et al. (2015) used the REBA method in their study and carried out an ergonomic risk analysis and evaluation at workstations on the production line in a compressor factory. In this context,

improvement suggestions were presented, such as adjusting the seat height of the operator of 10 workstations and purchasing a vacuum jib crane for transportation to stations with excess loads. Kaya and Özok (2017) aimed to determine the ergonomic risk factors and physical discomforts faced by employees working in production in ready-made clothing enterprises, and in this direction, they applied a Physical Discomfort Survey to 566 employees. Aytaç et al. (2018) aimed to evaluate ergonomic risk perception in terms of Occupational Health and Safety of women working in the metal industry. In their studies, it was stated that musculoskeletal disorders as an ergonomic risk factor have priority in female employees. Alaca at al. (2019) aimed to translate and culturally adapt the Nordic Nordic Musculoskeletal Questionnaire Extended Version (NMQ-E) for researchers in Türkiye. In the study, it was stated that the reliability study and cross-cultural adaptation of the Turkish version of the NMQ was done by Kahraman et al, (2016). However, it was stated that the safety assessment and cross-cultural adaptation of the Turkish NMQ-E version were not performed and the study was conducted for this purpose. Bulut (2022) investigated the differences in occupational accidents, risk awareness and risk perception levels of employees in an iron and steel business, primarily according to socio-demographic conditions. As a result of the study, it was stated that the level of knowledge of the employees about the concepts of occupational safety and risk, awareness of equipment, signs and warnings, awareness of responsibility about helmets, health risk status and perception are high.

In this study, it was aimed to examine the relationship between ergonomic risk perceptions and physical discomfort levels in a foundry factory employees. A questionnaire was used as a data collection tool and the data obtained were statistically analyzed using the SPSS 24 package program.

2. Method

Questionnaire form was used as data collection tool in the study. The questionnaires were delivered by the researcher to all employees working in different departments (modelling, molding, casting, grinding & cleaning, machining, quality-control) in the production department of a casting factory operating in Türkiye. All 52 employees in the production department participated in the survey and the data was collected in 2022.

The questionnaire consists of three parts. The first part consisted of questions to determine the demographic characteristics of the employees. In the second part, scales to measure the ergonomic risk perception levels of the employees are included. In the preparation of the ergonomic risk perception scale, Uskun et al. (2015) study was used. Ergonomic risk

perception questions are in a 5-point likert format and consist of "I strongly disagree, I do not agree, I am undecided, I agree and I strongly agree". In the third and last part of the questionnaire, scales to measure physical discomfort levels are included. The Extended Nordic Musculoskeletal Questionnaire (NMQ) was used to question physical disorders. In this survey, there are questions about how often and how much physical discomfort employees experience according to their body parts. Physical discomfort status scale consists of “Never, rarely, sometimes, often and always” options in a 5-point likert format.

SPSS 24 package program was used for statistical analysis of the data. Reliability analysis was performed in the study and the data were subjected to normality tests to determine which statistical tests would be used. In this context, the histogram graphics of the data were examined, the Kolmogorov Smirnov test was performed and the Skewness-Kurtosis values of the data were examined. According to these results, parametric tests were used in the analysis, analysis of variance, t-tests and correlation analysis were performed.

The hypotheses developed for the research are listed below.

Hypothesis 1: Employees' ergonomic risk perceptions differ according to demographic variables.

Hypothesis 2: The physical discomfort levels of the employees differ according to the demographic variables.

Hypothesis 3: There is a relationship between the ergonomic risk perceptions of the employees and their physical discomfort levels.

3. Result and Discussion

In this part of the study, the findings obtained as a result of statistical analyzes are included. If there is no relationship or difference in the analyses, these results are not included in the tables. Table 1 shows descriptive statistics.

Table 1. Descriptive statistics

		N	**%**
Age	Between 20-30	13	%25
	Between 31-40	23	%44,2
	41 and above	16	%30,8
Gender	Female	6	%11,5
	Male	46	%88,5
Educational status	Primary school	21	%40,4
	High school	17	%32,7
	Vocational school	3	%5,8
	University	11	%21,1
	Master's/PhD	-	-
Department	Casting	10	%19,2
	Molding	9	%17,3

	Machining	11	%21,2
	Quality Control	6	%11,5
	Modelling	7	%13,5
	Grinding & Cleaning	9	%17,3
Working status	Less than 2 years	13	%25
	2-5 years	21	%40,4
	More than 5 years	18	%34,6
Work accident status	I had	14	%26,9
	I did not have	38	%73,1

When the descriptive statistics of the research in Table 1 are examined, it has been determined that 25% of the participants working in different departments in production are between the ages of 20-30, 44.2% are between the ages of 31-40 and 30.8% are aged 41 and over. While the majority of the participants are men with 88.5%, 11.5% are women. When the educational status of the participants is examined, it is seen that the majority of primary school graduates are 40.4%. The number of university graduates is 21.1%. The study was carried out in different departments in a foundry factory. 21.2% of the participants are in the machining department, followed by the casting department with 19.2%. When the working hours and occupational accident situations of the participants were examined, it was determined that the majority of them, 40.4%, worked between 2-5 years, and 73.12% of them did not experience a work accident.

Table 2: Reliability Analysis Results

Items	**Cronbach's Alpha**	**Number of items**
Ergonomic Risk Perception	0,941	15
Physical Discomfort	0,941	12

Reliability is closely related to the consistency of the measurement. The most commonly used method for reliability analysis is the Cronbach Alpha coefficient and this value is between 0 and 1. As seen in Table 2, the Cronbach Alpha value (0.941) for both scale items is above the 0.60 value accepted in the literature (Hair et al., 1998). According to the analysis, the structural reliability of the questionnaire is quite high.

Table 3: t-test to compare the responses of female and male employees to the scales

Item	**Groups**	**N**	**Mean**	**Std. Deviation**	**t**	**df**	**P**
Ergonomic Risk Perception	Female	6	4,3667	0,28889	6,279	22,653	0,000
	Male	46	3,2391	0,91975			

As a result of the t-test for the gender variable in Table 3, it is seen that the ergonomic risk perception levels of the employees differ significantly according to the gender variable

($p<0.05$). Based on these findings, it is seen that the risk perception level of female employees ($\bar{x}=4.3667$) is higher than that of male employees ($\bar{x}=3.2391$).

Table 4: ANOVA results of employees' ergonomic risk perception differences by department

Item	Departmant	N	Mean	Std. Deviation	F	P	Significant Difference
Ergonomic Risk Perception	Casting	10	3,7667	0,49516	5,712	0,000	Machining-Grinding & Cleaning
	Molding	9	2,9185	0,97113			
	Machining	11	3,9273	0,69054			
	Quality Control	6	3,3889	0,81040			
	Modelling	7	3,7905	0,25655			
	Grinding & Cleaning	9	2,3556	1,10151			
	Total	52	3,3692	0,94174			

When the ergonomic risk perception levels are compared according to the departments in which the employees are grouped in Table 4, it is seen that the highest average is ($\bar{x}=3.9273$) among the employees in the machining department. This is followed by the employees in the modelling department ($\bar{x}=3,7905$) and the employees in the other department with various average levels. The lowest average is seen in the employees in the grinding & cleaning department ($\bar{x}=2.3556$). One-way analysis of variance, which is a parametric test from statistical tests, was used to test whether the ergonomic risk perception levels of the participants differed significantly. As a result of analysis of variance, $F=5.172$, $p<0.05$, statistically significant difference was calculated. Tamhane test, one of the Post Hoc tests, was used to determine the source of the difference. The direction of the difference was found as machining – grinding & cleaning. When the averages of the two departments are compared, it is seen that the ergonomic risk perception level is higher in the machining department and less in the grinding & cleaning department.

Table 5: ANOVA results of the differences in the physical discomfort level of the employees according to the department variable

Item	Departmant	N	Mean	Std. Deviation	F	P	Significant Difference
Physical Discomfort	Casting	10	3,1083	0,72547	7,872	0,000	* Molding - Machining * Molding - Modelling * Quality control - Modelling * Modelling - Grinding & Cleaning
	Molding	9	2,1667	0,78947			
	Machining	11	3,4924	0,93946			
	Quality Control	6	2,4167	0,45338			
	Modelling	7	4,1905	0,45316			
	Grinding & Cleaning	9	2,5833	0,83333			
	Total	52	3,0016	0,97943			

In Table 5, when the physical discomfort levels of the employees are compared according to the departments they are grouped into, it is seen that the highest average is ($\bar{x}$=4,1905) in the modelling department. This is followed by employees in the machining department ($\bar{x}$=3,4924) and employees in the other department with varying average levels. The lowest average is seen in the employees in the molding department ($\bar{x}$=2.1667). One-way analysis of variance, which is a parametric test from statistical tests, was used to test whether the physical discomfort levels of the participants differed significantly. As a result of analysis of variance, F=7.872, $p<0.05$, statistically significant difference was calculated. Bonferroni test, one of the Post Hoc tests, was used to determine the source of the difference. The direction of the difference was found as molding -machining, molding - modelling, quality control - modelling, modelling -grinding & cleaning.

Table 6: Correlation results

		Ergonomic Risk Perception	Physical Discomfort
Ergonomic Risk Perception	Pearson Correlation	1	0,632**
	Sig. (2-tailed)		0,000
	N	52	52
Physical Discomfort	Pearson Correlation	0,632**	1
	Sig. (2-tailed)	0,000	
	N	52	52

According to the correlation analysis conducted to reveal the relationships between the scales, it was determined that there was a moderate positive relationship between the ergonomic risk perceptions of the employees and their physical discomfort (r:0,632 ; $p<0,01$). In other words, there is a significant relationship between the ergonomic risk perceptions of the employees and their physical discomfort levels, and Hypothesis 3 was accepted.

4. Conclusion

The study was carried out in a foundry factory operating in Türkiye and all employees responsible for production participated in the survey. In the study, the effects of the ergonomic risks perceived by the employees in the production department and the physical discomfort levels they experience on the employees were investigated. According to the data obtained through the analyzes, the following results were obtained:

- When the descriptive statistical values of the answers given by the employees to the questions about their ergonomic risk perceptions are examined, it has been determined that the item "I think my health may be damaged while lifting a load" gives the highest value (4,13) above the average compared to the other items. This result shows that the

lifting movement in the working environment increases the ergonomic risk perception of the employees. Employees do most of the work with their hands, which can disrupt their current body posture and cause future back and waist problems. In addition, the transport of the cores is done by hand lifting and serious risks may occur during the laying of the cores on the ground. Ergonomic improvements to be made in the direction of lifting loads in the factory environment will positively affect the ergonomic risk perception. The second highest average value (3,96) belongs to the item 'I think the noise in my workplace can harm my health'. Sanding and grinding works to remove unwanted materials from the products after casting are a major source of noise. Pneumatic impact machines used during the removal of the inner mold after casting create vibration and long-lasting core removal works cause deterioration in the hand-arm coordination of the employees. Another high average value (3.67) belongs to item 'I think that I am exposed to chemicals that may be harmful to my health in my work environment'. Nitrous oxide, carbon dioxide gases, carbon monoxide gases may occur during welding processes. In addition, silica dust caused by molding sand can cause respiratory ailments such as silicosis, chronic obstructive pulmonary disease and lung cancer in workers (https://www.hse.gov.uk/pubns/indg463.pdf). In general, environmental risks in foundry factories can be listed as noise, vibration and inadequacy in thermal comfort conditions (Şener, 2005; Kısa, 2014).

- When the descriptive statistical values of the answers given by the employees to the questions about physical discomfort are examined, it has been determined that the item 'How often do you experience lower back pain?' gives the highest value (3.40) above the average compared to the other items.In other words, it is observed that the employees have pain in the lower back, that is, the lumbar region. Based on the high average response given to the item “I think my health may be damaged while lifting a load”, lower back pain was expected in the employees. In order to prevent lower back pain, workplace equipment such as cranes, forklifts, pallet trucks, elevators can be preferred as load lifting and conveying equipment.
- As a result of the t-test for the gender variable, it was concluded that the ergonomic risk perception levels of the employees differed significantly according to the gender variable and the risk perception levels of the female employees were higher than the male employees.

- When the ergonomic risk perception levels of the employees are compared according to the departments they are grouped into, it is seen that the employees in the machining department have the highest average ($\bar{x}$=3.9273).
- When the physical discomfort levels of the employees are compared according to the departments they are grouped into, it is seen that the highest average is in the employees in the modelling department ($\bar{x}$=4,1905). In this department and other departments, detailed investigations can be carried out to identify the factors that cause the employees to experience discomfort and improvement studies can be carried out to eliminate them. First of all, it is very important to give ergonomics and occupational health and safety trainings to the employees in the workplace.

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