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Cornell Kas-İskelet Rahatsızlık Anketi Kullanarak Kas-İskelet Rahatsızlıkları Kaynaklı Üretim Çalışanı Devamsızlıklarının Azaltılması ve Sıralı Lojistik Regresyon Modeli

Duygu İNCİ[a], Mürüvvet Deniz SEZER*[,b], Bengü GÜNGÖR[c], Pırıl ERGÖNENÇ[a]

[a] *Ege Fren Sanayi Tic. A.Ş., Yalın Ofis Mühendisi, İZMİR, TÜRKİYE*
[b] *Yaşar Üniversitesi İşletme Bölümü, 35100, İZMİR, TÜRKİYE*
[c] *İzmir Demokrasi Üniversitesi Endüstri Mühendisliği Bölümü, 35100, İZMİR, TÜRKİYE*

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ÖZ

Günümüzde, aşırı yüklenmiş işgücüne bağlı olarak çalışma ortamında insan motivasyonunu ve sağlığını etkileyebilecek zorluklar gitgide artmaktadır. Artan rekabet ortamının beraberinde getirdiği yoğun üretim faaliyetleri, özellikle üretim çalışanlarında kas-iskelet sistemi rahatsızlıklarının daha fazla meydana gelmesine neden olmaktadır. Bu nedenle, bu çalışma kapsamında otomotiv endüstrisinde faaliyet gösteren bir yan sanayi kuruluşunda talaşlı üretim sırasında meydana gelen kas-iskelet sistemi kaynaklı işe devamsızlıkların azaltılması için ergonomi analizi çalışması yapılması hedeflenmiştir. İlk olarak, ergonomik olmayan çalışma koşulları firma içindeki proje ekibi çalışanlarının katıldığı çalıştay sonucunda belirlenmiştir. Belirlenen bu koşullar, yapılacak olan analizin bağımsız değişkenlerini olarak tanımlanmıştır. Bağımlı değişken olarak adlandırılan bölgesel ağrı durumu üzerinde bağımsız değişkenlerin etkisinin analizi için veri toplama aracı olarak Cornell Üniversitesi tarafından geliştirilen "Kas-İskelet Sistemi Rahatsızlık Anketi" kullanılmıştır. Veri analizi kısmında ise, bağımsız değişkenlerin bölgesel ağrı durumu üzerindeki etkileri Lojistik Regresyon Analizi ile IBM SPSS Statistics 25.0 programı aracılığıyla gözlemlenmiştir. İstatistiksel analizden sonra, analiz çıktılarının validasyonu firmanın ilgili ekibinde yer alan çalışanların görüşleri alınarak sağlanmıştır. Çalışmanın uygulama aşamasında firma, üretim çalışanlarının kas-iskelet sistemi kaynaklı devamsızlıklarında karşı önlemler alarak düşüş sağlamayı hedeflemektedir.

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Reducing the Musculoskeletal Disorders-induced Production Employee Absenteeism Through the Cornell Musculoskeletal Discomfort Questionnaire and Ordinal Logistic Regression Model

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ABSTRACT

Today, the overworked workforce situation is getting more prevalent that may result in impair human motivation and health in the workplace. Increased musculoskeletal disorders, especially among production employees, are caused by increased production activities brought on by a more competitive economy. Therefore, the aim of this study is to conduct an ergonomics analysis in order to reduce absenteeism caused by musculoskeletal system disorders during machining in an automotive sub-industrial company. As a consequence of the workshop attended by the relevant project team workers within the company, non-ergonomic working conditions were determined at first. These defined conditions were also specified as the independent variables for the analysis section. The "Musculoskeletal Discomfort Questionnaire," developed by Cornell University, was

***Sorumlu yazar**: deniz.sezer@yasar.edu.tr

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Discomfort Questionnaire, Ergonomics analysis, Logistic Regression Analysis, Musculoskeletal disorders

employed as a data collecting method for the investigation of the effect of independent variables on the dependent variable, local pain status. The effects of independent variables on local pain status were analysed using Logistic Regression Analysis via the IBM SPSS Statistics 25.0 program. Following the statistical examination, the analytical outputs were validated by expert feedback with the company's relevant team workers. In the implementation phase, the company aims to reduce production employee absenteeism due to the musculoskeletal system disorders by taking precautions.

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1. INTRODUCTION *(GİRİŞ)*

Musculoskeletal disorders (MSDs) refer to a group of inflammatory and degenerative diseases and defined by the World Health Organization as "health issues involving the locomotor apparatus, including muscles, tendons, bone skeleton, cartilage, ligaments, and nerves." This includes any form of problem, from little annoyances to permanent and incapacitating traumas." [1]. The low back, neck, shoulder, forearm, and hand are the most typically affected body parts, while the lower extremities have recently garnered greater attention [2]. The number of workers eligible for disability pensions due to musculoskeletal illnesses, has increased dramatically during the previous ten years [3]. Workplace design that ignores ergonomic principles has negative effects for worker health and safety by creating musculoskeletal problems and psychological discomfort [4]. In addition to the unmeasurable human misery, there are higher costs to employers in the form of workers' claims, by causing less productivity, increasing scrap and creating lower manufacturing quality, and finally it creates decrease in the viability of a company [5].

The existing European Union regulatory framework has been used to act in the UK to avoid certain illnesses. Key directives, such as health and safety environment at work, manual handling of equipment, and display screen equipment using, were introduced in 1992 and have played a significant role in raising public awareness and implementing prevention measures across a wide range of industrial sectors [6]. Punnett and Wegman [2] indicate that musculoskeletal disorders are three to four times more common in industries and occupations than in the general population. Heavy and light manufacturing are assessed as high-risk industries in their study. As another aspect, Hiba [7] states that increased productivity and competitiveness can be achieved by improving the working environment and work structure. Additionally, entrepreneurs of small and medium-sized businesses in Asia, Latin America, and Africa have proved this by taking voluntary action to enhance working conditions and production.

The increased automation of the manufacturing processes in the automotive industry, which has assigned much of the assembly to machines, has greatly reduced the stress of heavy lifting on workers [6]. Despite workplace ergonomic improvements, many jobs still demand employees to complete repeated tasks [8]. Therefore, companies need to evaluate their work environment under the view of ergonomic-based potential risk conditions periodically. Ergonomic analyses can be performed in a variety of ways, according to the literature. Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) methods are the most prevalent and appropriate for usage with the other ergonomic assessment methods, used by combined with each other as well. For instance, ergonomic risk assessment of the walker design study developed by Top et al. [9] performed the analyses with both REBA and RULA methods via using Digital Human Modelling (DHM). As another joint-method study, Koç et al. [10] designed an assembly fixture for use in the building of the helicopter transmission and applied Biomechanical Movement Analysis (BMA) methodologies to assess the suitability for ergonomic conditions. As a precedent study for this study's methodology, Salazar and Prasetyo [11] performed the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), RULA, and REBA methods to measure ergonomic risk stemming from employee postures working in wafer industry.

In this study, a company operating in the automotive industry in Turkey is selected for analysis. An ergonomic evaluation matrix is used in this company on parts that are regarded to be ergonomically hazardous. Then, NIOSH, REBA and RULA analyses are carried out based on the outcome by concentrating on the operation. Following these evaluations, manufacturing and other divisions collaborate on improvement studies for activities that necessitate precautions. The workplace doctor's data, on the other hand, shows that Musculoskeletal Disorders account for 52 percent of the reports received by the operators. This issue has highlighted the importance of conducting company-wide research to reduce production employee absenteeism caused by musculoskeletal problems. The aim of this study was constructed based on this problem and, by this aim, the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) has been used to gather data for this study, which was designed to reduce employee absenteeism.

The Cornell Musculoskeletal Discomfort Questionnaire considers the severity and frequency of pain in the body, as well as body postures, gender, and the manner in which labor is performed [12]. CMDQ is a well-designed data gathering tool, which was developed at Cornell University in 1999, musculoskeletal disorders identification [13]. This tool has been used in research involving repetitive actions in a variety of industries. According to Koç and Testik [14], CMDQ's advantages include its low cost, effectiveness, and ability to handle big samples. For all these reasons, the fact that this study targets a real-world problem by considering human health and that it employs a low-cost data collection instrument owing to the CMDQ method are the primary motivators that will set it apart from similar studies.

Following the data gathering, the impacts of the determined independent variables (factors generating musculoskeletal disorders) on dependent variables (local pain states in the body parts) were examined using the logistic regression analysis approach, which is one of the statistical analysis methods. Gathered data stored in an Excel file and then exported to IBM SPSS Statistics 25.0 software to perform logistic regression analysis. The research questions addressed in the statistical analysis part are as follows:

RQ1: Which independent variable causes the most pain in multiple body parts?

RQ2: What are the independent variables that make a significant difference due to body parts?

RQ3: Which independent variables affect the right and left sides of the body parts (e.g., right wrist vs. left wrist) differently?

Section two explains how the Cornell Musculoskeletal Discomfort Questionnaire was used in the study and how the logistic regression analysis was methodologically conducted.

2. METHODOLOGY *(METODOLOJİ)*

In this section of the study, firstly, the structure of the Cornell Musculoskeletal Discomfort Questionnaire used as a data collection tool, some application examples in the literature and its application in the case company are mentioned. Then, the features of logistic regression analysis, which constitutes the statistical analysis methodology of the study, some similar ergonomics studies applied in the literature and its designed structure are presented.

2.1. Cornell Musculoskeletal Discomfort Questionnaire *(Cornell Kas-İskelet Rahatsızlıkları Anketi)*

One-dimensional pain scales may be used for anatomical locations are a frequent and valid way for obtaining pain intensity [15]. These scales, on the other hand, do not consider functional characteristics like occupational activity. The Roland-Morris Disability Questionnaire and the Oswestry Disability Index are two common questionnaires with functional outcomes [16]. However, these tools are only useful for chronic low back pain and limitations in everyday life. Other questionnaires dealing with office work, such as the RSI-QuickScan, focus specifically on problems in the arm and shoulder regions, as well as the neck area [17]. The Nordic Musculoskeletal Questionnaire (NMQ), unlike the RSI-QuickScan, collects data on the presence of musculoskeletal problems in nine important anatomical regions from the neck to the foot.

The Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) collects information on the severity of discomfort as well as the effects of the condition for specific regions of human body [18]. The survey is also a one-page chart that combines the frequency and intensity of musculoskeletal pain and complaints with work-related impairments for 20 body regions [19]. In the literature, there are similar studies applied to CMDQ in the automotive industry. Smets [20] investigated self-reported MSD in the neck and shoulders during the overhead work in automotive assembly. In another study presented by Aziz et al. [21], MSD and ergonomics risk factors are examined by using CMDQ among production team members at an automotive industry. As can be seen in the studies given as examples, similar CMDQ applications have been basically carried out in automotive assembly lines. However, in this study, the machining process, which requires more physical power and repetitive work, is discussed as different from those ergonomics studies.

The CMDQ was chosen as the data collection technique for this study because of the features described above. Within the case company, the production department was found to have the highest rate of absence due to musculoskeletal problems, as well as the highest number of reports received. The male type CMDQ was used because the production department is mostly made up of men employees. The Turkish version of the questionnaire (T-CMDQ) sample presented by Erdinç et al. [13] was used in this section of the study (see Figure 1).

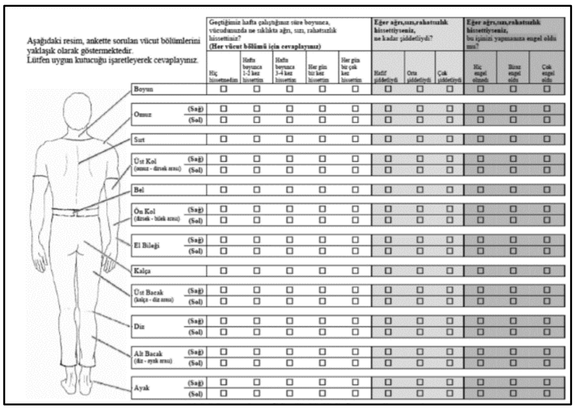

Figure 1. T-CMDQ sample for male employees
(Erkek Çalışanlar için T-CMDQ Örneği) [13]

According to the authors' validated results, the accuracy of the T-CMDQ was satisfactory; Kappa coefficients between Visual Analog Scale (VAS), mostly used in validation of health-related questionnaires, and T-CMDQ responses indicated substantial to almost perfect agreement (ranged between 0.62–0.92 across body parts), and Spearman rank correlation coefficients between VAS scores and T-CMDQ severity scale responses were all significant. Thus, this validation results supported its use in this study.

In addition to T-CMDQ data, demographic and individual data were also collected to examine various aspects of the sample group which are age, marital status, education, job experience in automotive industry, job experience in the case company, height, weight, frequency of sport in a week, average sleep time per day, having a chronic musculoskeletal disorder or not, and overtime in the last fifteen days. These had been also used as independent variables in logistic regression analysis. Independent variables were determined as pain states for each body part included in the T-CMDQ. Three separate questions were asked for each body part to participants. Questioner wanted to select the best suited response and tick a single box from each participant. The questionnaire is provided in the appendix

In section three, additional information about the data collection process with the Cornell Musculoskeletal Discomfort Questionnaire will be presented.

2.2. Logistic Regression Analysis *(Lojistik Regresyon Analizi)*

A classification procedure that uses a set of independent variables to predict a categorical variable is called as logistic regression [22]. Logistic regression analysis use statistics configuration approaches like those used in other models for its purpose. To develop a biologically appropriate model that can define the relationship between dependent and independent variables with the least number of variables possible to attain the greatest fit [23]. Logistic regression is useful for identifying correlations between one or more categorical or continuous predictor variables and a categorical outcome variable. The plot of such data for one continuous predictor X and one dichotomous outcome variable Y in the simplest case of linear regression results in two parallel lines, each corresponding to a value of the binary outcome [24].

The following is an example of a simple logistic regression model [24]:

$$logit(Y) = natural\ log\ (odds) = \ln\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta x. \quad (1)$$

where, β is a regression coefficient and π is the probability of the outcome of interest based on a specific value of x. In this study, Formula 1 is not mentioned in detail because Logistic regression analysis is performed using IBM Statistics SPSS 25.0 software tool.

The dependent variable is categorical in many studies that include demographic and individual data. For example, the dependent variable may be answered as “yes/no” and researcher might be curious about how this variable is related to sex, age, ethnic group, and so on. In this case, multiple linear regression could not be used, and logistic regression analysis is performed. As a result, logistic regression may be thought of as a variant of multiple linear regression that accounts for the fact that the dependent variable is categorical [25]. The independent and dependent variable data categories defined in this study are given in Table 1. Accordingly, logistic regression analysis was applied because all data were categorical. Local pain states independent variable was defined as separate independent variables for each of the body part specified in the T-CMDQ and evaluated as present or absent pain. The numerical value of each variable category specified in the table while being transferred to the SPSS software will be given in the application section of the study.

Table 1. Gathered data categories within the study
(Çalışma Kapsamında Toplanan Veri Kategorileri)

Independent variables	Defined categories
Tonnage in shift	0-15000; 15000-30000; 30000-60000; 130000 and over
Apparatus type	Hydraulic; Mechanic-Hydraulic; Mechanic
Job experience in the industry	Inexperienced; 0-1 year; 1-5 year; 5-10 year; 10 year and over
Job experience in the case company	0-1 year; 1-5 year; 5-10 year; 10 year and over
Body-mass index	15-20; 20-25; 25-30; 30 and over
Sport frequency in a week	Never; Sometimes; 1 day; 2-3 days; 4-5 days; Everyday
Sleep time in a day	Less than 3 hrs; 3-4 hrs; 5-6 hrs; 7-8 hrs
Overtime during the last fifteen days	Yes; No
Local pain status in a week	Never; 1-2 times; 3-4 times; Only one time in each day; Several times in each day

According to literature research, it was detected that logistic regression analysis was commonly used in similar MSD studies. Abledu and Abledu [26] applied multiple logistic regression analysis to investigate the prevalence and predicted characteristics of MSDs. As another study presented by Ling et al. [27], they used binary logistic regression is beneficial for the determining significant factors for MSDs development among back-end workers. Alexopoulos et al. [28] investigated the relationships between physical, psychological, and individual variables and several endpoints of musculoskeletal complaints of the low back, neck, shoulders, and hand/wrist using logistic regression analysis. In MSD investigations, different types of logistic regression analysis are performed, as demonstrated in the literature.

Within this study, Warner's work [29] on ordinal logistic regression was the source of inspiration for the study's statistical analysis method. As statistical aspect, the author mentioned that when a dependent variable only has two possible values (e.g., yes or no), binary logistic regression is typically used to test or model the relationship between that answer and a number of potential causal variables, with each relationship assessed in terms of an odds ratio (OR). On the other side, when such dependent variable is categorical and has more than two possible values, multinomial logistic regression is used. Ordinal logistic regression is a sort of multinomial regression that is particularly useful when the response variable is ordinal. Moreover, according to Warner's study, ordinal response variables are popular in medical research. For instance, a pain score could be recoded to "some discomfort" rather than "none" or "severe pain" rather than the rest which can be claimed as ordinal logistic regression's study scope aspects.

The dependent and independent variable categories identified in this study (see Table 1) both comply with the ordinal logistic regression features and are the recommended analysis approach in the evaluation of local pain state, as similar in the Warner's study, for all of the reasons described above. In section three, the data collection of the study with T-CMDQ and the implementation of ordinal logistic regression through IBM Statistics SPSS 25.0 software will be discussed.

3. RESULTS AND DISCUSSION (*BULGULAR VE TARTIŞMA*)

This study focuses on the investigate the ergonomics problems in order to decrease absenteeism caused by musculoskeletal system disorders in the automotive sub-industrial company. For the achieve these purposes, ordinal logistic regression is carried out based on Musculoskeletal Discomfort Questionnaire results.

The project conducted in the four stages. At the first stage, the field studies were carried out to determine employees' ergonomic conditions and to take initial actions for the first findings obtained as a result of the field studies. This stage is beginning with the explaining the project objectives to the operators. Understanding the project objectives by the operators is important for the project to proceed properly. In the first stage, various problems are identified in this stage. The first of the problem is unnecessary stretching motion. It has been observed that the operators frequently stretch to the apparatus to connect and disassemble parts during their working periods. Besides, another problem determined as an unnecessary bending over. Operators have to bend while picking up and leaving the part from the pallet. In addition to that, it has been observed that when the apparatus used in the benches is not ergonomic, it causes working at or above the shoulder level. The final problem of this stage is identified as the number of handlings which is important for ergonomically. The weight of the part and the difficulty of holding emerged as a problem to be dealt with. After the operators take the part from the bench, cleaning the burrs and chips remaining on the part need to be conducted. However, due to the design of the countersink gun used during this process, the operator performs movements that are not suitable for ergonomic conditions such as turning the wrist and lifting the gun. Based on the root cause analysis, it can be stated that the non-ergonomic design of the apparatus has been caused bending and stretching problem. In addition, the use of unsuitable covers and non-ergonomic hand tools such as sandpaper, file, wrench, countersink also caused unergonomic conditions for the operators.

Then, in the second stage, based on the field studies that analyse non-ergonomic conditions, questionnaire was conducted to employees. There are welding, assembly, paint shop and machining departments in the case company. The questionnaire was applied to all operators working in the machining workshop, since the production in the company is carried out intensively in the machining stage and most of the ergonomic problems mostly occur in this stage. Thus, it is important to suggest improvement for the enhancing ergonomic environment. In order evaluate of local pain state, the questionnaire was applied to 92 operators in a total of 2 weeks. Survey includes demographic data of employees, general information about employee's and Cornell survey analysis, which is used to assess of local pain state in this study.

For the third stage of this study, ordinal logistic regression analysis was used in order to model employees' local pain status based on the questionnaire. Independent variables are determined as a tonnage in shift which is consist of multiplying the number of shifts with the part weight and the number of handling, apparatus type which are machining, mechanical and hydraulic, job experience in the industry, job experience in the case company, body-mass index, sport frequency in a week, sleep time in a day, overtime during the last fifteen days; and dependent variable is the determined as a local pain status in a week. The final stage, the results and appropriate implications are suggested based on the regression analysis.

Frequency and percentage distributions of the model inputs are presented in the Table 2. According to the table 2, although 56% of the employees have experience in the industry, approximately 56% of them have less than 1-year experience in the case company. Besides, 87 % percent of the employees have been exposed to shift tonnage a more than 15000 kg in one shift. Besides, 62 % of the employees either do not do sports at all or rarely do sports. Almost 70 % of employees have done overtime during the last fifteen days.

Based on the effects of independent variables that mentioned before on the local pain status, ordinal logistic regression model is developed. The ordinal logistic regression analysis classified into four levels for local pain status. Table 3,4,5,6,7,8,9,10,11,12 and 13 presents the results of the ordinal logistic regression models based on local pain status.

According to the Table 3, while tonnage in shift and job experience in the industry was a significant predictor (p-value = 0.029 and p-value=0.013) in the ordinal regression model based on the wrist pain (right); apparatus type, job experience in the case company, body-mass index, sport frequency in a week, sleep time in a day, overtime during the last fifteen days was not a significant predictor in the regression model (p-value ≥0.05). Based on the table 4, Overtime during the last fifteen days was determined as a significant predictor (p-value = 0.019) for the ordinal regression model based on the left wrist pain. The others variable was not a significant predictor for left wrist pain status.

Table 5 presents output of the ordinal regression model considering the upper leg pain (right). Job experience in the industry is a significant predictor for the model (p- value = 0.041). According to the Table 6, while apparatus type was a significant predictor (p-value = 0.037) in the ordinal regression model for the right knee pain. The other predictors were not significant in this regression model (p-value ≥0.05). Table 7 showed output of the ordinal regression model based on the lower leg pain (right). Tonnage in shift and Body-mass index are significant predictor for the model (p- value = 0.023; p-value= 0.042).

Based on the Table 8 and 9, the one significant predictor which is body-mass index is determined (p-value = 0.004 and p- value= 0.001) in the ordinal logistic regression model for the foot pain (right) and the foot pain (left). Output of the ordinal regression model based on the neck pain are presented in the table 10. It indicated that job experience in the industry and job experience in the case company are significant predictor (p-value = 0.014 and p- value= 0.037) for the model. Based on the table 11, it can be seen that apparatus type is a significant predictor for the upper arm pain (p-value= 0.043). According to the table 12, tonnage in shift and overtime during the last fifteen days are significant predictors for the ordinal logistic regression model (p-value = 0.029 and p-value= 0.030). Based on the output of the ordinal regression model based on the forearm pain (right), apparatus type is determined as a significant predictor for the regression model.

According to the results, tonnage in shift is significant predictor for the wrist pain and lower leg pain. This shows us that the amount of tonnage carried by the operator increases pain score. In order to deal with this problem, the tonnage should be calculated for each operator based on tonnage and the job scheduling and job matching should be done according to tonnage that will provide ergonomic conditions [30,31]. 'Apparatus Type' is significant predictor for the right knee pain, upper arm pain (right), and forearm pain (right). While designing the apparatus, ergonomics should also be considered, and models should be standardized by the company, hand tools should be selected considering ergonomic conditions, and the use of torque guns should be expanded in the company [32, 33]. Overtime during the last fifteen days is determined as a significant predictor for the wrist pain (left) and low back pain. Thus, the firm should plan a more efficient working arrangement for employees [34]. Job experience in the industry and the case company is significant predictor for the upper leg pain and neck pain. Therefore, the company should provide effective on-the-job training [35]. With these improvements, it is aimed to prevent Musculoskeletal Disorders in the case company.

Table 2. Frequency and percentage distributions of the model inputs *(Model girdilerinin frekans ve yüzde dağılımları)*

Variable	**Categories**	**Frequency**	**Percentage**
Tonnage in shift	[0–14999]	12	13.0
	[15000–29999]	30	32.6
	[30000–59999]	40	43.5
	≥130000	10	10.9
Job experience in the industry	Inexperienced	1	1.1
	[0–1]	12	13.0
	[2–4]	16	17.4
	[4–9]	12	13
	≥10	51	55.4
Body-mass index	[15–19]	8	8.7
	[20–24]	39	42.4
	[25–29]	40	43.5
	≥30	5	5.4
Job experience in the case company	[0–1]	51	55.4
	[2–4]	8	8.7
	[4–9]	7	7.6
	≥10	26	28.3
Sport frequency	None	17	18.5
	Once in a while	40	43.5
	1 time per week	13	14.1
	2-3 times a week	15	16.3
	4-5 times a week	6	6.5
	Everyday	1	1.1
Overtime during the last fifteen days	No	64	69.6
	Yes	28	30.4
Sleep time in a day	0	1	1.1
	less than 3 hours	4	4.3
	3-4 hours	47	51.1
	5-6 hours	38	41.3
	7-8 hours	2	2.2

Table 3. Output of the ordinal regression model based on the wrist pain (right) *(Sağ Bilek ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Wrist pain (right)	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	.572	.029*	.059	1.086
Apparatus type	.508	.119	-.132	1.148
Job experience in the industry	-.548	.013*	-.979	-.118
Job experience in the case company	.248	.244	-.169	.666
Body-mass index	.146	.636	-.457	.749
Sport frequency in a week	-.148	.399	-.491	.195
Sleep time in a day	-.134	.672	-.756	.487
Overtime during the last fifteen days	-.901	.057	-1.829	.026

Table 4. Output of the ordinal regression model based on the wrist pain (left) *(Sol Bilek ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Wrist pain (left)	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	.451	.107	-.097	1.000
Apparatus type	.657	.061	-.030	1.344
Job experience in the industry	-.150	.523	-.610	.310
Job experience in the case company	.083	.717	-.366	.533
Body-mass index	.265	.443	-.413	.944
Sport frequency in a week	-.247	.200	-.623	.130
Sleep time in a day	.428	.232	-.274	1.131
Overtime during the last fifteen days	-1.270	.019*	-2.332	-.208

Table 5. Output of the ordinal regression model based on the upper leg pain (right) *(Sağ Üst Bacak ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Upper leg pain (right)	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	.172	.669	-.617	.962
Apparatus type	.489	.419	-.697	1.675
Job experience in the industry	-.964	.041*	-1.890	-.038
Job experience in the case company	.812	.085	-.111	1.735
Body-mass index	1.000	.063	-.056	2.055
Sport frequency in a week	-.161	.608	-.777	.454
Sleep time in a day	.012	.984	-1.191	1.216
Overtime during the last fifteen days	-.525	.515	-2.105	1.055

Table 6. Output of the ordinal regression model based on the right knee pain *(Sağ Diz ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Right knee pain	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	.747	.106	-.158	1.653
Apparatus type	1.285	.037*	.077	2.492
Job experience in the industry	-.652	.122	-1.479	.174
Job experience in the case company	.839	.053	-.010	1.687
Body-mass index	1.076	.077	-.115	2.266
Sport frequency in a week	-.071	.810	-.645	.504
Sleep time in a day	-.270	.657	-1.463	.923
Overtime during the last fifteen days	-2.010	.050	-4.022	.002

Table 7. Output of the ordinal regression model based on the lower leg pain (right) *(Sağ Alt Bacak ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Lower leg pain (right)	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	1.224	.023*	.171	2.276
Apparatus type	-.010	.988	-1.378	1.357
Job experience in the industry	-.723	.177	-1.771	.326
Job experience in the case company	.676	.196	-.348	1.700
Body-mass index	1.380	.042*	.051	2.709
Sport frequency in a week	-.103	.764	-.777	.570
Sleep time in a day	.584	.402	-.781	1.950
Overtime during the last fifteen days	-1.175	.256	-3.203	.852

Table 8. Output of the ordinal regression model based on the foot pain (right) *(Sağ Ayak ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Foot pain (right)	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	.032	.912	-.540	.604
Apparatus type	.103	.798	-.684	.890
Job experience in the industry	-.112	.662	-.613	.389
Job experience in the case company	-.150	.557	-.652	.352
Body-mass index	1.191	.004*	.384	1.999
Sport frequency in a week	-.343	.127	-.783	.097
Sleep time in a day	.069	.859	-.692	.830
Overtime during the last fifteen days	-.369	.499	-1.441	.702

Table 9. Output of the ordinal regression model based on the foot pain (left) *(Sol Ayak ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Foot pain (left)	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	.016	.958	-.560	.591
Apparatus type	.119	.768	-.670	.907
Job experience in the industry	.051	.844	-.456	.557
Job experience in the case company	-.318	.226	-.834	.197
Body-mass index	1.386	.001*	.531	2.241
Sport frequency in a week	-.327	.143	-.764	.111
Sleep time in a day	.200	.612	-.573	.972
Overtime during the last fifteen days	-.694	.223	-1.810	.422

Table 10. Output of the ordinal regression model based on the neck pain *(Boyun ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Neck pain	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	-.291	.251	-.789	.206
Apparatus type	-.035	.918	-.690	.620
Job experience in the industry	-.587	.014*	-1.054	-.121
Job experience in the case company	.470	.037*	.029	.911
Body-mass index	.223	.474	-.389	.836
Sport frequency in a week	-.176	.349	-.544	.192
Sleep time in a day	.146	.656	-.498	.790
Overtime during the last fifteen days	-.719	.138	-1.670	.231

Table 11. Output of the ordinal regression model based on the upper arm pain (right) *(Sağ Üst Kol ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Upper arm pain (right)	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	-.220	.488	-.842	.402
Apparatus type	.842	.043*	.027	1.657
Job experience in the industry	-.158	.578	-.715	.399
Job experience in the case company	.201	.432	-.301	.704
Body-mass index	.193	.638	-.609	.994
Sport frequency in a week	-.250	.272	-.696	.196
Sleep time in a day	.447	.310	-.416	1.310
Overtime during the last fifteen days	.304	.582	-.780	1.389

Table 12. Output of the ordinal regression model based on the low back pain *(Bel ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Low back pain	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	-.535	.029*	-1.016	-.054
Apparatus type	.103	.736	-.496	.701
Job experience in the industry	-.043	.835	-.444	.358
Job experience in the case company	-.073	.712	-.460	.314
Body-mass index	.329	.269	-.255	.912
Sport frequency in a week	-.041	.802	-.365	.282
Sleep time in a day	-.033	.912	-.621	.554
Overtime during the last fifteen days	-.963	.030*	-1.835	-.091

Table 13. Output of the ordinal regression model based on the forearm pain (right) *(Sağ Ön Kol ağrısı baz alınarak oluşturulan regresyon modelinin çıktısı)*

Forearm pain (right)	Estimate	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Tonnage in shift	.279	.391	-.359	.917
Apparatus type	1.048	.017*	.190	1.907
Job experience in the industry	-.480	.100	-1.052	.092
Job experience in the case company	.479	.100	-.092	1.051
Body-mass index	.434	.288	-.367	1.236
Sport frequency in a week	-.116	.603	-.554	.322
Sleep time in a day	.088	.841	-.770	.945
Overtime during the last fifteen days	-1.195	.070	-2.486	.097

4. CONCLUSIONS (*SONUÇLAR*)

Recently, companies attach importance to ergonomic analyses to increase employee motivation and improve their performance. Moreover, companies want to investigate working conditions that can affect the performance of employees in the firm. Therefore, the aim of this study is to conduct an ergonomics analysis to reduce absenteeism caused by musculoskeletal disorders during machining in an automotive supplier industry.

For this purpose, the "Cornell Musculoskeletal Discomfort Questionnaire (DMDQ)" was used for the data collecting stage to analyse the effect of independent variables on the dependent variable. In this study, independent variables are determined as a tonnage in shift, apparatus type, job experience in the industry, job experience in the case company, body-mass index, sport frequency in a week, sleep time in a day, overtime during the last fifteen days; and dependent variable is the determined as a local pain status in a week. Then, the effects of independent variables on local pain status were modelled through Logistic Regression Analysis.

According to the results, firstly tonnage in shift is significant predictor for the wrist pain and lower leg pain. Besides, Apparatus Type is significant predictor for the right knee pain, upper arm pain (right), and forearm pain (right). also, overtime during the last fifteen days is determined as a significant predictor for the wrist pain (left) and low back pain. Finally, job experience in the industry and the case company is significant predictor for the upper leg pain and neck pain.

Thus, this study is beneficial to investigate reducing absenteeism caused by musculoskeletal system disorders during machining in the case company. In terms of the used methodology, CMDQ provides a low-cost data gathering, easy marking and clearly understandable questions to use among employees, and ability to additional sample in a short time. Based on the suggested results, the company has made several improvements that have led to an increase in productivity in the company and increase employee's motivation. These improvements can be summarized as follows; in the packaging department, a one-piece flow started to be used instead of mass production. In addition, it has been observed that the use of unsuitable pallets and non-ergonomic hand tools such as sandpaper, files, wrenches, countersinks also have led to pain on the operators. Thus, in order to prevent Musculoskeletal Disorders in the case company, the material handling amount was reduced by 50% with the conveyor. A field analysis is carried out to make improvements for the types of apparatus and pallet. Ergonomically unsuitable apparatus was determined and improvements were conducted through the kaizen method. In order to improve ergonomic conditions, job matching of employees should be based on tonnages and the company should plan a more efficient working order for its employees. Besides, workshops are organized in the company with the participation of different departments in order to reduce the bending and stretching. The awareness of workers and employer was increased by giving ergonomics training in the company.

As a limitation of this study, it can be considered that it was carried out in an automotive supplier industry case company. Therefore, this study cannot be generalized for other sectors and other companies since ergonomic problems that occur within the case company are discussed in this study. Besides, limited number of parameters are included in the regression model and thus the study can be expanded by adding different parameters.

CONFLICT OF INTEREST STATEMENT *(ÇIKAR ÇATIŞMASI BİLDİRİMİ)*

The author declare that there is no conflict of interest.

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APPENDIX (EKLER)- EK 1. EGE FREN ERGONOMİ DEĞERLENDİRME ANKETİ

EGE FREN ERGONOMİ DEĞERLENDİRME ANKETİ

*Son 15 gün içerisinde çalıştığınız yerler için doldurulmalıdır.

Parça No:

Aparat Türü:

El aleti Kullanımı:

Tezgâh Bilgisi:

KIŞISEL BILGILER

Yaş: _______

Medeni Durum: ☐ Bekâr ☐ Evli

Eğitim Durumu: ☐ İlkokul ☐ Ortaokul ☐ Lise ☐ Üniversite

Sektörde Çalışma Süresi(ay/yıl belirtiniz): _______

EGE FREN 'de Çalışma Süresi(ay/yıl belirtiniz): _______

Boy: _______ cm

Kilo: _______ kg

Sigara kullanıyor musunuz?: ☐ Evet ☐ Hayır

Ne sıklıkla spor yapıyorsunuz?:

☐ Haftada 1 kez ☐ Haftada 2-3 kez ☐ Haftada 4-5 kez ☐ Her gün ☐ Arada bir ☐ Hiç

Günde ortalama kaç saat uyursunuz?:

☐ 3 saatten az ☐ 3-4 saat ☐ 5-6 saat ☐ 7-8 saat ☐ 8 saatten fazla

Son 6 aydır sürekli devam eden Kas İskelet Sistemi Rahatsızlığınız mevcut mu?
(Yanıtınız evet ise rahatsızlığınızı yazınız.)

☐ Hayır ☐ Evet; ____________________

Ege Fren'de çalışmaya başlamadan önce sahip olduğunuz kronik rahatsızlığınız var mı?
(Yanıtınız evet ise rahatsızlığınızı yazınız.)

☐ Hayır ☐ Evet; ____________________

Son 15 gün fazla mesai yaptınız mı? (Yanıtınız evet ise süresini yazınız.)

☐ Hayır ☐ Evet; ____________________

Son 3 ay fazla mesai yaptınız mı? (Yanıtınız evet ise süresini yazınız.)

☐ Hayır ☐ Evet; ____________________

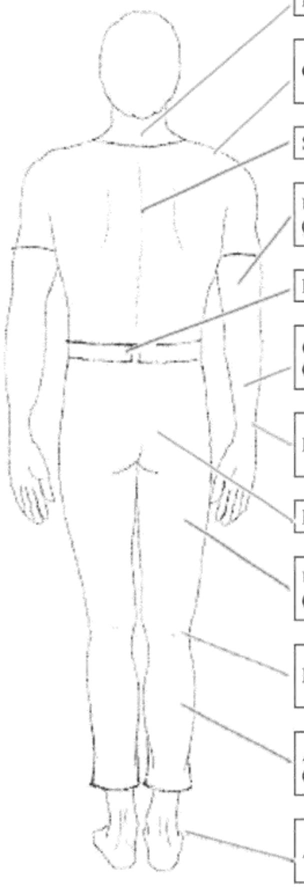
Son 6 ayda Kas İskelet Sistemi Rahatsızlığından dolayı rapor aldınız mı? (Yanıtınız evet ise süresini yazınız.)

☐ Hayır ☐ Evet; ____________________

Son 15 gün iş dışında güç sarf edilen bir aktivitede yer aldınız mı? (Örn: eşya taşıma, futbol oynama vb.)
(Yanıtınız evet ise ne olduğunu yazınız.)

☐ Hayır ☐ Evet; ____________________

Aşağıdaki resim, ankette sorulan vücut bölümlerini yaklaşık olarak göstermektedir.
Lütfen uygun kutucuğu işaretleyerek cevaplayınız.



		Geçtiğimiz hafta çalıştığınız süre boyunca, vücudunuzda ne sıklıkta ağrı, sızı, rahatsızlık hissettiniz? **(Her vücut bölümü için cevaplayınız)**					**Eğer ağrı,sızı,rahatsızlık hissettiyseniz,** ne kadar şiddetliydi?			**Eğer ağrı,sızı,rahatsızlık hissettiyseniz,** bu işinizi yapmanıza engel oldu mu?		
		Hiç hissetmedim	Hafta boyunca 1-2 kez hissettim	Hafta boyunca 3-4 kez hissettim	Her gün bir kez hissettim	Her gün bir çok kez hissettim	Hafif şiddetliydi	Orta şiddetliydi	Çok şiddetliydi	Hiç engel olmadı	Biraz engel oldu	Çok engel oldu
Boyun		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Omuz	**(Sağ)**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Sol)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sırt		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Üst Kol (omuz - dirsek arası)	**(Sağ)**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Sol)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bel		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ön Kol (dirsek - bilek arası)	**(Sağ)**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Sol)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
El Bileği	**(Sağ)**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Sol)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kalça		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Üst Bacak (kalça - diz arası)	**(Sağ)**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Sol)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Diz	**(Sağ)**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Sol)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Alt Bacak (diz - ayak arası)	**(Sağ)**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Sol)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ayak	**(Sağ)**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Sol)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐