INVESTIGATION OF ERGONOMIC RISKS IN MANUFACTURING SECTOR USING QUICK EXPOSURE CHECK METHOD

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ABSTRACT

INVESTIGATION OF ERGONOMIC RISKS IN MANUFACTURING SECTOR USING QUICK EXPOSURE CHECK METHOD

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Ergonomic risks are prevalent in the manufacturing industry due to the nature of the daily tasks completed by employees. Injuries and musculoskeletal disorders that result from poor ergonomics are some of the most commonly observed and severe kind of injuries in manufacturing. Therefore, investigating ergonomic risks towards improvement of the workplace is critically important for decreasing lost times and increasing effectiveness of the workforce. Ergonomic risk analysis is essential to specify the factors that potentially cause musculoskeletal disorders and to generate control strategies.

The main objective of this research study is to investigate ergonomic risks in the manufacturing industry. The elements of this main objective include identifying the sources of hazards that do not comply with the ergonomic nature of employees and determining the control actions to eliminate MSDs and risk sources resulting from inappropriate working conditions. Research methodology followed in this study has three main stages. At first ergonomic risks are investigated using Quick Exposure Check method by making observation. Then, the collected data via questionnaires are analyzed and risk assessment is carried out. Finally, essential potential counter-measures are recommended in order to eliminate or reduce the ergonomic risks.

Research findings and obtained results revealed that the majority of the CNC-5 axis multi-spindle operators got very high exposure scores in their back, shoulder/arm and neck part of body and technologically advanced machines significantly reduces ergonomic risk levels. The expected contribution of this research study is applying QEC methodology in manufacturing sector to identify the potential risks and propose improvements to eliminate these risks.

Keywords: Ergonomics, Quick Exposure Check Method (QEC), Musculoskeletal Disorder, Occupational Health and Safety, Manufacturing Sector

ÖZ

İMALAT SEKTÖRÜNDE ÇALIŞANLAR ÜZERİNDEKİ ERGONOMİK RİSKLERİN HIZLI MARUZİYET DEĞERLENDİRME METODU İLE İNCELENMESİ

İnalçuk, Ecem
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Ergonomik riskler, imalat sektöründe çalışanların günlük işlerinin doğası gereğince oldukça yaygındır. Kötü ergonomik koşullardan kaynaklanan yaralanmalar ve kas-iskelet sistemi hastalıkları, bu sektörde çok sık karşılaşılan ciddi sağlık sorunlarındandır. Bu nedenle, çalışma şartlarının iyileştirilmesine yönelik, kayıp iş sürelerini azaltmak ve işgücünün verimliliğini artırmak için ergonomik risklerin araştırılması kritik önem arz eder. Ergonomik risk analizi, kas-iskelet sistemi hastalıklarına sebep olabilecek faktörlerin belirlenebilmesi ve kontrol stratejilerinin oluşturulması için önemlidir.

Bu tezin amacı, ergonomik risklerin imalat sanayiinde çalışanlar üzerindeki potansiyel etkilerini araştırmaktır. Bu hedef doğrultusunda, çalışanların ergonomik doğasına aykırı risk etmenlerinin saptanması ve uygunsuz çalışma koşulları kaynaklı risk faktörlerinin ve MSD'leri ortadan kaldırabilmek için gerekli kontrol faaliyetlerinin belirlenmesi için çalışmalar yapılmıştır. Çalışmada izlenen araştırma metodu üç aşamadan oluşmaktadır. İlk aşamada, ergonomik riskler, Hızlı Maruziyet Değerlendirme metodu kullanılarak araştırılmıştır. Sonrasında, toplanan anket

formları analiz edilerek risk değerlendirmesi yapılmıştır. Son olarak ise, tespit edilen ergonomik riskleri ortadan kaldırmak için gerekli iyileştirmeler önerilmiştir.

Araştırma bulguları ve elde edilen sonuçlar, CNC-5 eksenli çoklu işleme operatörlerinin çoğunun sırt, omuz/kol ve boyun kısımlarında çok yüksek maruziyet puanlarına sahip olduğunu ve teknolojik olarak gelişmiş makinelerin ergonomik risk seviyelerini önemli ölçüde azalttığını ortaya koydu. Bu araştırmanın beklenen katkısı, imalat sektöründe çalışanlar üzerinde Hızlı Maruziyet Değerlendirme metodolojisini uygulayarak potansiyel riskleri tanımlamak ve bu risklerin ortadan kaldırılabilmesi için iyileştirmeler önermektir.

Anahtar Kelimeler: Ergonomi, Hızlı Maruziyet Değerlendirme Metodu (HMD), Kas İskelet Sistemi Hastalıkları, İş Sağlığı ve Güvenliği, İmalat Sektörü

To my great parents, who never stop giving of themselves

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CHAPTER 1

INTRODUCTION

1.1. Background Information

Occupational Health and Safety (OHS) aims to secure the health and safety of workers and workplaces by eliminating or minimizing the risks that workers are exposed while performing their job. In order to ensure the health and safety of the workers in the workplace, it is essential to provide the tools and equipment needed for the methods, to give education and training to workers, to implement health and safety policy in order to eliminate the risks. The main purpose of OHS studies is to provide the safety of employees and to ensure the integrity of the soul and body by protecting the employees against occupational accidents and occupational diseases.

> *"Any illness associated with a particular occupation or industry. Such diseases result from a variety of biological, chemical, physical, and psychological factors that are present in the work environment or are otherwise encountered in the course of employment"* (Kazantzis, 2019).

As it is mentioned in Encyclopedia Britannica, it is demonstrated that the diseases occur due to exposure to hazards at the workplace and the correlation between the exposures. In addition to these factors, there are many components of the work environment mostly psychological factor basis that may affect workers' health.

These components are workplace culture, organizational policies, psychological job demands, job control, work schedule and control over the working time, job rewards, organizational justice, working norms and social support, and union status (Sorensen *et al*., 2011).

According to the European Agency of health and safety at work, Musculoskeletal Disorders (MSDs) are injuries and disorders that are commonly observed as occupational disease in industry sector, which affect the musculoskeletal system for the human's locomotor apparatus such as tendons, nerves, blood vessels, the skeleton, muscles. (Schneider *et al*., 2010)

MSDs are affected by physical, biomechanical, organizational, psychosocial and individual factors. When the more risk factors are combined within the same job, then the risk of MSDs increases (Hagberg and Kuorinka, 1997). These factors are examined under three headings: ergonomic, psychosocial, and individual factors. Owing to lots of studies has been done since physical measures that can be taken against such factors give direct and quick results, it can be deduced that it is easier to eliminate ergonomic factors rather than other factors.

In terms of disability pensions and benefits, MSDs are fundamental causes of disability and as such result in significant costs.

- Austria: It was reported in literature, it shows that 35% of all new disability pensions stem from the Musculoskeletal Conditions (MSCs) in 2001 (Lang *et al*., 2003).

- Spain: As it was reported in the section, 18% of disability pension due to MSCs in 2007 (OECD, 2007).

- The Netherlands: In 2010, nearly one of three of all new allowances for work disability were expensed for MSDs (Netherlands, 2013).

- Belgium: In 2009 data, diseases of the 'locomotor' system were the main reason of invalidity of male employees with 28%, for female employees this number is slipped to 27% (Belgian National Institute for Sickness and Invalidity Insurance, 2007).

- The U.K.: As it was written in articles, 38% of employee was claiming Disability Living Allowance (DLA) were doing so because of musculoskeletal conditions, in 2010. DLA is given to whom needs for extra care or mobility as a result of disability (Department of Work and Pensions, 2011).

In Europe, one out of every four employees complains of back pain (24.7%) and muscle pain (22.8%), and stress (22.3%). 85% of the UK workers think that the risk of illness and injury is mostly in the musculoskeletal system. 74% of employees report a known stress risk that is closely related to MSDs (Irastorza, X. and Schneider E. 2007). Furthermore, almost 40 million workers in Europe suffer from MSDs of the limbs and the back; according to Eurostat (2010), these disorders account for almost 60% of work-related health problems, and are therefore the most common occupational disease in the European Union (EU).

When the records of musculoskeletal disorders are analyzed in Turkey, on the contrary the results can be observed in Table 1.1 (UHY-ME Çalışması, 2000). This following table carried out show the Disabled life expectancy (DALY) distribution of the common known disease groups such as cardiovascular diseases, injuries, cancer, *etc*. by gender and also the total percentages.

Table 1.1. *DALY Distribution of Major Disease Groups by Gender in National Diseases*

Diseases	Total DALY	%	Man DALY	%	Woman DALY	%
Cardiovascular	2.086.527	19.32	1.161.702	20.51	924.825	18.00
Neuropsychiatric	1.437.956	13.31	672.407	11.87	765.548	14.90
Other Inf. Diseases	1.206.637	11.27	590.239	10.42	616.398	11.99
Injuries	1.165.807	10.79	830.754	14.67	335.053	6.52
Maternal and Perinatal	1.084.718	10.04	500.691	8.84	584.027	11.36
Cancer	731.077	6.77	431.337	7.62	299.740	5.83
Disease of Respiratory System	675.876	6.26	352.616	6.23	323.260	6.29
Musculoskeletal System	485.459	4.49	225.394	3.98	260.065	5.06

According to the DALY distribution shown in the table above, Musculoskeletal System Diseases were recorded as 4.49% for total DALY. Due to the lack of records in Turkey, a low percentage of related diseases was observed (Table 1.1).

1.2. Problem Statement

In spite of developing technology, MSDs are gradually increasing in terms of the works based on manpower. This leads to inefficiency in the work of the employees, which causes enterprises to have no difficulty in living and losing their jobs.

When the Social Security Institution (SSI) of Turkey examined statistics in 2016, the number of occupational accidents in 2016 was 286.068 and it was increased by 11.8 percent compared to 2015. In addition, 21 of 597 registered occupational disease cases are associated with MSDs, which means 3.5% of accidents are related to MSDs (TMMOB Report, 2018).

MSDs constitute a considerable amount of occupational diseases. Since they are based on manpower, one of the main causes of these disorders is due to the lack of ergonomics. In order to take precautions without any possible discomfort, ergonomic risk analysis of the study should be done and the factors that cause physical strain on the human should be specified and in order to eliminate these factors corrective measures should be found.

In that case, at the end of the study, after getting data and evaluating the scores, suitable solutions are recommended. It is expected that these solutions like using special mechanical tools can help to reduce the ergonomic risks for the MSDs. Besides that, it can also be obtained that high number of MSDs are seen in manufacturing industry where manpower is used compared to employees working in the companies with technological development.

1.3. Objectives and Scopes of the Study

The main objective of this study is to determine the ergonomic risks of the employees by applying the risk analysis method and to analyze the risks that they are exposed to and to determine what can be done to reduce or even prevent these risks.

The scope of this research study covers the works in a manufacturing sector located in Ankara, in the period between May 2018 and June 2018. This survey has been applied to employees in the target company where ergonomic risks can be observed most frequently.

The application of the method is performed by both the observer and the employee. Seven of the questions are based on observation and eight of them based on employees answers directly. The main goal of the study is to identify the cause of the problem with following objectives:

- To identify the sources of hazards that do not comply with the ergonomic nature of employees

- To determine what can be done to eliminate MSDs and risk sources resulting from inappropriate working conditions.

1.4. Research Methodology

Research methodology of the study includes three main stages. As the beginning, before detecting the problem extensive literature survey is done. The prepared questionnaire is used in the survey.

The following stage is establishing the method to find how to analyze the main risk factor. As a result of finding the answer of the question, the Quick Exposure Check (QEC) method is decided to be implemented in order to collect data. QEC is a quantitative risk assessment method with scientific validity and reliability, which provides an easy way to analyze. Since quantitative data is more efficient, able to test hypotheses it is found more suitable for the survey (Miles and Huberman, 1994).

At the last stage, after the method is implemented to 47 employees who works in manufacturing industry in different departments, the analyze is done with the help of the Scale of QEC method which is a numerical method including observation and reporting of the evaluation of musculoskeletal risk assessments of observers and workers and obtaining their results.

1.5. Thesis Outline

This thesis comprises of five chapters. Chapter 1 is starting with introduction part including why the ergonomic risks is important in OHS. Following the introductory chapter, previous studies about occupational health and safety and ergonomic risks in manufacturing industry is introduced in Chapter 2. In order to understand the impacts of ergonomic risks, QEC method is clarified in detail with the comparing stages in Chapter 3. Results and discussions are presented comprehensively within Chapter 4. Conclusions and recommendations about the results of study are exhibited in Chapter 5. In this chapter, findings are reviewed and implications are mentioned to draw idea for other studies.

1.6. Expected Contributions of the Study

In this research, it is aimed to determine the ergonomics of the employees by implementing a method named Quick Exposure Check Method and analyzing the risks that can be observed in manufacturing plant. Although numerous works are done with this method, this research helps to find the risks in detail about musculoskeletal diseases and to guide administration to design efficient tool in order to reduce the most common risks in employees.

By investigating the results of the study and the survey results, the relationship between MSDs risks and cause of ergonomic risks in the manufacturing industry are demystified. The information obtained as a result of a comprehensive literature study is put into a conceptual framework and the practical results of theoretical knowledge are provided by the field research.

On the other hand, understanding the risks that employees can be exposed, is vital to predicting the future trend of accidents and occupational diseases. As a result, getting data after application of the method, it is realized that this type of accidents can be controlled and then financial and moral gains have been achieved at the manufacturing industry

CHAPTER 2

LITERATURE SURVEY

2.1. Occupational Health and Safety in Manufacturing Industry

The techniques in manufacturing industry have been improved due to rapid improvements in science and technology day by day. Due to this growth, number and frequency of work-related accidents and diseases are increased, so the manufacturing industry is recognized as a prior sector for occupational health and safety. In this manner, it assumes a significant role in both developed and developing countries. Therefore, it can be demonstrated that in all literature review of occupational health and safety, particular consideration was given for the manufacturing industry.

Since the manufacturing industry is labor-intensive and requires the use of various heavy and risky types of gear and use of machines with hands and bodies, the frequencies of word-related risks in the assembling business are essentially higher than those in different industries. As a result of these risks, Musculoskeletal Disorders (MSDs) are frequently observed and they were reported to account for 33% of all workplace injuries and diseases. However, with the use of ergonomic interventions, efforts to reduce the risk of MSDs among steel manufacturers remain limited (Dagenais *et al*., 2008).

As observed in Figure 2.1 when the world trade is taken into consideration, in the industrial sector, the manufacturing industry started to have an important place especially s after 1980s (WTO,2007).

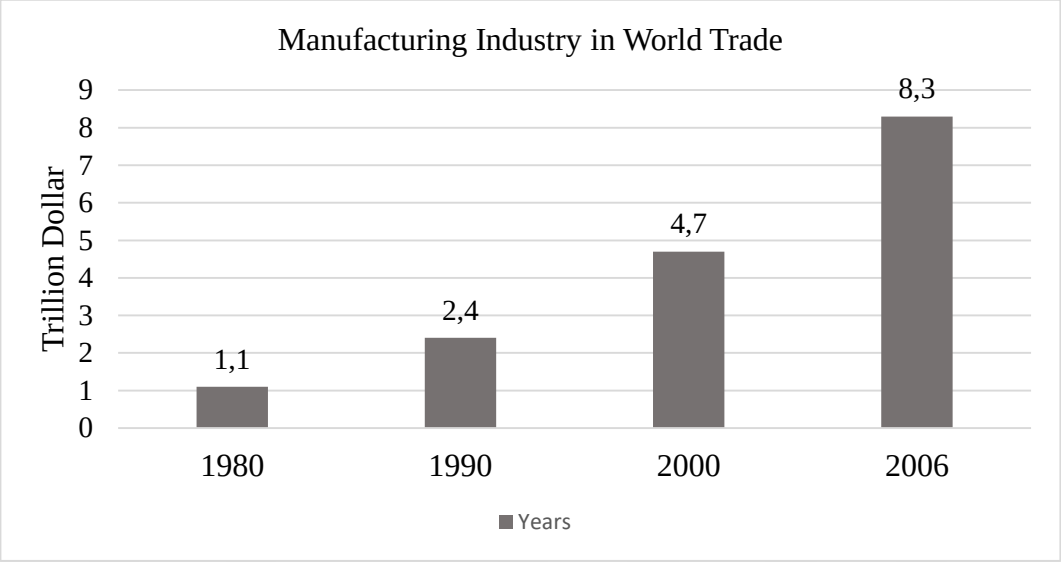
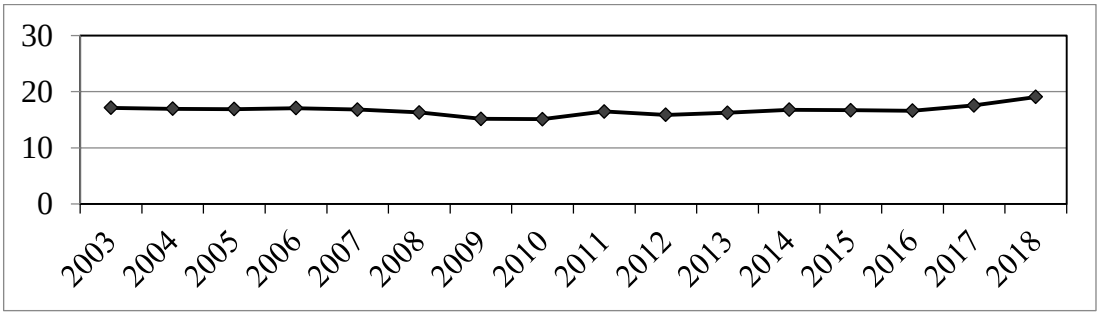


Figure 2.1. Manufacturing Industry in World Trade between 1980 and 2006 (WTO, 2007)

Besides, while in Turkey it can be seen in the Table 2.1, the manufacturing industry's share in GDP with 17.12% in 2003 decreased to 15.10% in 2010 but it was increased again to 19.05% in 2018 (The World Bank Group, 2019).

Table 2.1. *Share of Manufacturing Industry in GDP in Turkey (The World Bank Group, 2019)*



As a result of this increase, concerning safety work in manufacturing industry, several studies were made dealing with how to promote safer behavior among the workers, such as the use of safety equipment, giving safety training for new workers (Zubar *et al.*, 2014). The encountered studies concerned with the designing tools to find out how to propose any design tool and how to adjust it into the working methods.

2.2. Hazards in Manufacturing Industry

In manufacturing industry, branch of trade includes transformation, processing and preparation of raw materials or semi-finished products into final products. These hazards which directly affect the health and safety of the workers are classified as chemical hazards, physical hazards, biological, and psychological hazards (Thygerson *et al*., 2016).

With the help of developing sector in Industry 4.0 and although the companies trying to adopt this development, still there are so many companies who cannot follow or take this technology into their system while producing the material. Therefore, these companies are still using labor-intensive production with the help of manpower in their constitution. The common hazards in manufacturing industry can also be listed in detailed in the following sections.

2.2.1. Chemical Hazards

In the foundries, heavy dusts can be inhaled by employees. The dust in the workplace should never exceed the specified limit value. However, in cases where the high limit is reached, the one who spends approximately 8 hours at a shift, exposed to dusts, silica dusts, vapors and gases, it may cause risk to them.

Silicosis is a disease caused by exposure of workers to silica dust (granite stone-sand powder). People who are exposed to this silica dust have effects on their bodies when they get older. Depending on this hazard, it may develop up to heart failure and lung cancer due to its effect to lung.

In order to minimize and even eliminate these risks, first of all, to eliminate dust at source, if this is not possible to eliminate the exposure of the person, as a last resort should be kept at minimum risk level with personal protective equipment. As well as respiratory protection is appropriate when potentially dangerous exposures are possible or unpredictable. However, the proper selection and use of respirators is critical to its effectiveness and must be evaluated by an industrial hygienist or similarly trained professional (Wadl, 1967). Moreover, in order to prevent the hazards, the air structure of the work area should be checked continuously and it should be ensured that the ventilation is sufficient. If necessary, shift changes should be made during working hours to reduce the exposure of working people.

2.2.2. Physical Hazards

Generally, the sounds produced by the equipment used in the machines and workbenches that produce high noise, high frequency dense sounds in the operations performed with air pressure hammers cause noise. As a result, depending on the frequency range of the noise exposed and the duration and type of noise exposed, it causes temporary hearing loss and even permanent hearing loss when these levels are higher. In order to prevent noise, it may be a solution to temper the affected person, to use appropriate personal protective equipment and to reduce the exposure time by changing the work program or by operating in rotation. However, of course, eliminating or isolating the main source is one of these solutions.

Vibration, which is the most common of physical hazards due to the labor force, affects many workers in most of the works such as the use of machinery and machines in production, the use of lifting devices such as forklifts or cranes and the use of hand tools. Consequently, discomforts occur in the bone-joints. To prevent or reduce exposure to vibration risks, the source must first be eliminated or minimized since each job is unique, good ergonomic design requires careful task analysis.

Therefore, the equipment used for this work must have the appropriate design and equipment. In order to reduce exposure due to misuse, equipment users should be provided with appropriate information and training to use them correctly and safely.

Also hazards, which are resulted because using equipment, falling and transportation accidents, can be counted as the most common physical hazards. As shown in Figure 2.2, from distribution of the number of fatalities, the most observed fatalities are contacting with objective equipment (U.S. Private Industry, 2008).

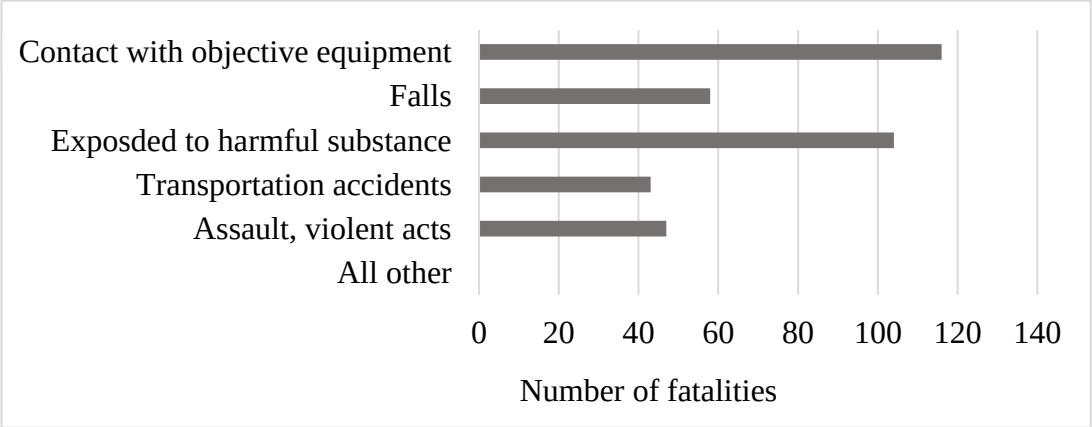


Figure 2.2. Number of Fatal Occupational Injuries in the Manufacturing Industry Sector by Event or Exposure (U.S Private Industry, 2008).

Additionally, the infrared rays formed in foundries, generally the melted/incandescent material and in the containers, are harmful when they are not controlled. Visually impaired and skin erosion can be observed to a large extent in employees exposed to this. In order to be protected from these hazards, at the first stage it must be determined whether the radiation source has adequate protective equipment. Employee can protect himself or herself by increasing the distance between the weld and by using proper personal protective equipment.

2.2.3. Biological Hazards

Genetically modified microorganisms, which can cause any infection, allergy or poisoning, and organisms or organic matters, such as parasites, viruses, bacteria *etc*. cause biological hazards and these are harmful to human health. These microorganisms can get into human bodies in such ways like effecting respiratory system, transmission with body fluid or by touching contaminated objects. As world statistics, it is estimated that approximately 320,000 employees die each year that caused by wok-related exposure to biological hazards (Driscoll *et al.*, 2005; OSHA, 2007).

Although this type of hazard is not mostly observed in manufacturing industry, biological hazards are observed in forging and pressing and mostly in the machining process. The most common hazard is bacterial contamination. Bacterial, virus, parasitic and fungal infections, allergic reactions, poisoning (food poisoning, allergic dermatitis, allergic rhinitis, allergic asthma, tinea pedis, anthrax *etc*.) can be seen (Parmeggiani, 1983).

Eliminating the source of contamination is essential for biological hazard prevention and control. In order to eliminate the source, improved ventilation, source isolation, improving air conditioning can help to reduce the spread of contaminants. If it cannot be prevented, then the employee must use suitable personal protective equipment, such as masks, gloves, face shields *etc*.

2.2.4. Psychological Hazards

In consequence of communication problems, which is caused by exposure to high noise, sleep problems observed in shifts and night workers and depression can be counted as physiological hazard. Since, employees working hours is about 10 hours

a day, it can be obvious the nervous system problems can occur for them if they expose to mentioned annoying vibration, noise (Grandjean, 1980). The nervous system problems experienced can often be easily prevented if anticipated during the planning stages of plant layout and work station design (Chaffin and Anderson, 1984).

2.3. Ergonomic Disease in Manufacturing Industry

In the production activities for metal production industry such as polishing, sanding, surface treatment and surface coating (electro, galvanizing, heat treatment, anodic oxidation, powder paint *etc*.) are carried out to obtain the end product. Each of these processes has its own hazard and risks as they are approached in detailed above.

In workplaces that do not pay much attention to OHS conditions, cause risks that cause many people to get occupational diseases. Many of the processes involved in manufacturing industry present hazards that are known to negatively affect the workers' health. For instance, in 1997, 1232 occupational accidents were reported according to the Swedish statistical data and the rate is calculated 18.3 accidents per 1000 employed (Statistics Sweden, 1999). Besides, the average number for whole manufacturing industry was founded as 12.9 accidents per 1000 employed (Willquist and Törner, 2002).

Factors that cause occupational disease can be listed as inadequate machinery and equipment for personal protection, employee's tendency to insecure behavior, employee's lack of training in occupational health and safety, personal reasons and excessive workload.

On the other hand, the lack of necessary audits by the state institutions and adverse working conditions can be considered as the cause of occupational accidents (Yaşar and Komut, 2018). As a result, ergonomic diseases can be observed in workers who are exposed to these hazards and risks more frequently.

Casting foundries are one of the jobs where accidents result in death due to the risks and dangerous processes in obtaining the product. According to the SSI statistics, the main metal industry, where the casting sector is located, ranks 4th among the most frequently observed activity branches in occupational accidents.

Ergonomic risk factors are because force, repetition and posture, by the way poor work, practices, poor fitness and poor health habits. Musculoskeletal diseases are the common group of ergonomic diseases.

According to SSI's statistics in 2017, because of the occupational diseases the total number of persons who receive permanent incapacity income is 6.6%. According to SSI's statistics in 2016, 3.5% of occupational diseases are detected in Turkey Musculoskeletal Disorders. In a study published by the Statistical Office of European Communities-Eurostat in 2010, it was reported that MSDs related to work were the most commonly reported disorders and accounted for 60% of all disorders (Mert, 2014).

Musculoskeletal system diseases are the most common occupational diseases. Occupational Musculoskeletal Disorders (MSDs) constitute 50% of all new occupational diseases (Roquelaure, 2018).

The U.S. Bureau of Labor Statistics found that in 2012 MSDs incidence rate in Figure 2.3, where incidence is calculated as the number of injuries and illnesses per 10,000 full-time workers, for musculoskeletal disorders across different industries (Bureau of Labor Statistics, 2012).

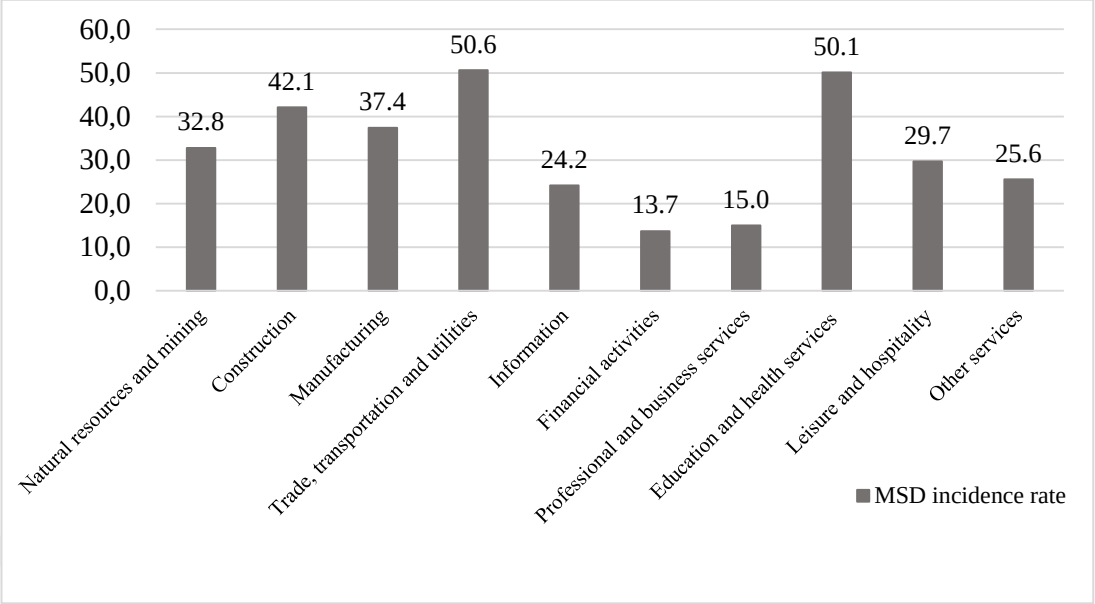


Figure 2.3. MSDs Incidence for Selected Occupational Sectors (Bureau of Labor Statistics, 2012)

As it is examined in the table looking more closely at a few types of jobs, it has been found that those working in homecare are at greater risk of developing an MSDs than those who work in construction, mining or manufacturing have greater risk in MSDs than other sectors.

MSDs are a group of disease that are characterized by pain and complaint in hand, wrist, elbow, shoulder, neck, low back, foot and legs. MSDs are usually caused by vibration, force exertion, repetitive tasks and working in an awkward posture.

Generally the cause of MSDs type are repetitive motion, repetitive placing, grasping or moving objects, typing or key entry and repetitive use of tools respectively (Figure 2.4).

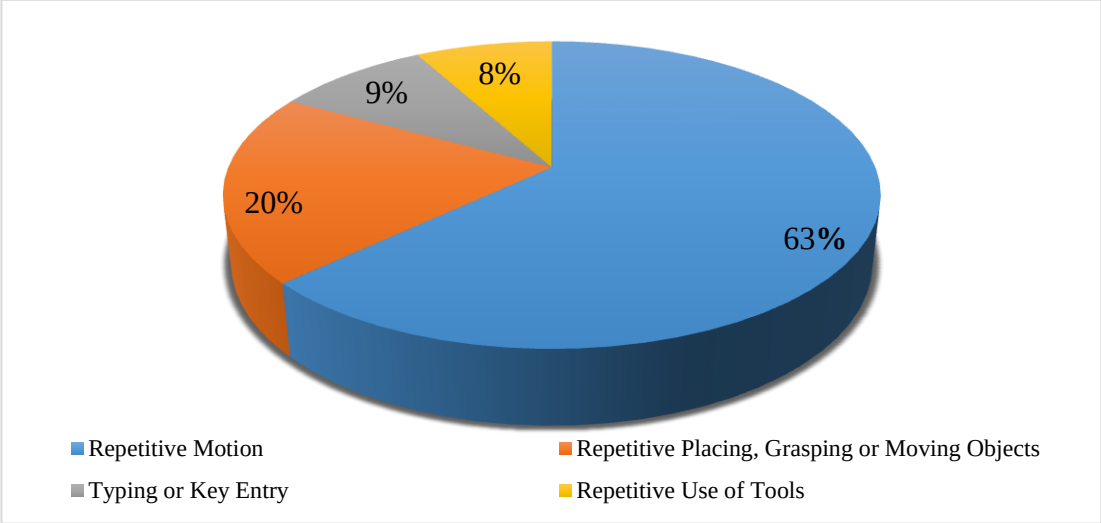


Figure 2.4. MSDs Types Injuries

By examining the above Figure 2.4, it can clearly be observed that repetitive motion is the first common injury type with 63% within specified injuries. If the working position is wrong, then an employee liable to get suffer from the hazard obviously. As a result of these injury types, the most common MSDs such as, Carpal Tunnel Syndrome, Trigger Finger, Tendonitis can be observed.

- **Carpal Tunnel Syndrome:** results from compromise of median nerve function at the wrist caused by increased pressure in the carpal tunnel, an anatomical compartment bounded by the bones of the carpus and the transverse carpal ligament (Bland, 2007).

- **Tendonitis**: It is most often caused by repetitive, minor impact on the affected area, or from a sudden more serious injury. Repeated strain on a tendon, attachment of a muscle to bone, can inflame the tendon resulting in pain and difficulty with movement involving the muscle. Tendons have a poor blood supply; therefore, they typically take a long time to heal on the order of six weeks or more (Bogaerts *et al*., 2014).

- **Trigger Finger:** It is an occupational disease, which is usually caused by repeated movements. Trigger finger is a common finger ligament that is thought to be caused by inflammation and subsequent contraction of the Al pulley that causes pain, clicking, catching and loss of movement of the affected finger. Tendons connect the bones to muscles, allowing them to move. As most patients complain of finger clicks or locking, the diagnosis is usually quite simple (Makkouk *et al.*, 2007).

2.4. Risk Assessment

The risk assessment is a vital element for health and safety regulations as it is included in the Occupational Health and Safety Regulation No. 6331 under the Occupational Health and Safety Law, its purpose is to reduce risks by complying with this law and relevant regulations.

> *"Risk Assessment is an examination of what could cause harm to people in the workplace. The good risk assessment will help avoid accidents and ill health, which can not only ruin lives but can also increase costs to business through lost output, compensation claims and higher insurance."* (Health and Safety Executive, 2016).

As it is stated in Health and Safety Executive, since it is a risk-based approach which is a powerful tool for us, hazards can be predictable as a result of assessment. Therefore, workers and others can be protected from potential damage if reasonable control measures are taken as a result of this assessment. This also shows us that, the very first step of the protection from any kind of disease, risk assessment takes place on the top. Consequently, required importance should be given to the specified approach.

Risk Assessment method has 5 significant steps as following;

Step 1: Identifying the hazards
Step 2: Deciding who can be affected
Step 3: Evaluating the risks and identifying precautions
Step 4: Recording the findings and application
Step 5: Reviewing assessment and updating

2.4.1. Ergonomic Risk Assessment Tools

The following methods can be used to do a risk assessment:

- **The Ergonomics Workplace Analysis Method**: It is an observational method that is developed by the Finnish Institute of Occupational Health (FIOH) (Ahonen *et al*., 1989) it includes both expert and worker opinions.

- **The Job Strain Index (JSI):** In order to estimate the risks of wrists and hands injuries, which are based upon assessments of force, repetition, posture and duration, this method was developed by Dr. J.S. Moore and Dr. A. Garg. The benefit of the usage of JSI, it gives a quick and systematic assessment of the hand/wrist postural risks to a worker (Moore and Garg, 1995).

- **Occupational Repetitive Action Index (OCRA):** The musculoskeletal load of the upper limbs that is caused by repetitive tasks and the risk of developing MSDs are evaluated through the instrument of OCRA (Occhipintini, 1998). OCRA is rather dedicated to movements of the arms below the shoulder level. It focuses on movements of the forearms without differentiating exposure caused by the posture of the arms.

- **The American Conference for Government Industrial Hygienists (ACGIH) Hand Activity Level:** It is a risk assessment tool designed to protect workers, who perform repetitive hand exertions for 4 or more hours per day, from distal upper extremity disorders. This method is developed for use with normalized peak hand force (NPF) to estimate the threshold limit value (TLV), which is a measure of the risk of work related distal upper extremity musculoskeletal disorders (Drinkaus *et al.*, 2005).

- **The Rapid Entire Body Assessment (REBA):** It was developed by Dr. Sue Hignett and Dr. Lynn McAtamney to fill a perceived need for a practitioner's field tool, specifically designed to be sensitive to the type of unpredictable working postures found in health care and other service industries (Hignett *et al*., 2000). This ergonomic assessment tool uses a systematic process to evaluate whole body postural MSDs and risks associated with job tasks (Middlesworth, 2019).

- **The Rapid Upper Limb Assessment (RULA):** This method is developed to evaluate the exposure of individual workers to ergonomic risk factors associated with upper extremity MSDs. It is a method, which is easy to use since there is no need for any advanced degree in ergonomics or expensive equipment (Middlesworth, 2019).

- **Quick Exposure Check Method (QEC):** This method is created by David, Woods, Li and Buckle provides a weighted score that indicates relative risk of a body region, task, or risk factor. Further, the weighted score can be used to show pre/post intervention impact. It is an observational tool developed for OSH practitioners to assess exposure to risks for work-related musculoskeletal disorders and provide a basis for ergonomic interventions (David *et al*., 2008).

Among the risk assessments, QEC has been decided to be used as a result of literature studies. This method is applied to employees after the Ethic Committee approval was obtained from the Applied Ethics Centre of Middle East Technical to use this questionnaire (Appendix C).

2.5. Quick Exposure Check Method (QEC)

2.5.1. History of Quick Exposure Check Method

The development of QEC method is started at the Robens Health Ergonomics Center at University of Surrey in the U.K. by Occupational Safety and Health practitioners and safety representative (David *et al.,* 2008). The reason that makes this risk assessment method special is to combine observational evaluation by supervisor and user's consideration (David *et al.,* 2005).

The main objective of NES is to equip practitioners with a scientifically valid, reliable and practical exposure assessment tool (Sim *et al.,* 2006). QEC has been developed and approved through comprehensive applications in a wide range of applications (Li *et al.,* 1999).

In 1999 the first version of QEC method was published in research report (Li *et al.,* 1999). Following this, the revised version of QEC method, including the improvement of usability and validity of the tools, was published by David and colleagues in 2005 (David *et al.,* 2005). The readaptation study of the Turkish version of HMD was conducted by Özcan et al in 2008 (Özcan *et al.,* 2008).

2.5.2. Advantages and Disadvantages of Quick Exposure Check Method

QEC method has several advantages like it is good for initial screening and prioritizing intervention, it is easy to learn, rapid to use and worker's perception is considered. Useful source of information for understanding root causes of the most severe risk factors and workstation tasks that are most difficult for the worker. This method also provides sub-scores for different body regions. QEC hands/wrist index requires significantly less effort compared to OCRA and both methods agreed 74% of the time for identifying high risk level workstations. QEC General Index, Rula and Reba agreed more than 90% of the time on high risk level.

However, there are also some limitations about this method. The very first one is that, since worker's interpretation is involved in the method, risk assessment may be biased. Provides little guidance regarding the targets to be met (Chiasson *et al*., 2015).

2.5.3. Previous Studies

After the QEC method 2005 is published, it is started to be used in several studies in many different sectors. Once a pilot study is done in 2012 by Ericsson *et al.*, the study is applied to several occupational groups at a hospital. In consequence of the study, the method is meet the expectations of a being a quick sensible and practical that covers physical risk factors in several parts of bodies (Ericsson *et al*., 2012). Besides to that deduction, the study which is about work ability and work demands among workers with neck pain, prepared by Stefan Oliv, it is found that QEC has good reliability in scores but a few of the individual items showed low reliability and the use of real case can give a risk of bias (Oliv, 2019).

In addition to these studies, QEC method application is also applied in many different sectors in Turkey. Based on the information obtained from the literature survey, the most recent study is published by Kuzucuoğlu in 2019. This study is about the investigation of ergonomic risk factors using the QEC method on the production line in the automotive superstructure sector. In this study, the findings were obtained by 3 different methods. The first one was the brainstorming method, the other was REBA method and finally QEC method were used. In this study, it has been determined the ergonomic conditions on the production line, and as a result of the evaluations, suggestions have been made to make changes or take action from the examined cases. (Kuzucuoğlu, 2019).

Furthermore, it has been observed that the QEC method is frequently applied especially to the health sector workers. Firstly, a risk assessment was performed by applying QEC method to 30 participants working in Pathology Laboratory of Karadeniz Technical University Medical Faculty in 2006 study. The aim of this study, as in other studies, is to determine the hazards and risks arising from the working environment in the laboratory, evaluate the risks and produce solutions for them. Ergonomic risks were observed as “very high” in shoulder-arm and hand-wrist for the workers mostly working in cleaning process. However, it has been concluded that the greatest risk source observed in this working place is chemical risks (Bulut, 2016).

Another study applied to healthcare workers is to apply QEC method of MSD related to dentists working in Gazi University Faculty of Dentistry. In this study, in addition to the method used to determine musculoskeletal problems, the relationship between occupational and demographic factors of 163 participants is discussed in detail (Bozkurt, 2011).

Other study in the same sector, MSD complaints and affecting factors of dentists working in oral and dental health centers in Ankara were evaluated by applying QEC method (Doğan, 2011). When the results of both studies were evaluated, the frequency of musculoskeletal diseases was found “high” in dentists due to wrong posture.

Further comprehensive study, which is one of the most interesting of studies in Turkey, is the application of QEC method to taxi drivers in Ankara. In this study, the QEC method was applied to 382 taxi drivers working about 10-12 hours per day. Driving is known as a stressful task that and results show that the risk of exposure to MSD is high or very high in taxi drivers. Restricted postures, repetitive movements, vibration, continuous attention to the road and work-related stress are found as the major risk factors for MSD (Bulduk *et al*., 2013).

CHAPTER 3

STUDY AREA AND DATA

3.1. Study Area

In this research study, it is aimed to investigate the ergonomic risk factors in a foundry in the metal industry, which operates in Sincan Organize Sanayi Bölgesi/Ankara. The company employs a total of 184 blue-collar, 32 white-collar, 17 engineers and 13 interns. Casting production capacity and operating capacity are 10,000 tons and 4,000 tons per year respectively and it works in two shifts. Nodular and grey cast iron parts that used in branches of industry such as agricultural machinery industry, ship building industry, general machinery industry, railways industry, construction industry and hydraulic industry are manufactured in factory. The production is starting with design, melting, core making, molding, cleaning/paint shop, machining processes, the product becomes the final product.

- **Melting:** Melting capacity is 20,000 tons/year with two induction furnaces which one has 3 tons'/hour capacity with one ladle and the other one has 1.5 tons/capacity with two ladles, on two shifts/day.

  Thermal comfort conditions in workplaces should not adversely affect the employees physically and psychologically. The temperature of the working environment should be suitable for the power and working style of the employees.

Employees are exposed to high heat risks due to the high temperature of the induction furnace during melting in the foundries and the heat emitted during the transfer of molten metal to the crucible. Due to hot working conditions, lack of airflow, thick and synthetic clothing, workers are adversely affected and workers are exposed to heat shock.

Workplace ventilation has a significant impact on employee health and work performance. Gas, steam, and dust from the environment pollute the workplace air. Dirty air in the environment causes workers to not get enough oxygen. As a result, employees' sensitivities are negatively affected and lead to occupational accidents.

- **Core Making:** The cores are produced together with the automatic sand preparation system at the 8 cold box core machines differing between 2.5 and 80 liters and at the 2 hot box core machines. Cores with bigger volumes are produced wit furan resin and CO_2 binders.

- **Moulding:** The company successfully produce parts up to 120 kg at automatic sand molding lines and the parts up to 1.200 kg with various dimensions at resin-bounded (Furan) moulding lines with high quality according to the required standards.

- **Foundries:** The mold preparation systems, moulding, cleaning processes, and heavy machines operating with vibration are sources of noise. The noise levels detected in foundries are high. For this reason, hearing loss due to noise is a common health problem among workers. In foundries, studies using engineering methods are needed to reduce noise.

- **Cleaning/Paintshop**: Fettling, grinding, deburring and cleaning operations are made by means of shot blasting machines, automatic industrial fettling robots, and various pneumatic hand tools and the last controls of castings are performed before dispatch. Also, if demanded, primary coating can be carried out through both dipping and spray methods in our painting shop.

  Adequate lighting in the workplace creates positive psychological effects on employees. In case of insufficient lighting, eye and body fatigue occurs in employees. In a research; if the intensity of light in the workplace increased from 50 lux to 200 lux, the accident rate decreased to 32%. After the walls of the same workplace were painted with a clear and reflective color, another 6.5% reduction in accident rates was observed.

  Machining part, the company has a modern, well-equipped machine park providing the annual machining capacity of 3,500 tons.

  - CNC Machining Centers:

  6 x CNC Horizontal Machining Center
  2 x CNC 5 Axis Multi-Spindle
  CNC Vertical Machining Centers

  - CNC Lathes:

  CNC Vertical Lathe DAEWOO Puma 550 Ø760 x 780 mm
  3 x CNC Horizontal Lather

Although it has modern production benches, it is a labor-intensive phase. CNC Machining Centers, which are used in the enterprise, is a technological plant, which reduces CNC Lathes and 3-D Sand Printer.

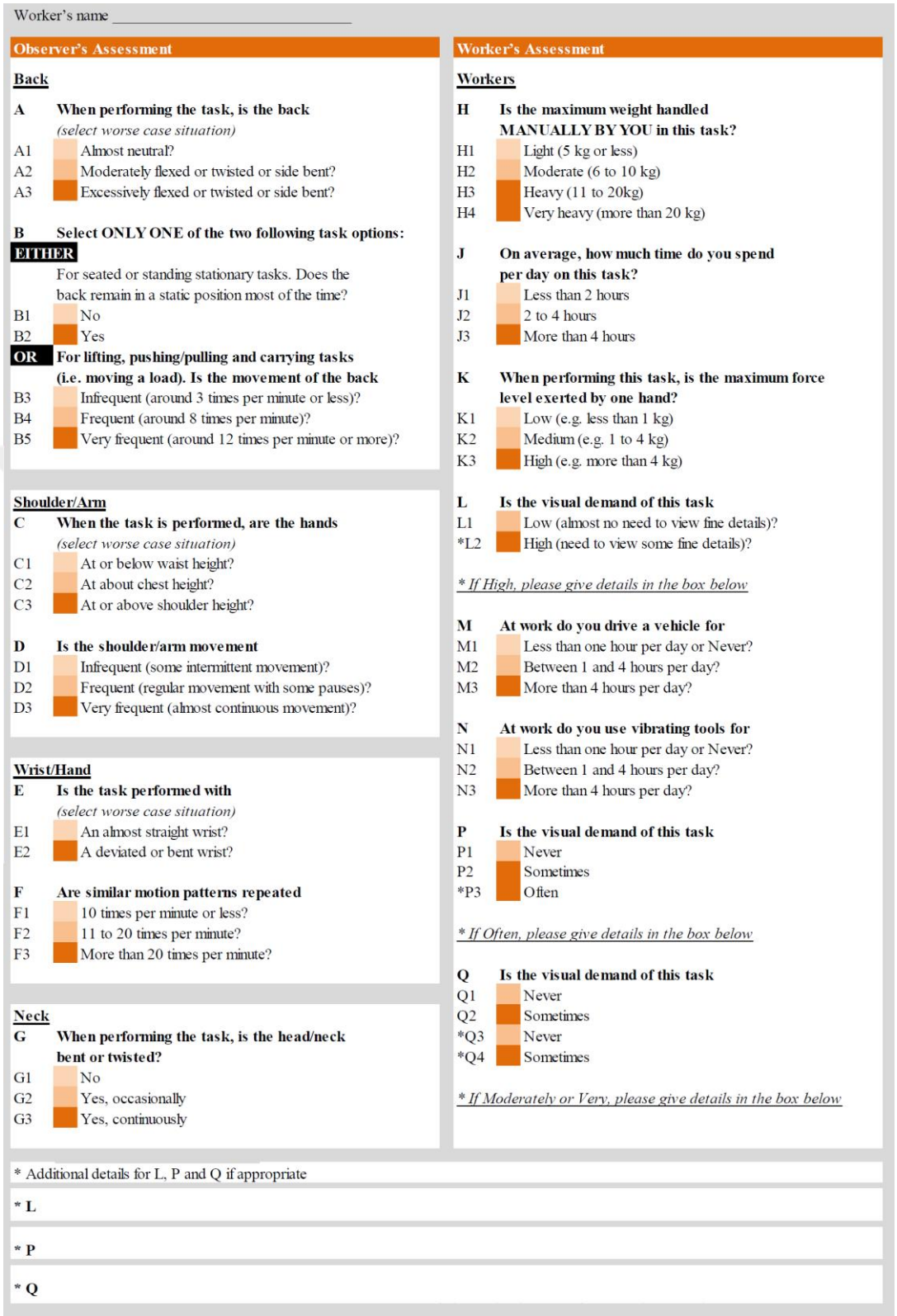
With the help of the 3-D Sand Printer, due to the increase in mechanization and the decrease in the need for manpower, production risk has been observed at minimum level when compared with the work done on CNC machines to produce the same product. The company aims to increase these machines used in production.

The bending of the workers and the weight of the crucibles during the casting of small sized materials extracted in high amounts in the ladles carried by hand in the foundries constitute an ergonomic risk

Considering all activities, the most commonly encountered plant with Musculoskeletal Diseases is the machining plant where more manpower is used. Therefore, the QEC method used was only applied to workers working in machining.

3.2. Implementation of QEC Method

In implementation of QEC method, the following assessment form as presented in Figure 3.1 is used to obtain the data from the workplace. QEC assessment form has both observers' and workers' assessment. After obtaining assessment form, the replies from observers and workers are assessed using the QEC scoring form as shown in Figure 3.2. The worker's back, shoulder/arm and wrist/neck scores are determined by QEC scoring form.



Worker's name _____

Observer's Assessment

Back

A When performing the task, is the back
(select worse case situation)
A1 Almost neutral?
A2 Moderately flexed or twisted or side bent?
A3 Excessively flexed or twisted or side bent?

B Select ONLY ONE of the two following task options:
EITHER
For seated or standing stationary tasks. Does the back remain in a static position most of the time?
B1 No
B2 Yes
OR For lifting, pushing/pulling and carrying tasks (i.e. moving a load). Is the movement of the back
B3 Infrequent (around 3 times per minute or less)?
B4 Frequent (around 8 times per minute)?
B5 Very frequent (around 12 times per minute or more)?

Shoulder/Arm

C When the task is performed, are the hands
(select worse case situation)
C1 At or below waist height?
C2 At about chest height?
C3 At or above shoulder height?

D Is the shoulder/arm movement
D1 Infrequent (some intermittent movement)?
D2 Frequent (regular movement with some pauses)?
D3 Very frequent (almost continuous movement)?

Wrist/Hand

E Is the task performed with
(select worse case situation)
E1 An almost straight wrist?
E2 A deviated or bent wrist?

F Are similar motion patterns repeated
F1 10 times per minute or less?
F2 11 to 20 times per minute?
F3 More than 20 times per minute?

Neck

G When performing the task, is the head/neck bent or twisted?
G1 No
G2 Yes, occasionally
G3 Yes, continuously

Worker's Assessment

Workers

H Is the maximum weight handled MANUALLY BY YOU in this task?
H1 Light (5 kg or less)
H2 Moderate (6 to 10 kg)
H3 Heavy (11 to 20kg)
H4 Very heavy (more than 20 kg)

J On average, how much time do you spend per day on this task?
J1 Less than 2 hours
J2 2 to 4 hours
J3 More than 4 hours

K When performing this task, is the maximum force level exerted by one hand?
K1 Low (e.g. less than 1 kg)
K2 Medium (e.g. 1 to 4 kg)
K3 High (e.g. more than 4 kg)

L Is the visual demand of this task
L1 Low (almost no need to view fine details)?
*L2 High (need to view some fine details)?

** If High, please give details in the box below*

M At work do you drive a vehicle for
M1 Less than one hour per day or Never?
M2 Between 1 and 4 hours per day?
M3 More than 4 hours per day?

N At work do you use vibrating tools for
N1 Less than one hour per day or Never?
N2 Between 1 and 4 hours per day?
N3 More than 4 hours per day?

P Is the visual demand of this task
P1 Never
P2 Sometimes
*P3 Often

** If Often, please give details in the box below*

Q Is the visual demand of this task
Q1 Never
Q2 Sometimes
*Q3 Never
*Q4 Sometimes

** If Moderately or Very, please give details in the box below*

* Additional details for L, P and Q if appropriate

*** L**

*** P**

*** Q**

Figure 3.1. QEC Assessment Form

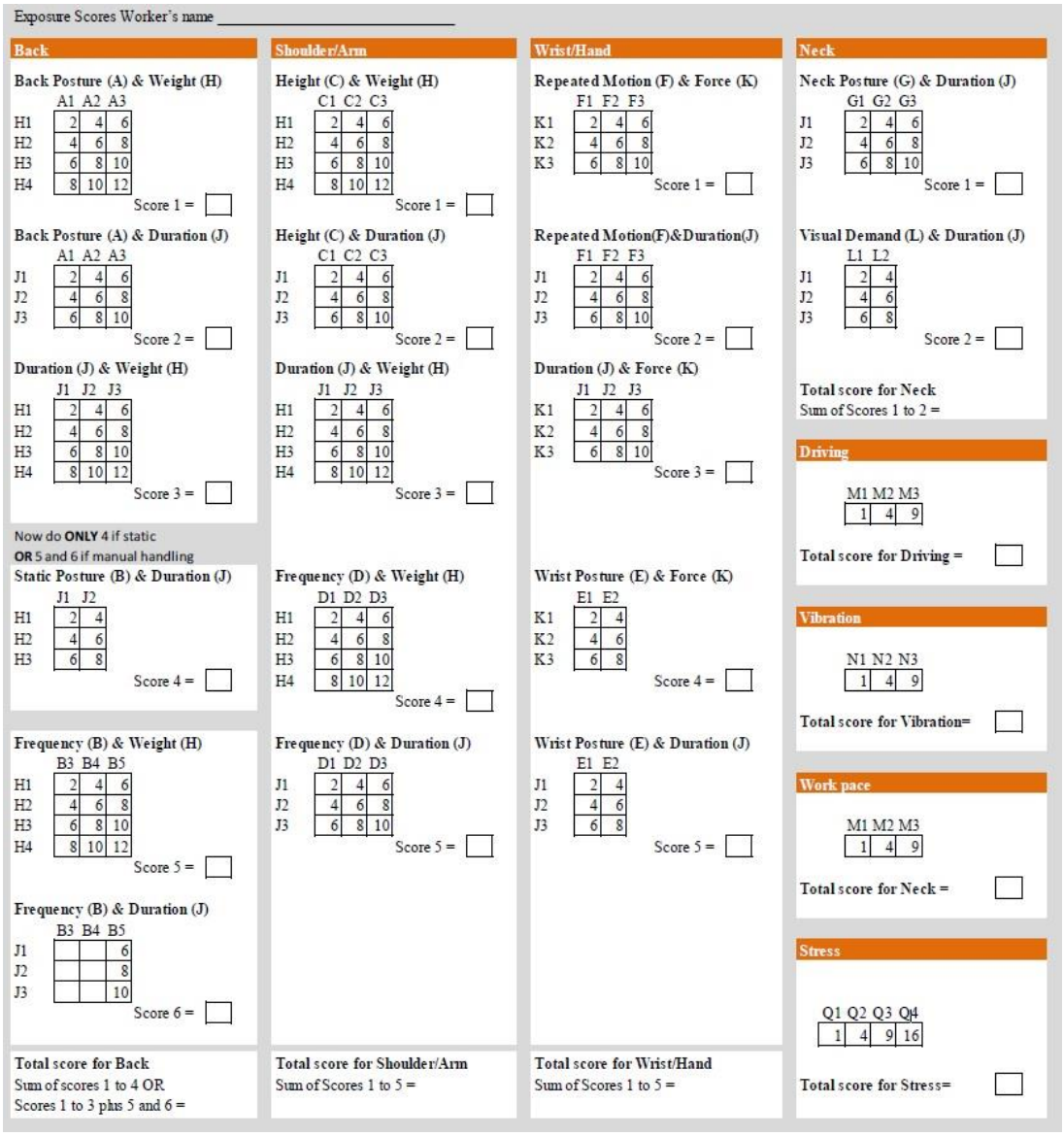


Figure 3.2. QEC Scoring Form

3.3. Data Distribution Information

After considering all risk assessment methods, the Quick Exposure Check method is chosen for this research. Although the entire universe for sampling includes 183 blue collars, the study was applied to only 47 people working in the machining plant only and 183 blue collars were not made in the whole universe. The gender of all employees to whom the method was applied was male. The number of workers between 18-20 age group is 4, between 21-30 age group is 28, between 31-40 is 12 and between 41-50 is 3 as shown in the following table.

Table 3.1. *Age Group Distribution of Workers*

Age Group	Number of People
18-20	4
21-30	28
31-40	12
41-50	3

When the educational status is considered, 13 out of them graduated from secondary school, 26 out of them graduated from senior high school and 8 out of them was graduated from high school.

Table 3.2. *Education Level Distribution of Workers*

Education Level	Number of People
Secondary School	13
Senior High School	26
High School	8

All were asked whether they would volunteer to participate in this study or not. After getting their confirmation, then a brief explanation about the research were given to employees. Before applying the questionnaire, at first, the permission is taken from METU Human Subjects Ethic Committee. During shift breaks, the questionnaire forms were distributed with the help of shift manager's guidance. Further, in order to avoid any misunderstanding or restraint, in this study participants' information are kept confidential, have not taken any name or related information from them.

The main purpose of choosing the employees from the same field was to demonstrate the effects of education and age. The research wants to get answers for following hypothesizes;

- Probability of MSDs is less likely for employees with higher education levels.

- Probability of MSDs is more likely for employees with higher age groups.

CHAPTER 4

ANALYSIS OF ERGONOMICS

4.1. Data Collection by Using QEC in Research

The figure shown in below demonstrates the data collection of research step by step and each step is explained in detail in following topics.

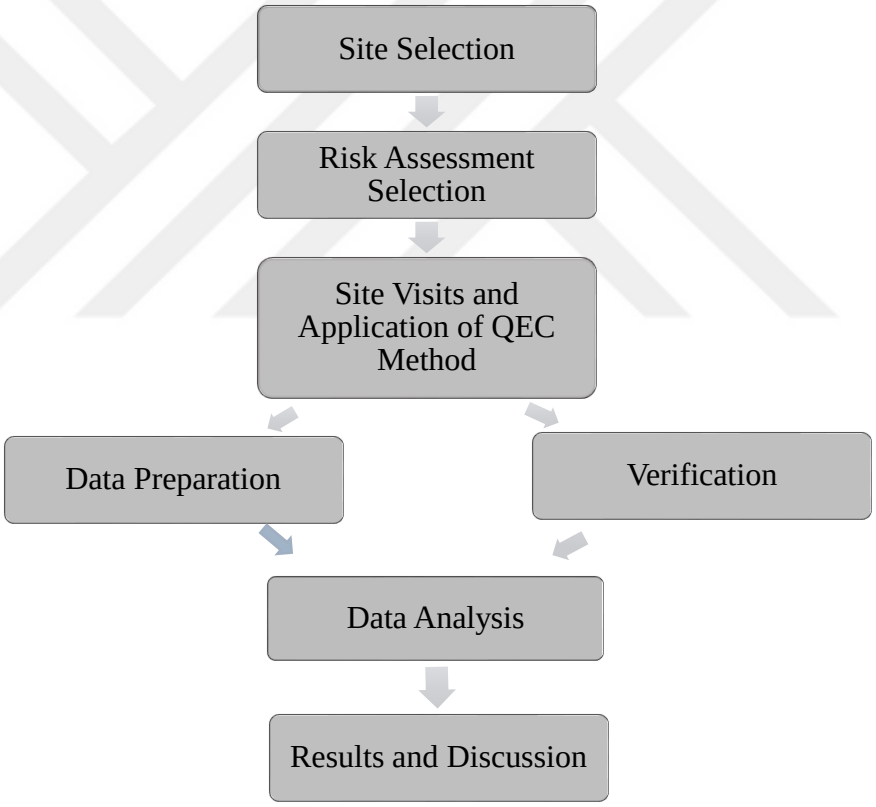


Figure 4.1. Research Analysis Process in Flow Chart

Research analysis of the study starts with selection of proper site, which can include ergonomic risk factors in it, as written in Figure 4.1. The following stage is choosing the method to find how to analyze these risk factors. The QEC is a risk assessment tool that assesses ergonomic risk factors, including physical, organizational and psychosocial factors. This method provides guidance for both employees and evaluators. After selection of the method, several site visits were done to apply the QEC method.

In the first part of the method that consists two parts, there are 18 assessments for posture and movements of waist, shoulder/arm, wrist/hand and neck during work. In the Step 1 of QEC, the evaluator observes a task to determine the posture and movement frequency of four body areas. The detailed information is presented in Table 4.1. The movement frequency for each body one posture is descripted and one movement is chosen to describe the task detailed in Table 4.1.

Table 4.1. *Posture Description and Movement Frequency Scale*

Body Part	**Posture Description**	**Movement Frequency**
Back	Almost neutral	For seated/standing stationary tasks, the back maintains a static position
	Moderately flexed or twisted or side bent	For seated/standing stationary tasks, the back does not maintain a static position
	Excessively flexed or twisted or side bent	For lifting, pushing/pulling and carrying tasks, back movement is infrequent
		For lifting, pushing/pulling and carrying tasks, back movement is frequent
		For lifting, pushing/pulling and carrying tasks, back movement is very frequent

Table 4.1. *Posture Description and Movement Frequency Scale (Cont'ed.)*

Body Part	**Posture Description**	**Movement Frequency**
Shoulder/Arm	At or below waist height	Infrequent
	At about chest height	Frequent
	At or above shoulder height	Very frequent
Wrist/Hand	Almost straight wrist	10 times per minute or less
	Deviated or bent wrist	11 to 20 times per minute
		More than 20 times per minute
Neck	Not bent or twisted	Occasionally
	Bent or twisteed	Continuosly

In the part of the employee-based evaluation; 25 assessments are made for maximum weight carried, work time, maximum force applied by one hand, visual attention required by the work, driving, vibration, work performance and work stress. In the second step evaluator make an interview with the worker relative to the key factors that is listed in Table 4.2.

Table 4.2. *Options for Worker Description of the Task*

Risk Factor	Risk Factor Descriptor
Maximum weight handled manually	Light
	Moderate
	Heavy
	Very Heavy
Average time spent per day on this task	Less than 2 hours
	2 to 4 hours
	More than 4 hours
Maximum force level exerted by one hand while performing the task	Low
	Medium
	High
Visual demand of the task	Low
	High

Table 4.2. *Options for Worker Description of the Task (Cont'ed.)*

Risk Factor	Risk Factor Descriptor
A vehicle is driven	Less than one hour per day or never
	Between 1 and 4 hours per day
	Move than 4 hours per day
Vibrating tools are used	Less than one hour per day or never
	Between 1 and 4 hours per day
	Move than 4 hours per day
There is difficulty keeping up with this work task	Never
	Sometimes
	Often
In general, this job is	Not at all stressful
	Mildly stressful
	Moderately stressful
	Very stressful

After the implementation of method, data are listed and as a final step, in the step 3, a scoring table is obtained from their interactions with each other. Exposure levels are verified and evaluated as low, medium and high according to the scores. A score for a specific body part and a total score for a task can be calculated. Table 4.3 shows the scoring risk factor combinations for specific body parts and other ergonomic concerns.

Table 4.3. *Various Combinations of Risk Factors for Specific Body Part/Other Ergonomic Concerns*

Body Part or Ergonomic Concern	**Risk Factor Combination**	**Scoring Range**
Back	Back Posture and Weight	2 – 12
	Back Posture and Duration	2 – 10
	Duration and Weight	2 – 12
	Static Posture and Duration	2 – 8
	Dynamic Posture Frequency and Weight	2 – 12
	Dynamic Posture Frequency and Duration	6 – 10
Shoulder/Arm	Height and Weight	2 – 12
	Height and Duration	2 – 10
	Duration and Weight	2 – 12
	Frequency and Weight	2 – 12
	Frequency and Duration	2 – 10

Table 4.3. *Various Combinations of Risk Factors for Specific Body Part/Other Ergonomic Concerns (Cont'ed.)*

Body Part or Ergonomic Concern	**Risk Factor Combination**	**Scoring Range**
Wrist/Hand	Repeated Motion and Force	2 – 10
	Repeated Motion and Duration	2 – 10
	Duration and Force	2 – 10
	Wrist Posture and Force	2 – 8
	Wrist Posture and Duration	2 – 8
Neck	Neck Posture and Duration	2 – 10
	Visual Demand and Duration	2 – 8
Driving	Duration	1 – 9
Vibration	Duration	1 – 9
Work Pace	Difficulty in Maintaining	1 – 9
Work Stress	Degree	1 – 16

To sum up briefly, it is composed of an evaluation form that includes 16 questions about postures and movements performed by the spine and upper limbs, as well as other risk factors (amount of weight handled; how long it takes to perform a task; manual force; visual demand; vibration and level of hand force exerted; work pacing; and stress).

Table 4.4. *Interpretation of the Quick Exposure Check Scores*

	Low	Moderate	High	Very High
Back (static)	8-15	16-22	23-29	29-40
Back (moving)	10-20	21-30	31-40	41-56
Shoulder/Arm	10-20	21-30	31-40	41-56
Wrist/Hand	10-20	21-30	31-40	41-46
Neck	4-6	8-10	12-14	16-18

Driving	1	4	9	-
Vibration	1	4	9	-
Work Pace	1	4	9	-
Stress	1	4	9	16

As it can be in Table 4.4, the score that allows for a partial (by body area) and total quantification of risk (David *et al*., 1936). This score results from the combination of answers given by the evaluator and the workers, were calculated by entering the score, derived from each question. The exposure score can be seen in Table 4.5 that shows the results in detail to one of employee.

Table 4.5. *An Example of Risk Assessment Tool Report*

Exposure Scores Worker's name and work *Mustafa - CNC Horizontal Lather Operator*

Back

Back Posture (A) & Weight (H)

	A1	A2	A3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 1 = **8**

Back Posture (A) & Duration (J)

	A1	A2	A3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2 = **2**

Duration (J) & Weight (H)

	J1	J2	J3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 3 = **8**

Now do **ONLY 4** if static
OR 5 and 6 if manual handling

Static Posture (B) & Duration (J)

	J1	J2
H1	2	4
H2	4	6
H3	6	8

Score 4 = **2**

Frequency (B) & Weight (H)

	B3	B4	B5
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 5 =

Frequency (B) & Duration (J)

	B3	B4	B5
J1			6
J2			8
J3			10

Score 6 =

Total score for Back
Sum of scores 1 to 4 OR
Scores 1 to 3 plus 5 and 6 = **20**

Shoulder/Arm

Height (C) & Weight (H)

	C1	C2	C3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 1 = **8**

Height (C) & Duration (J)

	C1	C2	C3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2 = **2**

Duration (J) & Weight (H)

	J1	J2	J3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 3 = **8**

Frequency (D) & Weight (H)

	D1	D2	D3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 4 = **10**

Frequency (D) & Duration (J)

	D1	D2	D3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 5 = **4**

Total score for Shoulder/Arm
Sum of Scores 1 to 5 = **32**

Wrist/Hand

Repeated Motion (F) & Force (K)

	F1	F2	F3
K1	2	4	6
K2	4	6	8
K3	6	8	10

Score 1 = **4**

Repeated Motion(F)&Duration(J)

	F1	F2	F3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2 = **2**

Duration (J) & Force (K)

	J1	J2	J3
K1	2	4	6
K2	4	6	8
K3	6	8	10

Score 3 = **6**

Wrist Posture (E) & Force (K)

	E1	E2
K1	2	4
K2	4	6
K3	6	8

Score 4 = **4**

Wrist Posture (E) & Duration (J)

	E1	E2
J1	2	4
J2	4	6
J3	6	8

Score 5 = **2**

Total score for Wrist/Hand
Sum of Scores 1 to 5 = **18**

Neck

Neck Posture (G) & Duration (J)

	G1	G2	G3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 1 = **4**

Visual Demand(L)&Duration(J)

	L1	L2
J1	2	4
J2	4	6
J3	6	8

Score 2 = **2**

Total score for Neck
Sum of Scores 1 to 2 =

Driving

M1	M2	M3
1	4	9

Total score for Driving = **9**

Vibration

N1	N2	N3
1	4	9

Total score for Vibration= **4**

Work pace

M1	M2	M3
1	4	9

Total score for Neck = **4**

Stress

Q1	Q2	Q3	Q4
1	4	9	16

Total score for Stress= **4**

4.2. Results

Ergonomic risk analysis has become more important with an increasing number of occupational diseases, especially in terms of employee health in recent years. Thanks to ergonomic risk analysis methods, deficiencies and failures that directly threaten the health of employees can be determined more easily. In this study musculoskeletal disorders determined by QEC method.

The low level of education is also immediately relevant for high probability of MSD, which is observed in the field. With different education level showed that, 8 of 13 employees who graduated from secondary school gets higher exposure level scores while doing their tasks. Besides, minimum effects are observed with 2 of 8 employees who graduated from high school.

In addition, older workers are more sensitive than younger workers because of decrease in physical work capacity, more MSDs can be observed on them (Okunribido and Wynn 2010). Although the number of workers between the ages 20 and 30 are more than the other groups, it is expected the high number score of exposure to the disease would be higher but compared to those in the plus 40 age group, the effects of disease is observed the most.

The numerical results of the ergonomic risk assessment analysis, which was made to all of the operators work in the field, are shown in the tables below in detail with several tables specific to the operators in each unit.

Table 4.6. *Metal Modelling Operators Results*

Back (static)	Back (moving)	Shoulder /Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
-	26	30	12	6	9	4	4	9
-	20	32	18	6	4	1	1	4
-	24	32	16	4	4	4	1	4
-	26	28	18	8	9	4	4	9
-	26	30	20	4	4	4	1	9

As a result of the ergonomic risk assessment analysis performed with the QEC method, it is shown in the Table 4.6, the most evident risk was observed in the “neck” and “shoulder/arm” (exposure level: high), whereas the least risk was observed in the “hand / wrist” and “neck" (exposure level: moderate) on Metal Modelling Operators.

Table 4.7. *Milling Machine Users Results*

Back (static)	Back (moving)	Shoulder /Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
8	-	14	14	6	9	1	1	1
10	-	12	18	8	4	1	1	4
10	-	16	20	6	4	1	1	1
12	-	14	24	10	9	4	4	4
8	-	14	18	6	4	4	1	1

Table 4.7 shows that exposures score of milling machine users results of “driving” scores are higher than the other ergonomic concern. Besides, when compared to other workers, the lowest risk exposed body parts is observed in milling machine users.

Table 4.8. *CNC Vertical Lather Operators Results*

Back (static)	Back (moving)	Shoulder /Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
-	18	18	16	10	4	1	1	1
-	16	18	14	12	4	1	1	1
-	18	18	18	14	4	1	1	4

In Table 4.8, result of each component was examined in detail and it was found that there was no value higher than 18. According to this, we can say that none of body part except the neck part get risky situation. However, the interpretation of the score results shows that exposure level of CNC vertical lather operators' neck is high.

Table 4.9.*CNC Vertical Machining Centers Operators Results*

Back (static)	Back (moving)	Shoulder /Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
26	-	32	10	6	9	1	1	4
20	-	26	20	16	1	1	4	1
24	-	30	32	8	4	1	1	4
22	-	30	20	4	1	1	1	4

When Table 4.9 is examined, exposure score of neck value was found to be 16, which is considered as very high risk. Thus, in order to decrease this number, we may say that, the level of the CNC Vertical machining center bench was not proper for working so the neck posture should be bended or twisted.

Table 4.10. *Styrofoam Part Making Operators Results*

Back (static)	Back (moving)	Shoulder /Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
-	20	20	16	10	9	1	4	4
-	22	22	20	6	9	1	4	9
-	18	24	18	8	4	1	1	1
-	18	16	18	8	9	1	4	1

When Table 4.10 is examined, it is observed that exposure score of "Driving" gets higher than the other ergonomic concern. In addition, two of Styrofoam part making operators get high results from the body part of "Shoulder/Arm".

Table 4.11. *CNC Horizontal Machining Center Operators Results*

Back (static)	Back (moving)	Shoulder /Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
-	20	32	18	6	9	4	4	4
-	22	28	18	4	9	4	4	4
-	20	30	16	8	4	4	1	1
-	18	32	20	10	4	4	4	1
-	18	28	22	8	9	9	4	16
-	16	26	16	8	4	4	4	4

As can be seen from Table 4.11, the most evident risk was the "stress" (exposure level: very high) on CNC Horizontal Machining Center Operator when it is considered with other operators and units. Secondly, this table reveals that the exposure level scores of "shoulder/arm" results are high. These findings may indicate that there are negative factors contributing to shoulder/arm in the workplace of the employees.

Table 4.12. *CNC Horizontal Lather Operators Results*

Back (static)	Back (moving)	Shoulder /Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
22	-	22	34	14	1	1	4	4
24	-	24	36	12	1	1	1	4
18	-	26	30	12	4	1	4	4
16	-	30	32	14	1	1	4	9
26	-	30	30	8	4	1	1	4
22	-	22	30	10	1	1	1	1

As can be seen from Table 4.12, the most evident risk was observed in the "wrist/hand" and "neck" (exposure level: very high) on CNC Horizontal Lather Operator. The operators who do the work stated that the muscles of the hand have difficulty due to the fast working tempo and repetitive wrist movements.

Table 4.13. *CNC 5 Axis Multi-Spindle Operators Results*

Back (static)	Back (moving)	Shoulder /Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
36	-	40	22	18	1	1	1	1
34	-	38	22	18	1	1	9	9
32	-	38	20	16	1	1	4	9
34	-	42	26	18	1	1	4	4

As seen from the Table 4.13, the majority of the CNC 5 axis multi-spindle operators got very high exposure scores in their back, shoulder/arm and neck part of body. Due to these results, MSD problems among the industrial work force mostly involve the neck, back and low back

Table 4.14. *3-D Sand Printer Operators Results*

Back (static)	Back (moving)	Shoulder/ Arm	Wrist/ Hand	Neck	Driving	Vibr-ation	Work Pace	Stress
-	10	12	10	4	1	1	1	1
-	10	10	10	8	1	1	1	4
-	12	10	12	4	1	1	1	1
-	12	14	10	4	1	1	1	1
-	10	22	12	4	1	1	1	1
-	10	10	10	6	1	1	1	1

Furthermore, there are many old type and technologic type CNC machine tools used by the employees in the factory. When the QEC scores is examined, higher scores are observed with technologically less advanced machines due to the nature of the machine.

In order to cope with this problem, the new CNC machines with technologically advanced machines that did not require manpower is started to use. It can be observed from the Table 4.14 that all eight factors showed acceptable levels of exposure risk score. After all, with this technology, according to the results that observed the exposure levels of people working on these machines can be even negligible.

Table 4.15. *Casting Final Check Operators Results*

Back (static)	**Back (moving)**	**Shoulder /Arm**	**Wrist/ Hand**	**Neck**	**Driving**	**Vibr-ation**	**Work Pace**	**Stress**
12	-	24	22	8	1	1	4	4
14	-	24	30	12	1	4	4	4
-	32	32	24	6	1	1	1	1
-	32	30	22	6	1	4	1	4

As it can be seen clearly in Table 4.15, two operators of casting final check work by sitting and two of them are not. As a result of this difference, it shows that workers who move their bodies have higher exposure score. It may even be concluded that, higher exposure levels are observed in the neck part of operators, who are not moving during working, while the neck of mobile workers have low level exposure score.

4.3. Discussions

The metal manufacturing sector need more physical strength and the risk factors are considerably high and it threats the employees due to the heavy work. Most of these risks are ergonomic risk factors. Therefore, ergonomic risk analysis has become more important in recent years with the numerical increase of work accidents and occupational diseases, especially musculoskeletal diseases.

The increase in the number of these accidents has been observed not only in Turkey but also in the whole world. It has been shown that MSDs accounts for 45% of total diseases observed in aluminum industry workers in Norway (Morken *et al.,* 2003). In India among brass metal workers, the rate of MS discomfort in the wrist and upper limb was found to be 62% and 40%, respectively (Gangopadhyay *et al.,* 2007). In UK, the results are not different either, the prevalence of pain in the neck and arm was estimated as 50.5% among ceramic industry workers (Sim *et al.,* 2006). These several serious data showed that assessment of the factors that leads to MSDs is extremely important for occupational health and safety.

Similar studies conducted in the literature have been examined and in the study named “Investigation of Ergonomic Risk Factors in Production Line of an on-vehicle Manufacturer Factory” which is published by Kuzucuoğlu, was observed that there was similar relationship when compared with the results obtained the results of this study dealing with 3 different ergonomic risk assessments of an enterprise taking place in the serial production line in the automotive sector (Kuzucuoğlu, 2019).

In general, the production lines of all enterprises operating in this sector are considered to be similar and the results obtained by the risk assessment method in this study are thought to be similar to the results.

It is essential for a thorough understanding of the work process and the interaction between the worker, the equipment and the environment to fully define the ergonomic risk factors of the musculoskeletal disorders. The ergonomic principles underlying the equipment design for adjustability are essential to optimize employee comfort and efficiency and to reduce the risk of injury.

Since the method is based on live assessments due to the nature of the method, interviewer cannot view the work task as many times as they like and cannot use slow motion. If there were a chance to record, the interviewer would have seen fast movements and positions more easily. At the same time, the use of real cases can also give a risk of bias. (Leskinen *et al.*, 2011).

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

In this study, the questionnaire named with Quick Exposure Check Method as a risk assessment method is implemented to employee works in a well-known company placed in Sincan Organize Sanayi Bölgesi / Ankara. The advantage of using QEC by observing results is that the interviewer can clearly see the different body parts being evaluated and that employees are closer to the way in which assessments are used in practice.

At the end of the study findings obtained from the answers taken from 47 employees, according to Table 4.13 it can be clearly seen that the highest risks are observed in Back and Neck part of workers who work in old CNC 5 Axis Multi-Spindle. These parts are regarded as very high in the Exposure Level table. By scoring the assessment, as it is obvious Back and Neck parts highly affected from the risk factors such as load weight, posture, duration and frequency of movement.

The findings from this study supported the first research hypothesis that probability of MSDs is less likely for employees with higher education levels. As a second hypothesis, that the higher age groups are more likely to observe MSDs.
In iron and steel manufacturing industry, it is necessary to continuously monitor the compliance of working conditions with occupational health and safety principles and to establish incentives for improvements.

With the increase of education level, the working conditions and equipment used meet occupational health and safety requirements when it is observed from the results. Workers who have graduated from secondary school have scored higher exposure levels, on the other hand a lower exposure score were observed in high school graduates.

Besides, it is an important requirement that machinery-equipment used in enterprises be replaced by systems with a higher level of safety equipment. This can already be observed in Table 4.14, by comparing the results of the data analysis with usage of new CNC machines with developing technology in the site and other older CNC machines.

5.2. Recommendations

Observational ergonomic risk assessment tools are useful measures of work related MSDs which was a common occupational health problem for the workers in a place when there is highly labor intensive work place. This research review summarized the latest literature on work-related musculoskeletal disorders, which is done in manufacturing sector.

- Employees have been informed about the details of study before the survey, so there is a possibility that they may have tried to reduce the wrong or inappropriate actions they would normally take while working. Therefore, it may not be possible to obtain totally reliable results during the survey. However, data is obtained by observing the employees and asking one to one questions with the QEC method. Therefore, when different risk assessment method is applied to employees and if a comparison is made with an external observation without the knowledge of the employees, the data will be changed and may be more reliable.

- It may be helpful for administrators to take some measures such as ergonomics solutions, stress reduction plan, and training program about how to protect from risky behaviors and deal with hazards and seminars to all employees in the most risky department.

- Although the method gives reliable results, it does not give very detailed results due to the small number of survey participants. Therefore, in a manufacturing sector where the number of workers is higher, a re-study can be performed with this method.

- Work related MSDs are associated with organizational factors without demographic characteristics of manufacturing industry workers. Due to the nature of the method, different questions cannot be added to the method, and the rubric does not differ in this direction. However, in order to reach more detailed results, a study can be performed by using a method which includes demographic characteristics questions like education level of the employees, age group, experience of the employees.

- According to the risk levels obtained as a result of the QEC method in the workplaces, it is very important to plan and implement corrective actions by focusing on the body parts determined and to carry out continuous improvement studies with the participation of the employees. Particularly during the planning of corrective actions, the opinions of the employees performing the task should be taken and the work should be rearranged. Trainings should also be provided to increase the sensitivity of employees to the risk factors of MSD formation.

- In addition to providing occupational health and safety training to employees as required by the legislation, it is recommended to increase the educational and promotional activities aimed at improving occupational health and safety awareness. Outcomes of these trainings should also be monitored and reported by regular inspections.

- With the help of the study, after determination of the MSDs on employees, a booklet and banners is recommended to be prepared which includes warnings and showing false posture while working to increase awareness for these diseases.

- One of the most critical findings from the study shows that the use of devices to transfer and remove materials to avoid the use of their bodies may reduce the risk of MSDs within them. Future research should focus on minimize hazards and risks with the help of developing any tools and adjusting it to the system. The findings from this study can provide comprehensive information for researchers.

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APPENDICES

A. Legal Provisions of the Questions

The Turkish revision of Quick Exposure Check Method that applied to employees

GÖZLEMCİ DEĞERLENDİRMESİ	**BEL**	**A**	**İş yaparken bel;**		
			(Çalışanın kötü pozisyonunu seçiniz)		
			A1 - Hemen hemen nötral (düzgün) pozisyonda mı? (Eğilme ve/veya dönme 20 dereceden az)		
			A2 - Orta derecede öne veya yana eğilmiş ya da yana dönmüş mü?(Eğilme ve/veya dönme 20 ile 60 derece arasında)		
			A3 - Aşırı derecede öne ya da yana eğilmiş veya yana dönmüş mü? (Eğilme ve/veya dönme 60 dereceden fazla)		
		B	(Aşağıdaki iki görev seçeneğinden SADECE BİRİNİ seçiniz.		
		Otururken veya ayakta sabit pozisyonda yapılan bir iş ise ; (hareket gerektirmeyen işle veya tekrarlamalı işler gibi)		**Kaldırma, itme/çekme ve taşıma işleri ise; (belin hareketi ile yükün hareket etmesi gibi)**	
			Çoğunlukla (50%) bel sabit pozisyonda mı kalıyor?		**Belin hareketinin sıklığı**
			B1 - Hayır		B3 - Seyrek mi? (dakikada yaklaşık 3 kez veya daha az)
			B2 - Evet		B4 - Sık mı? (dakikada yaklaşık 8 kez)
					B5 - Çok sık mı? (dakikada yaklaşık 12 kez veya daha fazla)
	OMUZ/KOL	**C**	**İşi yaparken eller**		
			(Çalışanın kötü pozisyonunu seçiniz)		
			C1 - Bel düzeyinde ya da altında mı?		
			C2 - Yaklaşık göğüs düzeyinde mi?		
			C3 - Omuz düzeyi ya da üstünde mi?		
		D	**Omuz/kol hareketi**		
			(Çalışanın kötü pozisyonunu seçiniz)		

			D1 - Seyrek mi? (Aralıklı hareket)
			D2 - Sık mı? (Arada duraklamalarla düzenli hareket)
			D3 - Çok sık mı? (Hemen hemen sürekli hareket)
	BİLEK /EL	**E**	**İş yaparken**
			(Çalışanın kötü pozisyonunu seçiniz)
			E1 - Bilek hemen hemen düzgün pozisyonda mı? (Eğme ve/veya bükme 15 dereceden az)
			E2 - Bilek yana eğilmiş ya da bükülmüş pozisyonda mı? (Eğme ve/veya bükme 15 dereceden fazla)
		F	**Benzer tekrarlamalı hareketlerin sayısı**
			F1 -Dakikada 10 kez ya da daha az mı?
			F2 - Dakikada 11 -20 kez mi?
			F3 - Dakikada 20 kez kezden fazla mı?
	BOYUN	**G**	**İş yaparken baş/boyun aşırı derecede öne veya arkaya eğik mi ya da yana dönük mü?**
			G1 -Hayır (Eğilme ve/veya döndürme 20 dereceden az)
			G2 - Evet, bazen (Eğilme ve/veya döndürme 20 dereceden fazla ve çalışma süresinin %70'inden azını kapsıyor.)
			G3 - Evet, sürekli (Eğilme ve/veya döndürme 20 dereceden fazla ve çalışma süresinin %70'inden fazlasını kapsıyor.)
ÇALIŞAN DEĞERLENDİRMESİ	KALDIRILAN/TAŞINAN EN FAZLA AĞIRLIK	**H**	**Bu işi yaparken ELİNİZLE kaldırdığınız ve/veya taşıdığınız, en fazla ağırlık ne kadardır?**
			H1 -Hafif (5 kg ya da daha fazla)
			H2 - Orta (6-10 kg)
			H3 - Ağır (11-20 kg)
			H4 - Çok ağır (20 kg'dan fazla)
	HARCANAN ZAMAN	**J**	**Bu işi yaparken günde ortalama ne kadar zaman harcıyorsunuz?**
			J1 -2 saatten az
			J2 -2-4 saat
			J3 -4 saatten fazla
	EN FAZLA KUVVET DÜZEYİ	**K**	**Bu işi yaparken bir elinizle uyguladığınız en fazla kuvvet düzeyi ne kadardır?**
			K1 -Düşük (1 kg'dan az)
			K2 -Orta (1-4 kg)

			K3 -Yüksek (4 kg'dan fazla)	
	GÖRSEL DİKKAT	**L**	**Bu işin gerektirdiği görsel dikkat düzeyi nedir?**	
			L1 -Düşük mü? (İnce ayrıntıları görmeye neredeyse gerek yoktur)	
			K2 -Yüksek mi? (Bazı ince ayrıntıları görmeye gerek vardır)*	
			**Eğer yüksek ise lütfen yandaki boşlukta ayrıntıları belirtin*	
	TAŞIT KULLANMA	**M**	**İşinizde günlük taşıt kullanma süreniz ne kadardır?**	
			M1 -Günde 1 saatten daha az veya hiç	
			M2 -Günde 1-4 saat	
			M3 -Günde 4 saatten fazla	
	TİTREŞİM	**N**	**İşinizde günlük titreşimli aletler kullanma süreniz ne kadardır?**	
			N1 -Günde 1 saat yada hiç	
			N2 -Günde 1-4 saat	
			N3 -Günde 4 saatten fazla	
	İŞ TEMPOSU	**P**	**Bu işi sürdürürken zorluk çekiyor musunuz?**	
			P1 -Hiçbir zaman	
			P2 -Bazen	
			P3 -Sık*	
			**Eğer sık ise lütfen yandaki boşlukta ayrıntıları belirtin ---------->*	
	STRES	**Q**	**Genel olarak bu işi ne kadar stresli buluyorsunuz?**	
			Q1 - Hiç	
			Q2 - Az	
			Q3 - Orta*	
			Q4 - Aşırı*	
			**Eğer orta derecede veya çok ise lütfen yandaki boşlukta ayrıntıları belirtin ->*	

B. An Example of Risk Assessment Tool Report

Exposure Scores Worker's name and work *Mustafa - CNC Horizontal Lather Operator*

Back

Back Posture (A) & Weight (H)

	A1	A2	A3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 1 = **8**

Back Posture (A) & Duration (J)

	A1	A2	A3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2 = **2**

Duration (J) & Weight (H)

	J1	J2	J3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 3 = **8**

Now do **ONLY** 4 if static
OR 5 and 6 if manual handling

Static Posture (B) & Duration (J)

	J1	J2
H1	2	4
H2	4	6
H3	6	8

Score 4 = **2**

Frequency (B) & Weight (H)

	B3	B4	B5
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 5 =

Frequency (B) & Duration (J)

	B3	B4	B5
J1			6
J2			8
J3			10

Score 6 =

Total score for Back
Sum of scores 1 to 4 OR
Scores 1 to 3 plus 5 and 6 = **20**

Shoulder/Arm

Height (C) & Weight (H)

	C1	C2	C3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 1 = **8**

Height (C) & Duration (J)

	C1	C2	C3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2 = **2**

Duration (J) & Weight (H)

	J1	J2	J3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 3 = **8**

Frequency (D) & Weight (H)

	D1	D2	D3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 4 = **10**

Frequency (D) & Duration (J)

	D1	D2	D3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 5 = **4**

Total score for Shoulder/Arm
Sum of Scores 1 to 5 = **32**

Wrist/Hand

Repeated Motion (F) & Force (K)

	F1	F2	F3
K1	2	4	6
K2	4	6	8
K3	6	8	10

Score 1 = **4**

Repeated Motion(F)&Duration(J)

	F1	F2	F3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2 = **2**

Duration (J) & Force (K)

	J1	J2	J3
K1	2	4	6
K2	4	6	8
K3	6	8	10

Score 3 = **6**

Wrist Posture (E) & Force (K)

	E1	E2
K1	2	4
K2	4	6
K3	6	8

Score 4 = **4**

Wrist Posture (E) & Duration (J)

	E1	E2
J1	2	4
J2	4	6
J3	6	8

Score 5 = **2**

Total score for Wrist/Hand
Sum of Scores 1 to 5 = **18**

Neck

Neck Posture (G) & Duration (J)

	G1	G2	G3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 1 = **4**

Visual Demand(L)&Duration(J)

	L1	L2
J1	2	4
J2	4	6
J3	6	8

Score 2 = **2**

Total score for Neck
Sum of Scores 1 to 2 =

Driving

M1	M2	M3
1	4	9

Total score for Driving = **9**

Vibration

N1	N2	N3
1	4	9

Total score for Vibration= **4**

Work pace

M1	M2	M3
1	4	9

Total score for Neck = **4**

Stress

Q1	Q2	Q3	Q4
1	4	9	16

Total score for Stress= **4**

C. Ethical Permission

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05 NİSAN 2018

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Doç.Dr. Nuray DEMİREL

Danışmanlığını yaptığınız yüksek lisans öğrencisi Ecem İNALÇUK **"İmalat Sektöründe Çalışanlar Üzerindeki Ergonomik Risklerin Hızlı Maruziyet Değerlendirme Metodu ile İncelenmesi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2018-FEN-017** protokol numarası ile **06.04.2018 - 30.09.2018** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

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