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A HYBRID MODEL FOR THE ASSESSMENT OF ERGONOMIC RISK FACTORS IN LOGISTICS INDUSTRY

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ABSTRACT

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In order to adapt to the ever-changing conditions brought by the developing technology, companies have gone to rapid mechanization. As a result of this intense mechanization, the logistics sector was affected by these developments and followed these recent advancements closely to keep pace with the changing world. However, in this rapid mechanization process, distribution activities gather momentum, the environment in which the workers are located briefly human physiology and many ergonomic risk factors were neglected by the managers within this period. This study aims to present an ergonomic intervention by conducting a hybrid model for the assessment of ergonomic risk factors in the logistic industry. Therefore, a hybrid model has been built for the study depending on worker attitudes, working behaviors, postures of the worker, and workplace conditions in order to detect problems to eliminate ergonomic risk factors. The research results indicate that repetitive-sustained awkward postures, extreme reaching distance, static postures over time, and moving distance are the main causes of the Work-related Musculoskeletal Disorders for Company A. In this context, reactive and proactive approaches have been used for the presentation of the ergonomic interventions.

Key Words: WMSDs, ergonomic risk assessment, hybrid model, OWAS method, NORDIC questionnaire, logistics industry

ÖZ

LOJİSTİK SEKTÖRÜNDEKİ ERGONOMİK RİSK FAKTÖRLERİNİN DEĞERLENDİRİLMESİ İÇİN HİBRİT MODEL

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Gelişen teknolojinin getirdiği sürekli değişen koşullara uyum sağlayabilmek için şirketler hızlı makineleşmeye gittiler. Bu yoğun makineleşmenin bir sonucu olarak lojistik sektörü bu gelişmelerden etkilenmiş ve değişen dünyaya ayak uydurmak için bu son gelişmeleri yakından takip etmiştir. Ancak bu hızlı makineleşme sürecinde dağıtım faaliyetleri ivme kazanmış, çalışanların içinde bulunduğu ortam kısaca insan fizyolojisi ve birçok ergonomik risk faktörü bu dönemde yöneticiler tarafından ihmal edilmiştir. Bu çalışma, lojistik sektöründeki ergonomik risk faktörlerinin değerlendirilmesi için hibrit bir model yürüterek ergonomik bir müdahale sunmayı amaçlamaktadır. Bu nedenle, ergonomik risk faktörlerini ortadan kaldıracak sorunları tespit etmek amacıyla çalışma için işçi tutumlarına, çalışma davranışlarına, çalışanın duruşlarına ve işyeri koşullarına bağlı olarak hibrit bir model oluşturulmuştur. Araştırma sonuçları, A Şirketi için işe bağlı kas-iskelet sistemi hastalıklarının ana nedenlerinin, tekrarlayan ve sürekli garip duruşlar, aşırı uzanma mesafesi, zaman içinde statik duruşlar ve hareketli mesafe olduğunu göstermektedir. Bu bağlamda ergonomik müdahalelerin sunumunda reaktif ve proaktif yaklaşımlar kullanılmıştır.

Anahtar Kelimeler: işe bağlı kas iskelet sistemi rahatsızlıkları (KİSR), ergonomik risk analizi, hibrit model, OWAS metodu, NORDIC anketi, lojistik endüstrisi

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Çisem Lafcı
İzmir, 2021

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SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS:

ILO	International Labor Organization
WHO	World Health Organization
WMSDs	Work-Related Musculoskeletal Disorders
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
OWAS	Ovako Working Posture Analyzing System
REBA	Rapid Entire Body Assessment
RULA	Rapid Upper Limb Assessment

CHAPTER 1
INTRODUCTION

With the advances brought by the developing technology, many business lines have gone to mechanization to adapt to the ever-changing and developing consumer demands in the fastest way, to satisfy the growing demands and to increase the variety of products and services in the market to excel its competitors. As a result of this intense mechanization, the logistics sector was affected by these developments and followed these recent advancements closely to keep pace with the changing world. However, in this rapid mechanization process, distribution activities gather momentum depending on the production speed and the workers, the environment in which the workers are located briefly human physiology and many ergonomic risk factors were neglected by the managers within this period. Risk factors such as improper and repetitive positions, force, overexertion, long hours of work without a break and poor and bad working conditions, etc. were ignored while trying to get the work done in limited time with work pressure and it results in musculoskeletal disorders and occupational diseases. In this respect, ergonomics serves to provide ergonomic improvements that are necessary to reduce and remove these risk factors which prevent workers' health, the proper regulation of work environments according to the worker, to the equipment and tools, or to work itself. Because many businesses contain various hazardous agents and potential risk factors by their nature and the workers who are exposed to those hazards face with occupational diseases, injury, and disabilities. Ignoring these risk factors that people are exposed to in their working environments is not only decreases the workers' living standards but also affect companies' productivity and continuity of service significantly and cause many financial and emotional damages in the enterprise. Moreover, one of the most prevalent risks among the job environment is ergonomic risk factors. Ergonomic risk factors like heavy physical demand (lifting, twisting, pulling, and pushing activities) and weak postures are often caused by poor working conditions because while a worker handling a strenuous task, they perform heavy exertion workload in a limited time and because of that many factors such as improper postures, repetitive-long term movements, moving distance, fatigue can lead postural stress on the worker that can cause work-related pain. Therefore, ergonomics assists many sectors in a matter of predicting and minimizing these risk factors and their damage. The purpose is designing the workplace as the user can fit without physical limitations and make work safer with fewer injuries, work accidents, health problems, etc. By doing that, ergonomics provides enterprises many benefits such as developing quality with few errors, enhancing productivity effectively and efficiently and improved morale, etc. Thus, the regulation of the work environment is very crucial for both workers' health and labor productivity. Hence, making these ergonomic arrangements are beneficial for both workers to work comfortably and increasing production volume and profitability of the companies (Sağırlıoğlu et al., 2015).

The logistics industry is directly related with these ergonomic risk factors and hazards and this intimate relationship among them affect workers who are working on logistics sector and exposing many physical activities such as manual material handling (e.g., overload lifting, lowering, carrying, pulling, and pushing) and improper working postures (Choobineh, et al., 2009).

To prohibit these risk factors that cause damage to worker's both physical and mental health conditions, detection of those risk factors is taking an important place. To examine exposing risk factors for Work-Related Musculoskeletal Disorders (WMSDs), a wide range of methods have been improved and most of those assessments are belong to the upper regions of the body such as the back, neck, shoulder, arms and the wrists (David, 2005). The methods used for ergonomic risk analysis listed into three groups as self-reports, observational methods, and direct measurements (David, 2005).

Precaution strategies take forward after the identification step of the risk factors. To decrease the effects of WMSDs and to make ergonomic interventions, control measures are used. These ergonomic interventions are classified as; engineering/technical, administrative/organizational, and personal control measures (Nunes, 2009).

This study aims to present an ergonomic intervention by conducting a hybrid model for the assessment of ergonomic risk factors in the logistic industry. Therefore, a hybrid model has been built for the study depending on worker attitudes, working behaviors, postures of the worker, and workplace conditions in order to detect problems to eliminate ergonomic risk factors. In the next section of the study, background information about ergonomics, musculoskeletal disorders, and the interaction among them are examined in order to develop an understanding of related issues and present deeper insights about the topic.

1.1. Background Information

For further understanding of the problem, main topics such as ergonomics and musculoskeletal disorders are defined and mentioned below.

1.1.1. Genesis of Ergonomics and Historical Evolution

The "ergonomics" word derived from two Greek roots which are *ergos*, meaning work, and *nomos*, which means natural law. So, the basic definition of the ergonomics deducted from the root words is "law of work". The term ergonomics was coined by Wojciech Jastrzebowski, who is a polish educator and scientist, and introduced to the literature (Choi et al., 2014). Ergonomics has been presented as a scientific discipline with a wide variety of interests and applications that addresses many aspects of human activity, involving labor, entertainment, reasoning, and dedication (Karwowski, 1991, 2005, 2006). In its early stages, ergonomics was generally applied to connective problems, worker interaction with machine or job, or performing job within an environment that has visible substantial ergonomic factors e.g., temperature, noise, time pressure, and so on (Wilson, 2000). Moreover, ergonomics concept was used as an interchangeable term with human factors, and denoted as Human Factor Ergonomics (HFE), over the last 50 years, however, it has been developed as a distinct and separate discipline (Karwowski, 2005). Especially in the early twenty-first century, the concept of ergonomics has started to be more widely known and used than ever in the past (Moray, 2005). Historical evolution and development of the ergonomic with more specific information are presented in Table. 1.

Ergonomics can be defined as a science of work that is focused on people who do the job and the ways the job is done, which tools and equipment they use, the working environment they work in, and the psychosocial viewpoints of the working situation (Pheasant & Haslegrave, 2005). Another definition of the ergonomics described by Moray (2005) as an *"ergonomics or human factors is an applied discipline which draws on basic research in (behavioral) science and engineering, and on fieldwork and experience in industrial practice and many other domains, and of which the goal* *is to match how people work, their environment, their tools and equipment, and the products they use, to human qualities and limits.*

Table 1.1. Historical Evolution and Development of Ergonomic (Moray, 2005)

1857	Jastrzebowski, W. B. "An Essay on Ergonomy, or Science of Labour Based on the Laws of Natural Science"
1898	Bryan, W. L., and Harter, N. Studies on telegraph operators
1900	Sechenov, I. Physiology of work and working conditions
1890–1920	Taylor, F., and Gilbreth, F. B. "Scientific Management"
1915	U.K. Health of Munition Workers Committee
1918	U.K. Industrial Health Board
1918	Soviet Department of Occupational Psychology and Labour Research Department
1920	The Hawthorne Experiments
1921	Tanaka, K. "Human Engineering," published in Japan
1930	Dobrotvorsky, N. Human factors analysis of aircraft cockpit
1930s	Development of personnel psychology, motivation, and group dynamics in the United States
1937	First volume of *Le Travail Humain*
1939-1945	World War II Tavistock industrial psychology U.K. Flying Personnel Research Committee Military human factors research, United States
1949	U.K. Ergonomics Research Society founded
1953	U.S.A. First National Symposium on Human Factors
1957	Human Factors Society founded First volume of *Ergonomics*

1961	International Ergonomics Association founded
1970-1980	NATO Science Committee Special Panel on Human Factors
1987	MANPRINT program
1993	Human Factors Society becomes Human Factors and Ergonomics Society

1.2. Musculoskeletal Disorders

Musculoskeletal disorders (MSDs) are determined as injuries or dysfunctions that affect muscles, bones, nerves, tendons, ligaments, joints, cartilages, and spinal disks (Humantech, 2016). Examples of these MSDs are tension-neck syndrome, rotator cuff tendinitis and impingement syndrome in the shoulder, epicondylitis in the elbow, carpal tunnel syndrome (CTS), wrist tendinitis, and hand-arm vibration (HAV) syndrome, etc. (NIOSH 1997). Work-related musculoskeletal disorders (WMSD) are one of the most common occupational illnesses. Risk factors causing work-related musculoskeletal disorders (WMSD) are grouped into three main categories as physical, psychological, and environmental risk factors. Physical risk factors are defined as the factors that workers are exposed to and cause some effects in their body and biology. These physical risk factors comprise iterative motion, extreme force application, and inappropriate postures which include sustained postures, prolonged sitting, and standing (Humantech, 2016). Psychological risk factors are the factors present in the workplace and affect a person’s mental health and social circumstances in a bad way. These psychological risk factors may arise from many causes like work stress/ pressure, mobbing, harassment/bullying, time pressure, and accordingly cause depression and mental health disorder, etc. Environmental risk factors: there might be a substantial agent that causes musculoskeletal strain by exposure in the environment in which work is performed (Silverstein 1995). Examples of environmental risk factors can be vibration, dust, noise, temperature, fumes, etc.

1.3. Outline of the Thesis

As seen in the figure below (Figure 1.1), this study contains 9 main chapters. Each of these sections are divided into related subtitles and, these sections are arranged according to the establishment stages of the study.

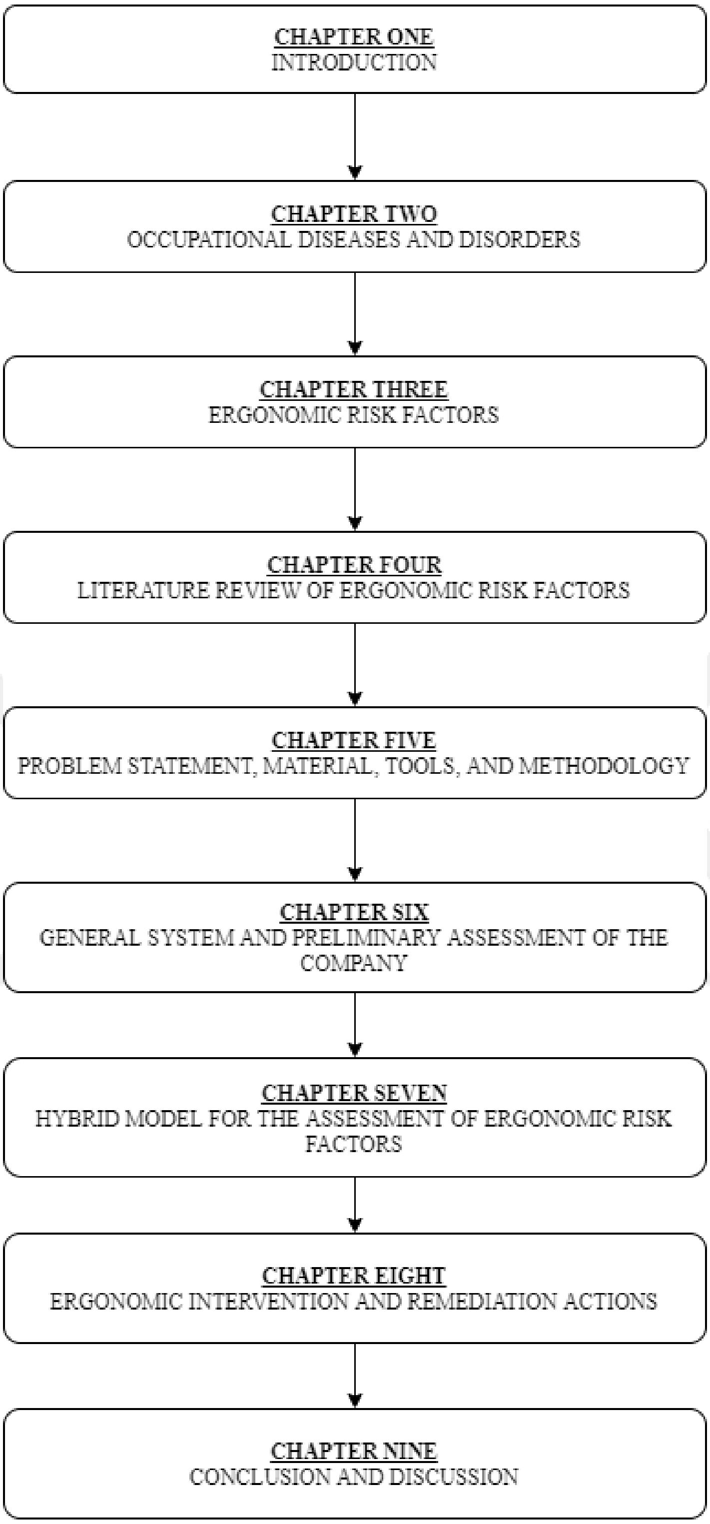


Figure 1.1. Outline of the Thesis

CHAPTER 2
OCCUPATIONAL DISEASES AND DISORDERS

Each year, approximately 2.3 million people around the world succumb to occupational accidents and work-related diseases. Besides, suchlike millions of people suffer from non-fatal injuries and illnesses. This global figure is drawn from the ILO's (International Labor Organization) most recent estimations. According to these figures, it corresponds to over 6000 deaths in a day. Moreover, around 360 million occupational accidents, fatal or non-fatal, occur and 160 million people have occupational diseases annually across the globe (ILO, 2019). These stupendous statistics are a social and economic burden for both enterprises, communities, countries, and families of the workers (ILO, 2019). According to the ILO's estimations, four percent of the world's Gross Domestic Product (GDP) is lost because of occupational accidents and work-related diseases (ILO, 2019). As serious as the situation, preventing these work-related accidents and disease becomes a priority because accidents do not happen without a reason as the illnesses and most of these occupational accidents, injuries and diseases are dissuadable with required prevention techniques.

Other key statistics about ILO's occupational accidents, diseases, and work-related deaths all around the world are about exposing hazardous substances which cause 651,279 deaths in a year and become a factor causing the most deaths between the occupational diseases. Furthermore, the construction industry is the sector which has the highest rate in sense of recorded accidents. Accordingly, younger, and older workers are in the risk group just because they are fragile and require some special consideration to prevent any state of distress in the work environment (ILO, 2019). Taking into account these empirical data, we can surmise that many hazardous elements are in the working environment inherently and the workers' health conditions are threatened as a result of exposing these risk factors and this result as an occupational disease, work-related pain and some kind of restriction in the movements of the worker and even deaths. To prevent these diseases and deaths, we need to examine the reasons behind them, determine the risk factors, and examine the occupational diseases which are caused by them one by one.

Occupational diseases are any disorder or health condition that can occur as temporary or permanent illnesses (physical or mental) because of exposure to risk factors in the work environment by working conditions or occupational activities. These diseases not only reduce the standards of living of the worker but also may result in restrictions of the movements, work-related pain, health problems, and even some serious damages such as some kind of joint injuries, dismemberment, vital competencies, and loss of life. Occupational diseases are not different from non-occupational diseases clinically and pathologically. For that reason, workers may have difficulty in specifying symptoms and differentiate it from non-occupational diseases. In that case, the significance of the training about occupational accidents and diseases which is given by the companies to workers increases because every line of work requires different lifting activity (pulling and pushing task), posture, repetitive actions, etc. By knowing the proper postures for work activities and the possible risk factors they may face can decrease occupational accidents and diseases. Also, the records about workers' previous illnesses or health conditions may provide more precise estimations and help companies to take required ergonomic precautions. In this chapter of the study, occupational diseases which are grouped by ILO into four groups will be given and explained one by one. In addition, ILO's list of occupational diseases were given in Appendix-1.

This chapter enlightens about the identification and recognition of occupational diseases and assists this research in respecting the risk factors which cause occupational diseases and the detection of these risk factors. In this context, most of the below mentioned occupational diseases are relevant within the scope of this study however, WMSDs are the most relevant diseases caused by work-related conditions.

According to the Protocol of 2002 to the Occupational Safety and Health Convention, 1981, the phrase ''occupational disease'' includes any disease contracting because of exposure to work-related risk indicators (ILO, 2010). ILO defines occupational diseases as following terms: ''Each Member should under prescribed conditions, regard diseases known to arise out of the exposure to substances and dangerous conditions in processes, trades or occupations as occupational diseases'' (ILO, 2010). In Turkey, social security institution defines occupational disease as a condition of temporary or permanent illness, physical or mental disability suffered by the insured for a repeated reason due to the nature of the work in which the insured works or due to the conditions of execution of the work (SGK, 2016).

2.1. Occupational Diseases Caused by Exposure to Agents

According to the ILO's list of occupational disease, occupational diseases caused by exposure are classified into three main groups of agents which are arising from the work activities. These are chemical, physical, and biological agents.

2.1.1. Chemical Agents

Chemicals are broadly used in all industries and our daily lives and many practical products like plastics, paints, pharmaceuticals, detergents, etc. are derived from chemicals. Some of these chemicals may seem innocuous however in the case of getting in touch with it can cause injuries (Lim & Koh, 2014). Therefore, chemical agents have the most extensive rate of causing occupational diseases among all agents. These chemical substances can be in gases form such as sulfur dioxide, chlorine, and fluorine which can be resulting in local irritations in the eyes and the respiratory tract by inflaming mucous surfaces (Lim & Koh, 2014). But some gases like nitrogen oxides and phosgene are a way harder to confirm because of the immediate effects of these gases. After a few hours, symptoms such as breathlessness and fatal cardiorespiratory failure due to pulmonary edema, which means the collection of fluid in the lungs, maybe see. Other chemical substances are metals and their compounds. Mercury can be given this as an example of metal poisoning. Mercuric chloride (corrosive sublimate) appears by the ingestion of mercury salts and it is toxic by inhalation (vapors, dust, etc.), ingestion, and skin absorption. Exposure to these substances leads to nausea vomiting and bloody diarrhea. In extreme conditions, kidney damage which results in death may follow (Lim & Koh, 2014). Other examples of chemical agents are selenium, nickel, arsenic, beryllium, cadmium, ammonia, manganese, thallium, and so on.

2.1.2. Physical Agents

Physical agents can also cause occupational diseases. Examples of these physical agents consist of temperature, atmospheric pressure, noise, vibration, ionizing/nonionizing radiation, electricity, etc. Exposure to an extreme level of noise can cause permanent hearing loss or other damage to the ear such as tinnitus (OSHWIKI, 2018). Also, being exposed to vibration for a long time can result in some disorders in joint, lower-back pain, and other musculoskeletal problems.

2.1.3. Biological Agents

Biological agents involve bacteria, viruses, fungi, other microorganisms, and toxins. They can significantly have an impact on people's health in many ways, differing from relatively mild, allergic reactions to serious medical conditions including death (OSHA, 2019). Ebola, zika virus, anthrax, hepatitis viruses, avian flu, botulism, tetanus, tuberculosis are some of the examples of occupational diseases caused by biological substances.

2.2. Occupational Diseases by Target Organ Systems

According to the list of occupational diseases by ILO, occupational diseases by target organ systems are divided into four categories. These are occupational respiratory diseases (respiratory system diseases), occupational skin diseases, work-related musculoskeletal disorders, and mental and behavioral disorders.

2.2.1. Occupational Respiratory Diseases

Occupational respiratory diseases are a lung condition that shows a wide range of symptoms caused by the inhalation of dust, fumes, gases, chemicals, or proteins related to the material in the work environment by the worker. These hazardous dust particles must be in sizes between 0.5 and 100 microns in order not to be hazardous to human health (ÇASGEM 2013). Otherwise, it causes an occupational disease which results in a dust accumulation in the lungs and causes as a consequence of infirmity and death. This disease is known as pneumoconioses. Pneumoconioses is an occupational lung disease which is caused by fibrogenic mineral dust (silicosis, anthraco-silicosis, asbestosis) and silicotuberculosis (ILO, 2010).

Furthermore, it occurs as a result of iterative and continual exposure to hazardous toxins (directly/indirectly) in the workplace. The varieties of these respiratory system diseases depend on the intensity of the exposure (toxicity of the agents) and duration of it, routes of exposure work setting, state of health, and so on. Examples of other types of occupational diseases are asbestosis, silicosis, bisinoz, coal workers' pneumoconiosis (black lung disease), farmer's lung (allergic alveolitis), chronic obstructive pulmonary diseases and Bronchopulmonary diseases. Also, some forms of asthma, bronchitis, emphysema, extrinsic allergic alveolitis, silicotuberculosis are considered as occupational respiratory diseases. The symptoms of these occupational diseases can be a runny nose, dry, scratchy or sore throat, cough, fever, pain in the chest, some sort of body or muscle aches, and of course breathing problems that are very alike non-occupational diseases such as cold, the flu and allergies. For that reason, workers might think these symptoms are usual and common among people. Specifying these symptoms and differentiate it from non-occupational diseases might seem like a tough task to do but at this stage, occupational health and safety specialist is becoming prominent. Every business especially factories, coal mines, etc. have indoor dust measurements and these measurements can tell us the risk factors which presents in the work environment and level of agents that workers are exposed to. Occupational health and safety specialists keep these records and examine them in the case of a state of distress and take ergonomic precaution when needed.

2.2.2. Occupational Skin Diseases

Occupational skin diseases (occupational dermatoses) are skin condition or diseases which occur as a result of exposure to chemical, physical, biological, and individual (genetics) risk factors at the work environment. Around 50 percent of the occupational illnesses are count as work-related skin diseases and it is estimated that 25 percent of all lost working days are due to occupational skin diseases (Peate, 2002). Exposure to chemical hazards is the most common cause of skin diseases in the workplace (OSHWIKI, 2017). Irritants, sensitizers, allergens, and acnegenic agents lead to dermal exposure in the skin, and the chemicals absorbed through the skin cause allergenic or irritant effects. Repeated exposure and direct contact with the hazardous agents enhance the chemical and allergic reactions and correspondingly increases the occupational skin diseases. On the other side, bacteria, skin parasites, fungi, plants, and animal materials are classified as biological hazards that cause skin diseases. Work environment conditions like high or low temperature, humidity, radiation mechanical pressure, and work activities that affect the skin such as excessive handwashing, rubbing are classified as physical hazards. Examples of occupational skin diseases are irritant contact dermatitis, allergic contact dermatitis, airborne contact dermatitis, contact urticaria, acne skin cancers, vitiligo, infections and injuries, and other skin diseases.

2.2.3. Work-Related Musculoskeletal Disorders (WMSDs)

Work-related musculoskeletal disorders (WMSDs) are discomforts and injuries affecting motional body movements and musculoskeletal systems which are induced by the work environment, individual factors, and degrees of the work performed. Health problems in the locomotor system, e.g. muscles, tendons, bones, ligaments, nerves, joints, blood vessels, cartilages, spinal discs, indicate the existence of a musculoskeletal disorder (European Commission, 2017). Pain and loss or limitations in the body functions, mobility, dexterity that restrain workers from many physical abilities and mental wellbeing are qualified as musculoskeletal disorders. These musculoskeletal diseases are generally classified as chronic and reveal after overtime exposure to risk factors that present in the work environment such as poor posture, repetitive actions, heavy physical demand, and heavy exertion, force, or pressure (Eurofound, 2014). Other risk factors that lead to musculoskeletal disorders are extreme reaching distance, inaction, quick motions, work involving vibrations, and so on. Musculoskeletal diseases are generally divided into two groups; upper extremity diseases (neck, shoulder, elbow, hand, and wrist) and low back diseases (ÇASGEM, 2013). Carpal Tunnel Syndrome (CTS), tendonitis, thoracic outlet syndrome, muscle/tendon strain, ligament sprain, tension neck syndrome, epicondylitis, trigger finger, radial tunnel syndrome, mechanical back syndrome, etc. are the examples of common musculoskeletal disorders.

2.2.4. Mental and Behavioral Disorders

Mental and behavioral disorders are illnesses that are caused by exposing psychological and psychosocial risk factors such as work-related stress, excessive workload, tight deadlines, ineffective communication, low socioeconomic status, job insecurity, etc. in the work environment and affect workers' psychological (work relationships, mood, life functions, ability) and physical health negatively. The occurrence of these mental and behavioral disorders can be work-based or may depend on the genetic, psychological origin, or other reasons. Mental disorders are generally categorized as a wide range of problems which contains different symptoms such as some combination of irregular thoughts, emotions, behavior, and relationship with others (WHO, 2019). These kinds of unbalanced movements of the worker may lead to lack of concentration, unwillingness against the work and may even result in some injuries, work accidents, etc. because these diseases affect workers' ability to hold a job, perform a task. Examples of these mental and behavioral disorders are depression, schizophrenia, bipolar affective disorder, anxiety, stress-related and somatoform disorders, post-traumatic stress disorder, intellectual disabilities and disorders, and so on.

2.3. Occupational Cancers

Occupational cancer is cancer that is caused by exposure to cancer-causing chemicals, which is called a carcinogen, in the work environment and that substances or agents lead some mutations which cause unrestrained growth in the cells and increase the degree of cancer. Statistically, thousands of people suffer and die as a result of occupational causes every year and it is estimated that occupational cancers are the leading cause of work-related deaths across the globe (IOSH, 2018). There are innumerable cancer varieties, and each has its name and treatment. Therefore, each type of cancer has its own set of causes (IOSH, 2018). For that reason, for an understanding of cancer and identify the root causes behind the diseases the workers' habits, characteristics, genetics features, current medical conditions must be considered and environmental and psychological factors that the workers are exposed to must be analyzed because cancer is a disease that may result in a combination of all of these components. So, the treatment must suit the causes and it should be for reducing the risk factors which are exposed to. Additionally, most affected organs are generally the ones who have the initial contact and have the highest degree of exposure and mostly damaged organs from these carcinogen substances which leads to occupational cancers like respiratory system organs or skin. And the carcinogens which cause cancer are divided into 3 groups: biological, chemical, and physical carcinogens. Micro-organisms like viruses, Hepatitis B, HIV viruses, etc. can be given as an example of biological carcinogens to cause cancer. Asbestos, anilines, chromates, benzene, chloride, arsenic, cadmium compounds, and nickel compounds are classified as chemical carcinogens. Lastly, physical carcinogens are generally included ultraviolet (UV) and ionizing radiation such as X-rays and alpha, beta, and gamma radiation. Examples of cancer are lung, river, leukemia, kidney, bladder, skin, and so on.

CHAPTER 3
ERGONOMIC RISK FACTORS

Most of the occupational illnesses and injuries are caused by exposure to risk factors such as overtime, job activities involving work positions and postures, and exposure to risk factors that present in the working environment, etc. Ergonomic risk factors are among these risk factors that lead to Work-Related Musculoskeletal Disorders (WMSDs) and injuries. Understanding and identifying these risk factors has vital importance in order to restrain WMSDs by practicing ergonomic principles and using proactive methods. For that reason, determining these risk factors associated with the workplace conditions and work activities assists ergonomics to control those ergonomic risk factors, preventing and minimizing the possible injuries and diseases, and maintaining the balance for productivity. Hence, after detecting possible risk factors, required remediation actions and precautions needs to be taken by ergonomist or occupational health and safety specialist. These ergonomic risk factors can be detected and assessed by using exposure measurement techniques such as analyzing infirmary records, self-reports, observational methods, and direct measurements to reveal exposures related to WMSDs. Infirmary records are used to observe previous and current health records of the workers for the analysis to diagnose the disorder or injuries that the worker has experienced before and by doing that, it helps to visualize the distribution of the diseases and injuries according to department, office or throughout the company. Besides, discomfort, report days, and lost days reports are used for lost working day analysis. On the other hand, the self-reports technique is used for the purpose of collecting data from workers about workplace exposure on both physical and psychosocial factors via using methods such as worker diaries, interviews, and questionnaires (David, 2005). Another exposure measurement method is observational methods which are a postural assessment that assists to observe various body segments or critical physical exposures such as the risky postures and movements and define a risk level for all postures and movement in different body parts to analyze the risk factors that threaten the worker's health condition by the observer with the help of using a checklist. To identify risk elements regarding work-related diseases and injuries, various types of checklist and questionnaires are commonly used such as Standardized Nordic Musculoskeletal Questionnaire (NMQ), Dutch Musculoskeletal Discomfort Questionnaire (DMQ), Cornell Musculoskeletal Discomfort Survey (CMDQ), Body Discomfort Map, Rating of Perceived Exertion (RPE) in the literature. After the detection of the risk factors with the help of checklists, appropriate observational method/s needs to be chosen by looking at the risk factors that observed the working environment and the features of the observational methods. And several different techniques have been developed for recording workplace exposures in a wide range of workplace, work, etc. such as Ovako Working Posture Analyzing System (OWAS), Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), NIOSH Lifting Equation, etc. Lastly, direct measurements are made by directly attached sensors to the subject that has been developed for the purpose of measurement of exposure variables at work (David, 2005). These direct measurement systems help ergonomists in the matter of detecting the exposure variables which is hard to detect in the work environment and measuring their risk level in order to not making damage workers.

Several control methods have been using for the purpose of detection of the risk factors. These control measures that enable to facilitate ergonomic interventions are classified as engineering/ technical, administrative/ organizational, and personal control measures (Nunes, 2009). OSHA provided the hierarchy of controls (See Figure 3.1) to represent which of the controls can be feasible and most effective. First of all, elimination takes forward to control the hazard from the source and then, substitution is considered in the case of elimination is not an option anymore and in substitution, the hazardous material, equipment, or process is being replaced or substituted. Engineering/ technical control measures are the methods that seek to control, eliminate, or minimize the exposure and hazards by modifying the source of exposure in order to avoid workers from ergonomic issues such as hazardous positions and toxic respired gases, etc. Readjustment of the workstations and tools, the transition to automated processes and using mechanical lifting aids, modifying workspace layout, reducing heavy lifting, overexertion, repetitive movements are examples of engineering/ technical control measures. Administrative/ organizational control measures including work practices that are used as a next step after the engineering/ technical control methods and aim to control and minimize the exposure by job rotation, work assignments, breaks and time periods, etc. Thereby, administrative/ organizational control measures including work practices deal with the work processes and procedures to control or eliminate the existent risk factors. Job rotation, warm-up stretching and stretch breaks, training for proper lifting postures, occupational diseases, musculoskeletal health, etc. are the examples of administrative/ organizational control measures. Lastly, personal control measures are the methods that least effective among the hierarchy of control measures. Personal control methods consist of personal protective equipment (PPE) in order to increase the protection of the worker by providing some protective clothes, padded and thermal gloves, elbow pads, knee pads, head protection, eye, face, hearing, respiratory protection, fitting, and slip-resistant footwear, etc.

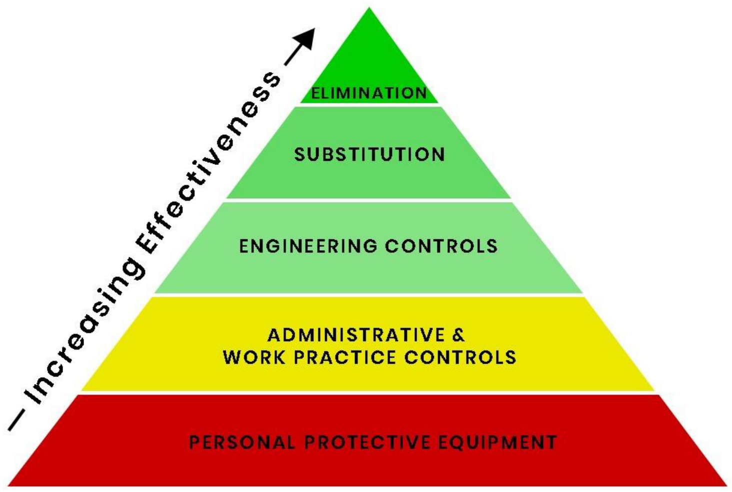
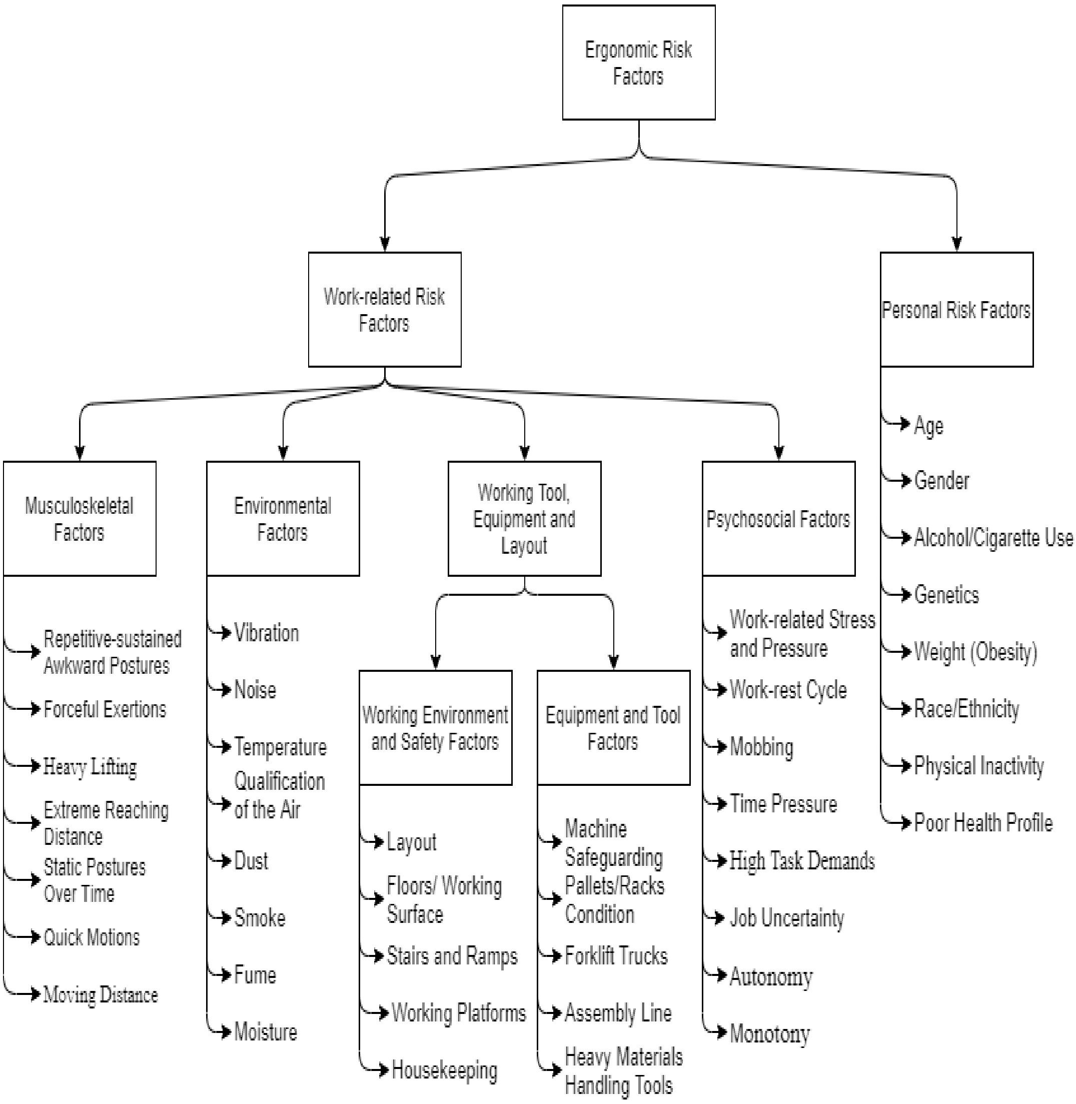


Figure 3.1. OSHA Hierarchy of Controls

In this section of the study, ergonomic risk factors that pose a threat to the workers will be enlightened and discuss in detail. The risk factors leading WMSDs are going to be analyzed under two headings: work-related risk factors and personal risk factors. Work-related risk factors will be given under four main sub-headings as follows: musculoskeletal factors, environmental factors, working tool, equipment and layout, and psychosocial factors (see Table 3.1.).

Table 3.1. Ergonomic Risk Factors



2.4. Introduction to Ergonomic Risk Factors

Ergonomic risk factors can be defined as an aspect of a work environment that is caused by exposure to physical loading of some sort as a matter of course such as high task repetition, lifting weight, static postures over time, force applications, awkward/ inappropriate postures, etc. or environmental factors such as temperature, noise, vibration or humidity. Being exposed to at least one or more of these ergonomic risk factors leads to Work-Related Musculoskeletal Disorders (WMSDs) and injuries. In this study, ergonomic risk factors are examined under two main headings which are work-related risk factors and personal risk factors.

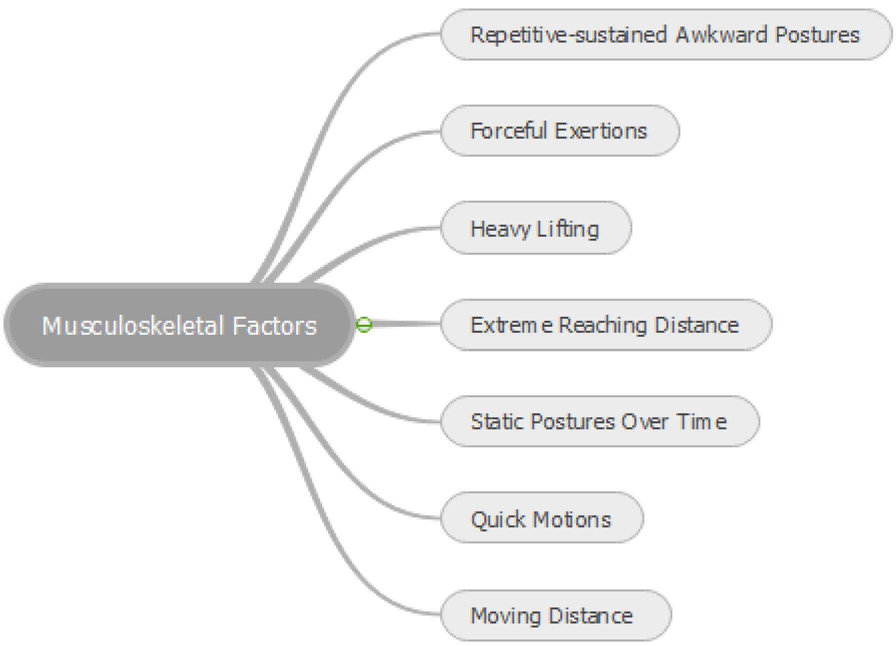
3.1.1. Work-Related Risk Factors

Work-related musculoskeletal disorders are generally resulting from a cumulative and compelling set of actions (Felekoğlu & Taşan, 2017). Work-related risk factors which are arising from work activities that are divided into four sections in this part of the study as followings: musculoskeletal factors, environmental factors, working tool, equipment, and layout and psychosocial factors.

3.1.1.1. Musculoskeletal Risk Factors

Musculoskeletal factors are comprised of factors such as repetitive-sustained awkward postures, forceful exertions, heavy lifting, extreme reaching distance, static postures over time, quick motions, moving distance, etc. (see Table 3.2.).

Table 3.2. Musculoskeletal Risk Factors

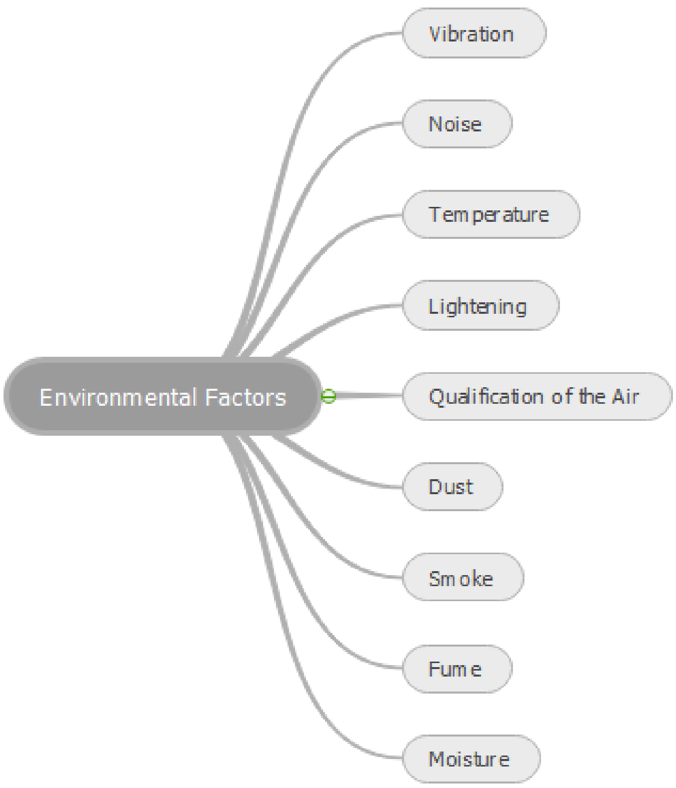


These compelling, repetitive, cumulative, and sustained awkward postures have strong interaction among the incidence of WMSDs and injuries. Moreover, the major factors that lead to WMSDs are musculoskeletal risk factors. In this section of the study, each of these musculoskeletal factors will be described one by one. First, repetitive-sustained awkward postures are associated with work-related musculoskeletal discomfort and injuries in the lower back (Moore et al., 1991). Posture is the required position that is needed to get the job done. However, the effect of limited time, workload, and the work stress caused by in a rush to complete the job on time can cause inappropriate posture. Also, high repetitive tasks and long-term movements are leading causes of fatigue and which may lead to awkward/ inappropriate posture. For that reason, to prohibit the repetitive-sustained awkward postures, education about the required good posture to complete the task by using appropriate tools must be provided because these repetitive-sustained awkward postures are usually related with forceful exertions. The workers who have fatigue because of the awkward posture tend to apply more force to finish the job. For that reason, the applied force to the joint structures is a crucial determinant for the possible injury because if tissue tolerance is exerted, it results as an injury (Silverstein, 1995). Another risk factor is heavy lifting which is a common risk factor observed in the cargo transfer center which is where the application of this study will be conducted. The activities of the cargo transfer center include a lot of manual handling task which requires workers to lift, move, or support weighted objects repetitively. Also, one of the reasons for low back pain is lifting and carrying a heavy load (pulling and pushing task), heavy physical demand, frequent bending, twisting, and inappropriate postures. These low back pains may not life-threatening however it affects social activities and limits work. According to WHO’s estimations, 37% of the back pain can be associated with occupational risk factors (WHO, 2009). Another risk factor is extreme reaching distance. There is a proper distance between the load and the body. As the weight of the load increases, the distance among the body and heavy objects must be minimized. If the distance between the load and the body increases, the activity is classified at the high-risk level. Therefore, extreme reaching distance includes activities that are risky for the workers that can cause WMSDs. Static postures over time are the other factor that can lead to occupational diseases and injuries. Sitting or standing extended periods cause tension in the legs and back which poses a danger for the worker. Besides, workers may tend to make quick motions in order to finish the task earlier than the deadline which can result in some injuries in the tissue. And lastly, moving distance is the last examined factor under the headings of musculoskeletal factors. When the workers' workspace is limited, the postures and the movements in other word moving distance of the workers are restricted and that may cause some injuries and undesirable results.

3.1.1.2. Environmental Risk Factors

The environment is one of the substantial indicators of the exposures and the musculoskeletal strain that contributes to injuries or diseases because, the work environment in which the tasks are performed may include many hazardous ingredients that can cause discomfort, fatigue, strain, and even some dangerous conditions such as fatalities (see Table 3.3.).

Table 3.3. Environmental Risk Factors

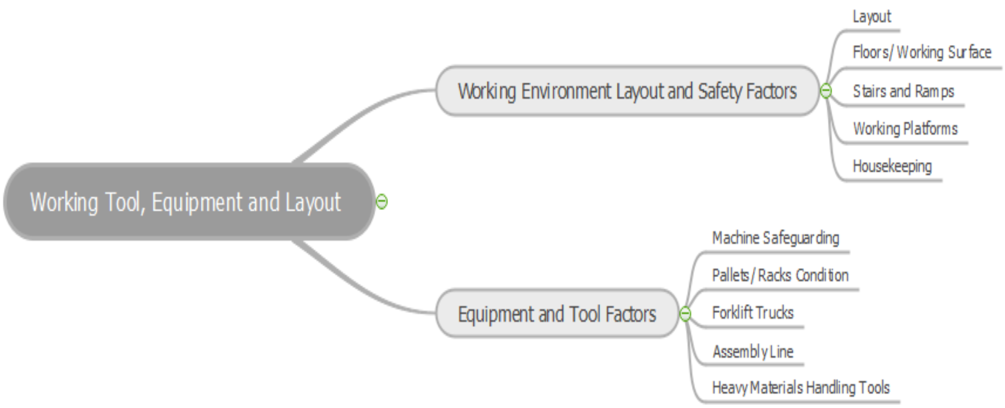


Environmental factors include a wide range of topics such as vibration, noise, temperature (thermal comfort conditions), lightening (poor or insufficient light), qualification of the air (pollution, waste, chemicals, radiation), dust, smoke, fume, and moisture. These environmental elements pose a potential risk for the health of workers in many ways e.g., by the way of exposures to several physical, environmental, and biological substances that may affect respiratory systems. So, in this section, the environmental risk factors mentioned above will be covered briefly. First of all, vibration is an important environmental risk factor that can be caused by hand-held tools or vehicles that give shocks or vibrations while using it. Because of exposure to vibration, several discomforts such as loss of sense of touch or temperature, long-term painful damages in several body regions, painful joints, white finger, severe back pain, carpal tunnel syndrome, loss of grip strength can occur. Moreover, vibration is divided into two parts as hand-arm vibration and whole-body vibration in terms of affected organs or body segments. While being exposed to hand-arm vibration which results by using hand-held power tools can cause long-term painful damage in hands and fingers, being exposed to all that shocks and jolt via using fixed machinery tools such as bench grinders and some sort of driving vehicles as whole-body vibration results in severe back pain. The other environmental factor ‘‘noise’’ is one of the most common occupational hazards. These types of exposures are mostly preventable with required remediation actions and engineering controls. Otherwise, it can cause irreversible hearing impairment. For that reason, noise levels should be minimized, or protective hearing equipment must be provided for the workers to reduce the effects of excess noise. Another important environmental risk factor is the temperature in other words thermal comfort conditions. Both high and low level of temperature poses a danger for workers in terms of their comfort levels and causes increased levels of stress which lower the work efficiency. For example, working in cold or low temperatures pose a problem for the worker who works as sedentary because of low body heat which results in tension in the muscles and additional demands of the body particularly in the neck and shoulder. Furthermore, reduced blood flow to the hands and upper limbs, decreased sensation and dexterity are the other effects of being exposed to the cold or low temperature. To prohibit the effects of it, personal protective equipment e.g., thick, or thermal gloves, etc. must be provided. As the low heat, high temperature poses a problem too. For that reason, recommended air temperature is defined as between 20-21°°C for summer and 20–24°°C for the winter (Silverstein, 1995). Lightening is the factor that is certainly related to productivity because poor lightning can cause symptoms like eye strain, improper posture, tension, and headache, etc. on the worker. Hence, improvement of the lighting quality is a good way to start as a remediation action. Also, the qualification of the air has vital importance for the workers because there may present many hazardous substances in the work environment such as radiation, chemicals, dust, smoke, fume, moisture, and waste which can cause respiratory diseases like lung cancer or dust accumulation in the lungs, etc.

3.1.1.3. Working Tool, Equipment and Layout

The ergonomics of the working environment, layout, tools, and equipment are prominent factors for safe, comfortable, healthful, and efficient workspace which enables comfort to workers that increase efficiency and productivity. These working tools, equipment, and layout factors are divided into two categories in terms of getting a better understanding of the topic (see Table 3.4.). First, the working environment layout and safety factors will be examined, and then, equipment and tool factors will be covered.

Table 3.4. Working Tool, Equipment and Layout Risk Factors



3.1.1.3.1. Working Environment Layout and Safety Factors

Working environment, in other words, workspace, can be defined as a location that contains all working tools, equipment, machines, etc. that is required to perform the task for a relatively long period. Besides that, the working environment can also be classified as the features of the workplace such as the layout, floors/ working surface, stairs, and ramps, working platforms, housekeeping, etc. These characteristics are substantial for workers because it relatively integrated with the performance of the workers. So, in this part of the study above mentioned features of the working environment that poses a hazard for workers will be mentioned. First, the layout can be determined as the design of the workplace in order to provide maximized benefits with minimum working space. To achieve that purpose, most of the time, the human factor is being forgotten and workplaces are temper to machines, tools, equipment, etc. However, the layout should be designed as functional according to the worker that every size of worker can fit. Another important point that a functional workspace design must include is the layout of the workspace should not be complex or crowded in order to be safe and efficient. Required tools and equipment must be organized as the worker can reach easily with minimum distance and movement because more movement means more likelihood of injury or discomfort. Furthermore, except the adequate positions, the layout should provide little demand for extended reaching distance. Also, workstation height must be arranged according to the characteristics of the job e.g., standing or sitting. The workstation must be adjustable in terms of height and length to the worker in either condition of the job. Moreover, the layout must have enough space for both machines/ tools and the worker so that the worker must be able to change their positions very easily and safely. It is crucial to have enough space for postural flexibility and relieve the pressure or stress of a posture for the worker. Hereby, the fatigue that is caused by postural stress will be diminished by making ergonomic accommodation. Another factor that is important for the worker while performing the task without any risk of getting injured is floor condition or working surface. Wet/slippery floors are hazardous and unsafe working surfaces for the workers in terms of falling hazard which is one of the most important causes of injuries and discomforts among the working environment-related risk factors. Also, some differences in the ground (obstacles), poor construction features are posing a potential risk for the workers. For that reason, the non-slippery and surface that purified from obstacles, holes, and rise must be provided for the safety of the workers. Stairs and ramps are the else important risk factor for a safe working environment. Handrails must be available for the ladders in order to use safely. Also, the condition of the working platforms such as the scaffold must be in good shape and all the protective equipment needs to be provided in case of accidents. Lastly, housekeeping is the final risk factor that is examined in this category. The cleanliness of the working environment can accomplish more than just preventing potential accidents. It can also keep all processes and standards in order by arranging material and prevent excessive material handling to make work much easier.

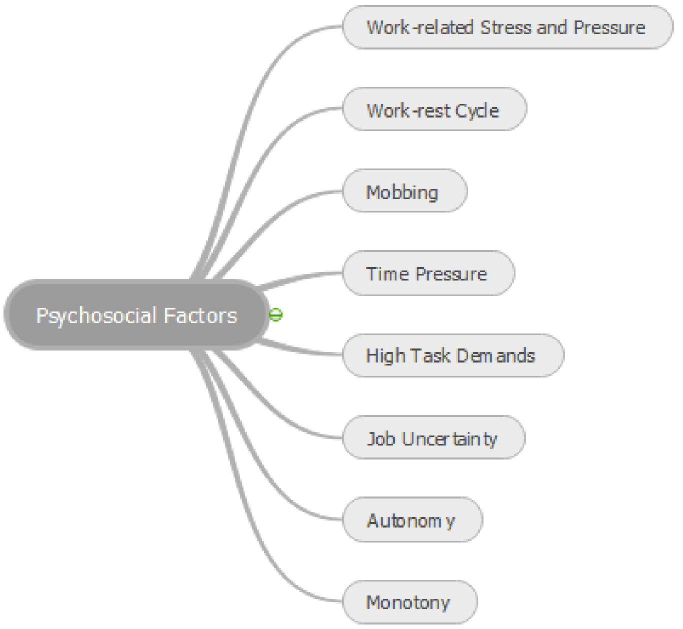
3.1.1.3.2. Equipment, Machine and Tool Factors

Equipment is used as a general phrase of a set of tools that contains all kinds of functional devices, machinery, etc. in order to serve a specific purpose related to the work task. Congruently, tools are multipurpose and small physical objects that are used for achieving a goal in the working process. Under the equipment, machine and tool factors sub-heading, machine safeguarding, pallets, racks condition, heavy material handling tools, forklift trucks, and assembly line will be mentioned. Firstly, safeguarding, and routine maintenance of these tools, equipment, and machines have vital importance in order to maintain a safe working environment for the workers in terms of eliminating hazards by controlling the machines in case of breakdown. These periodic maintenances provide management to observe the condition of the machines and if there is a breakdown, it enables to repair of the machine before any injury. Therefore, it prevents potential injuries that can be caused by machines by diminishing the use of an unsafe tool. Moreover, it helps to keep processes in track because the breakdown of the machines can retard the tasks and it can affect productivity. For that reason, tools, and machines such as the pallets, pallet rack, forklift trucks, and assembly line must be inspected periodically in case of breakdown and their maintenance must be provided to not cause work-related accidents or injuries. Heavy material handling tools are the other substantial cause of injuries and these risk factors can be prevented by taking required ergonomic interventions such as providing a training program for the workers that include proper material handling methods. Besides, the substitution of mechanical handing with manual handling can eliminate hazards.

3.1.1.4. Psychosocial Risk Factors

Psychosocial stressors may arise from the combination of many physical and psychological activities that job contains such as work activities, characteristics of the job, task demands, work-related stress, etc. (see Table 3.5). Therefore, the psychological reaction of the worker to jobs and work conditions has a major impact on health and the reporting of the symptoms (HSE, n.d.).

Table 3.5. Psychosocial Risk Factors

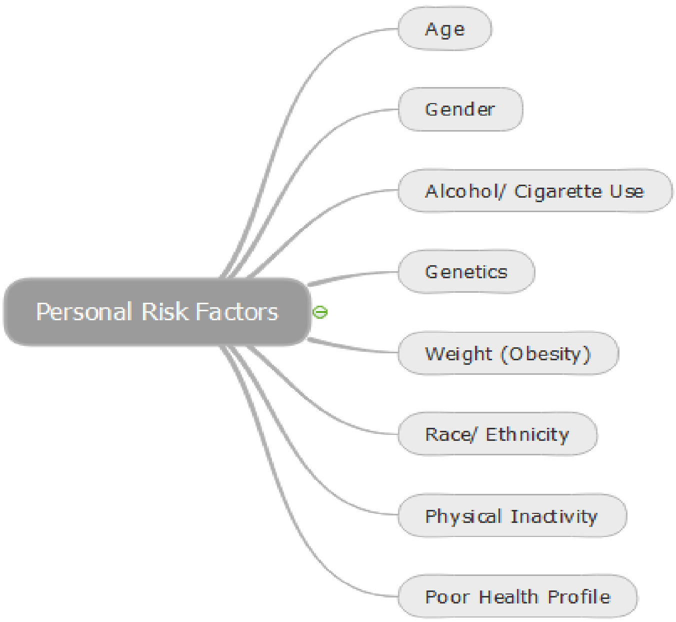


These reactions that affect worker health conditions both physically and psychologically are referred to as psychosocial risk factors and hazards. Psychosocial factors and hazards are listed as following of the study such as work-related stress and pressure, work-rest cycle, mobbing, time pressure, high task demands, job uncertainty, autonomy, and monotony. First, work-related stress has the ability to influence the psychological and physical wellbeing of the worker in a negative way, as well as the organization's performance and effectiveness. Furthermore, work-related stress is recognized as a major challenge to the health of the workers and accordingly an organization's safety (WHO, n.d.). The factors that cause work-related stress and pressure can be any psychological stressors from monotonous work to time pressure. Moreover, many psychosocial risk factors that are covered in this section such as work-rest cycle, mobbing, time pressure, task demands, job uncertainty, harassment bullying, etc. can be triggering factors of work-related stress and pressure. Also, the work-rest cycle is an important indicator for the worker because a lack of breaks, inadequate resting time, and overtime work can cause fatigue on the worker which can cause a worker to perform the job not properly. Besides, factors like overtime work or short break can lead to a lack of motivation, mental fatigue, distractibility, absence, etc. Mobbing is another important psychosocial risk factor that can affect the motivation and efficiency of the worker. Mobbing is a generalized name for being bullied by an individual or a group that can cause isolation, humiliation, harassment in the worker by their co-workers, subordinates, or superiors. Mobbing can be confronted in many ways such as gossip, slander, the threat of violence that affects the productivity and the psychological status of the worker. Time pressure is another important subheading that has a crucial effect on workers' psychological state of health. Performing a task with limited time and due date stresses workers to finish the job as soon as possible. These kinds of movements can affect both the physical and psychological status of the worker in terms of work-related diseases, injuries, and psychological wellbeing. High task demands are also one of the substantial psychosocial risk factors that should not be ignored by the management. Assigning a task that exceeds the capacity of the worker, over-work and high task demands tire workers and so that it leads to some mental health problems and other stress-related disorders which is an obstacle to the healthy work environment. Besides, the uncertainty of the task may lead to some misunderstandings about task definitions that can cause failure to vary tasks Herewith, the stress level of the worker may increase depending on the performing job wrong. Lastly, autonomy and monotony of the job are an important determinant for the physical and mental wellbeing of the worker.

3.1.2. Personal Risk Factors

The characteristics of a person, behaviors, routines, habits, and physical features gave us many information about people's health conditions accordingly, the likelihood of getting a disease or injury. For that reason, personal (or individual) risk factors must be considered with the work-related risk factors as an ergonomic risk factor in order to unveil the root causes underneath. Age, gender, alcohol/ cigarette use, genetics, weight (obesity), race/ethnicity, physical inactivity, and poor health profile are the subtitles that need to be covered under this heading (see Table 3.6).

Table 3.6. Personal Risk Factors



First, age is an important indicator because as the age increases, some health problems show up and increase, and accordingly, the intensity of physical activity of the person decreases based on these health conditions. Also, as the body ages, it loses many features such as flexibility, strength, endurance, mobility, etc. and these people are more likely to fight with the musculoskeletal diseases than a normal, healthy person. Hence, work-related movements such as pulling, pushing, bending, twisting, etc. pose a risk as to the age factor increases. Secondly, gender is another crucial component that needs to be considered respecting WMSDs. Because, as it is known, men's ability and endurance about hard work, such as carrying heavy loads, are higher than women. Thus, giving hard work to women beyond their lifting limits and capacity leads to occupational diseases. In addition, addictive substances use (such as tobacco and alcohol) is more common in men (EUPATI, 2015), so that, related diseases or disorders are more common among men that could threaten their health condition. Moreover, addictive substances such as alcohol and cigarette (tobacco) use pose a danger for the worker and its one of the most critical health issues worldwide. Due to addictive ingredients (e.g., nicotine), toxicants, and carcinogens that cigarette and other tobacco products contain, smoking may cause many lung-related diseases or problems such as lung cancer, COPD, chest diseases, respiratory diseases, and so on. Therefore, workers who use tobacco products and alcohol are in a hazard group because exposure to other risk factors along with alcohol and cigarette use can speed and increase occupational diseases. Genetics is another substantial risk factor that is based on an individual's genes (EUPATI, 2015) because of some of the diseases (e.g., cystic fibrosis, muscular dystrophy, asthma, diabetes and so on.) are passed on to the next generation through genes. Thusly, the genetic makeup of the person reflects the combination of the person's ancestors' genes, and accordingly, it also shows the likelihood of the person getting a genetic disorder from the ancestors. So, the combination of the genetic disorder with the exposure to risk factors in the workplace can affect worker's health and performance and the detection of the risk factor and understanding the root causes underneath of the diseases, in terms of it is an occupational disease or not, can be hard for the occupational health and safety specialist. Moreover, the weight (obesity) of the worker affects workers' mobility and degree of fatigue because the overweight person consumes more energy than the normal weight individual and get tired easily. Because overweight people spend extra energy for routine tasks and get tired, they require more breaks to take a rest. Race and ethnicity are another substantial risk factor than can be examined under personal risk factors. Different backgrounds such as genetic heritage, cultural differences, and identity, different racial and ethnic groups pose a danger for an individual. In the United States, the research about deaths caused by heart diseases is found out that certain race and ethnicity groups are in the high-risk group. According to these statistics of the American Heart Association, blacks are among the highest risk group and then, non-Hispanic or Latino whites come as second (Harvard Health Publishing, 2019). So, certain racial and ethnic groups are in the risk group in order to have occupational or non-occupational diseases. Another personal risk factor is physical inactivity which can be caused by many components such as for overweight, fatigue, diseases, and so on. The level of inaction may increase the person's blood pressure, cholesterol, etc. and can cause many related diseases and poor health profile.

2.5. The Combination of the Risk Factors

Risk factors are generally discussed separately, but in fact, they do not occur alone.

For that reason, risk factors should not be handled alone due to the interaction with one another (EUPATI, 2015). Also, the cumulative effect on risk factors is a substantial issue that can lead to WMSDs or contribute to the development of a disease or injury. Hence, many work-related diseases, disorders, and injuries can be caused by exposure to more than one risk factor, (WHO, 2009). The reason underneath of the combination of these risk factors does not have to be work-related. It also can be intrinsic based (unrelated to work) or both intrinsic and work-related. For example, high priority tasks, urgent requirements, and difficult missions, etc. may swamp workers and can cause work-related stress in a prolonged time period. Accordingly, job stress affects workers physically and mentally such as headache, migraine, impairment of concentration, aggressive and nervous behaviors, muscle tension, musculoskeletal pain, and so on. Especially, when people are under stress, their muscle tense up and body strains, sweat and that can promote musculoskeletal pain particularly in shoulders, neck, and head. For a long process, some of the stress-related musculoskeletal disorders can be triggered with the combination of other risk factors which can be a combination of both intrinsic and work-related. Also, the combination and cumulation of work-related risk factors such as forceful exertions, extreme force application, heavy lifting, etc. can be linked with many work-related musculoskeletal disorders on the low back and upper extremities. Therefore, the combination of the risk factors must be considered in order to prevent and eliminate risk factors.

CHAPTER 4
LITERATURE REVIEW OF ERGONOMIC RISK ASSESSMENT: METHODS AND TOOLS

Ergonomic risk assessment is an evaluation of the working environment, work activities, layout, workflow, etc. in order to identify the possible ergonomic risk factors or stressors and their degree of priority and urgency for the job to develop and implement ergonomic remediation plans. Ergonomic risk assessment is a crucial and essential piece of the ergonomics process because it examines the working environment for eliminating unnoticed and unfavorable ergonomic conditions by analyzing the working environment and interpreting the signs and findings. Therefore, it facilitates the organization's ergonomic process by choosing the right and applicable methods and tools that fit the workplace and prevents waste of time and money for required ergonomic interventions. Hereby, ergonomic risk assessment is positioned at the center of effective and efficient ergonomic risk management (HSA, 2019) in many aspects. Firstly, it displays the current ergonomic level of the organization by evaluating the working environment for the analysis of the ergonomic risk factors for the health and safety of the workstation and worker. In addition to that, it assists ergonomic specialists in the selection of the right and appropriate ergonomic methods and tools that are suitable for the workplace. Moreover, it provides a framework to observe ergonomic risk levels with their priority and urgency. So, it shows which of the identified risk factor/s needs to be focused in order to make an ergonomic intervention.

4.1. Risk Assessment Process

Risk assessment is a complex process that requires high effort as it contains many steps and considers many variables regarding the work-related conditions. For effective analysis of the working environment and work-related activities, being systematic is very substantial. As shown in Figure 4.1, the first thing to do when starting an ergonomic assessment process is the identification of the problem. After the detection of the problem, it is required to have knowledge about the organization's current ergonomic conditions, processes, layout, workflow, and so on to have an opinion. In this respect, basic job analysis is necessary in order to identify and determine the characteristics of the jobs and tasks. Thus, prioritizing the departments, jobs, etc. might facilitate the researcher's job in order to analyze every segment of the work in detail and more systematically. Moreover, the observational approach might provide insight to the researcher in order to get to know the processes better and gather information about the ergonomic risk factors and stressors. Furthermore, an ergonomic specialist needs to be knowledgeable about the tools, equipment, and machines that workers are engaging with in order to how these tools need to be used and is maintenance necessary for the tools or not? Because most of the work accidents occur due to misusage of the tools and equipment by the worker and the defects of the machines. After the evaluation of the working environment, scientifically valid, common, appropriate, and correct ergonomic methods and sets of tools need to be established according to the features of the work. For this purpose, screening observational methods and gathering technical information about work-related activities is essential in order to select the correct method for the job. The selection of the correct method enables effective, efficient, usable, and comprehensible implementation. Data/information acquisition is the next step after the selection of the correct ergonomic methods and set of tools. Predetermined ergonomic methods and tools need to be conducted in a way that both via observation and receiving feedback (self-report) from the worker via surveys. Hereby, ergonomic risk factors can be evaluated both from the perspective of the organization and the worker. Data analysis takes a step forward by using collected data from the working environment and workers in order to prioritize the risk ratings related to the risk factors according to their priority and urgency. Determination of the ergonomic requirements is needed after the data analysis because high-risk factors need to be remediated and ergonomic improvements need to be put in place. Redesign of the workstations, workflows, processes, tasks, etc. that have high-risk for the worker is the last step of a systematic ergonomic risk assessment in order to make ergonomic improvements and taking remediation actions about musculoskeletal health of the worker.

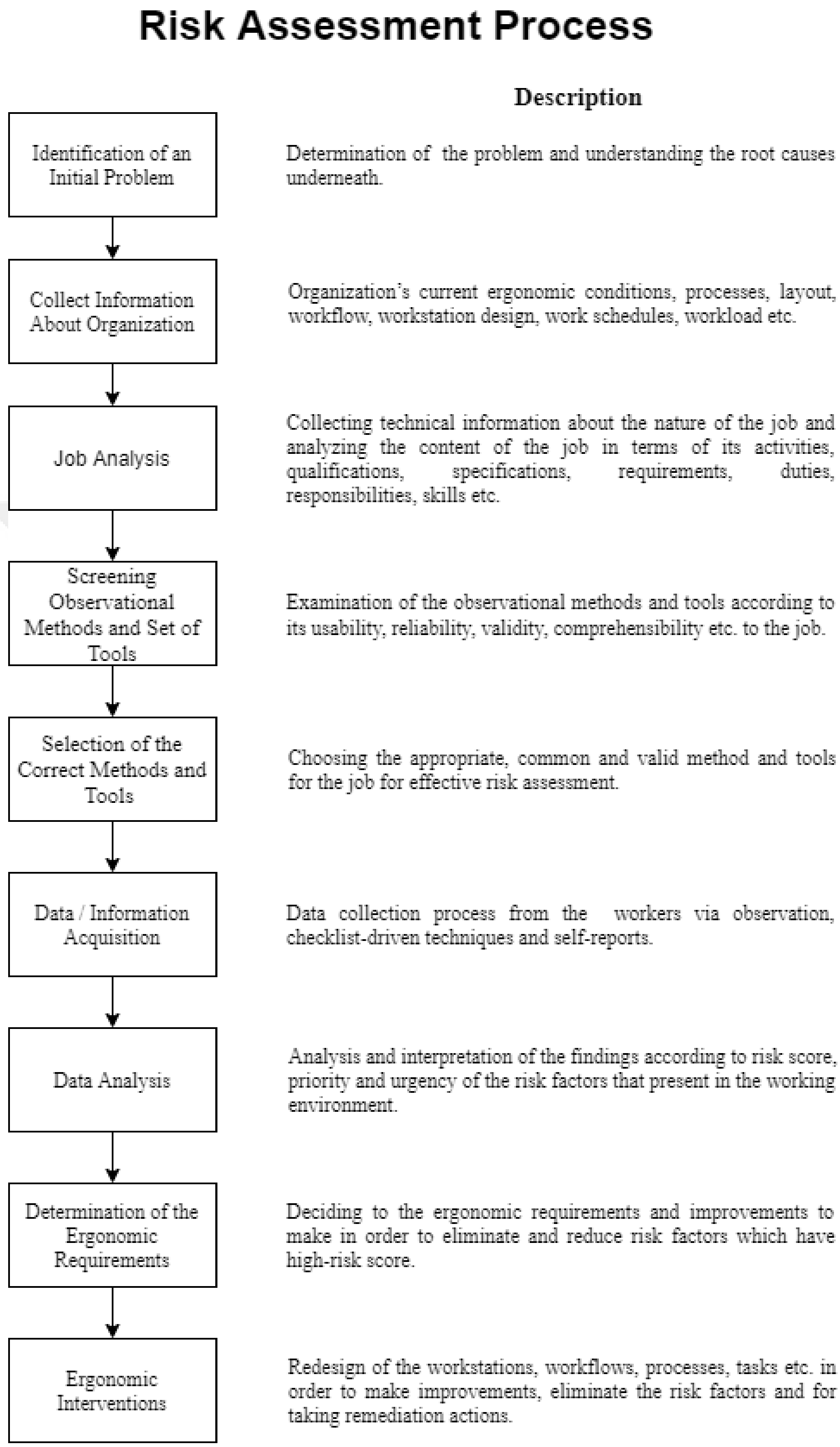


Figure 4.1. Systematic Ergonomic Risk Assessment Process

4.2. Literature Review

The literature review can be defined as a collection of available research documents and materials relevant with the topic which consists of data, ideas, information, a written argument of certain sources in order to be used in research in the matter of associate the problem or research question (RQ) with the purpose of drawing a road map and solution to a problem or research question under the research (Hart, 1998). The reason why literature review matters for the research studies is because it displays all related studies in a systematic manner. It proposes a framework that can guide researchers in terms of many aspects such as research gaps, concerns, barriers, current studies, and future directions.

In this study, the purpose of this chapter is to investigate all conducted risk assessment methods and set of tools in previous research to observe the advantages and disadvantages of these methods in specific areas and sectors. Therefore, the literature review has been used for the purpose of assisting the researcher in the selection of the correct methods and tools for the study by evaluating the literature.

While generating the literature review about ergonomic risk assessment based upon the ergonomic risk assessment methods and tools, various types of assessments have been used in order to determine the ergonomic risks such as collected data assessment, and observational assessment as shown in Figure 4.2. These three subheadings are necessary for effective analysis and for the detection of the risk factors and their risk ratings. Firstly, collected data assessment comprises of many specific methods such as exposure data assessment, self-assessment questionnaire (self-reports), infirmary records and lost working day data. The reason why infirmary records and lost working day data assessment have not been included in the figure as subtopic is because they will not be used for this study. Workers do not always prefer to apply infirmary in case of discomfort, pain, and diseases especially in the company that this study has conducted. Also, the lost working day analysis may not always show the real cause underneath the absence of the worker. Thereby, infirmary records and lost working day analysis are excluded from the study. The second subheading is the observational assessment which consists of two subtopics which are ergonomic risk assessment checklists and ergonomic evaluation tools.

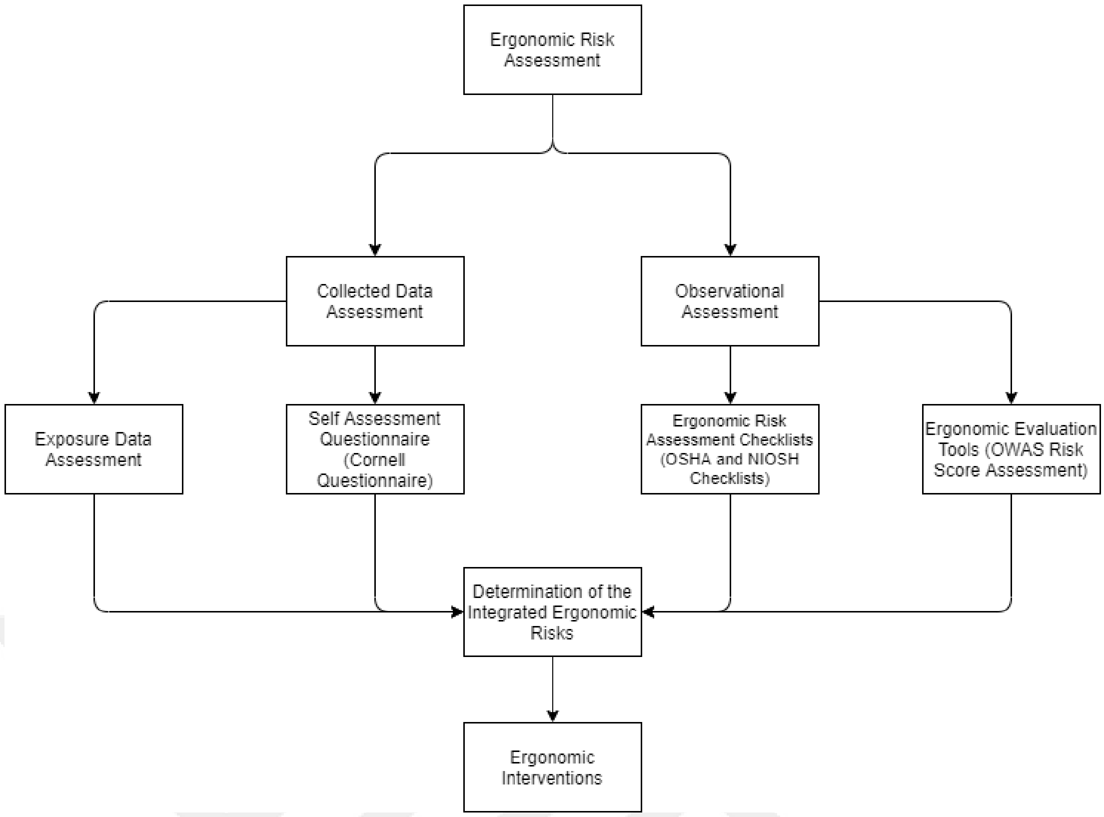


Figure 4.2. Literature Framework of the Study

4.2.2. Collected Data Assessment

Collected data assessment can be generated by examining and collecting data from both workers and working environment related to the WMSDs and the risk factors in the organization. This collection process can be done by examining the company's records about workers' WMSDs reports, lost working days, and exposures present in the working environment such as respired harmful gases, chemicals, etc. Because these records that the company kept gives an insight into the current ergonomic status of the company's and the workers. Moreover, exposure data assessment displays the exposures and environmental conditions that can threaten workers health and safety. Also, collected data assessment can be done via self-assessment questionnaires from the worker in order to understand and get data from the worker side.

In the literature below, collected data assessment methods that are examined during the study are presented and summarized as in Table 4.1.

Table 4.1. Literature Review of Collected Data Assessment Methods

Number	Year	Name of the Authors	Name of The Study	Participant/s	Methods
1	2018	Rizkya et al.	Evaluation of work posture and quantification of fatigue by Rapid Entire Body Assessment (REBA).	14	- Standard Nordic Questionnaire (SNQ)
2	2015	Rabiei et al.	Musculoskeletal disorders in dentists	92	- Standard Nordic Questionnaire (SNQ)
3	2013	Habibi et al.	Assessment of physical risk factors among artisans using occupational repetitive actions and Nordic questionnaire	94	- The Nordic Questionnaire - OCRA index
4	2016	Shariat et al	Prevalence rate of musculoskeletal discomforts based on severity level among office workers	753	- Cornell questionnaire
5	2017	Damayanti et al	Occurrence of Work Related Musculoskeletal Disorders among School Teachers in Eastern and Northeastern Part of India	72	-Dutch Musculoskeletal Questionnaire (DMQ) - SPSS
6	2014	Shuai et al.	Assessing the effects of an educational program for the prevention of work-related musculoskeletal disorders among schoolteachers	500	- Dutch Musculoskeletal Questionnaire (DMQ) - Nordic Musculoskeletal Questionnaire (NMQ)

In the first article, Standard Nordic Questionnaire has been applied to the material handling operators for the identification and detection of musculoskeletal disorders and symptoms. 12 workers from the printing station to the drying stations are sampled and observed in one of the small-medium industries that produce food in North Sumatra. Activities of the operator which contain a high risk of disruption, pain, stiffness, and disorders are undertaken. As a result of that, musculoskeletal disorders and discomforts have been found in the activities of the workers because manual handling operators work in the standing position and bend. And REBA (Rapid Entire Body Assessment) sheet of assessment is filled with the corresponding values depending on the related body position, movement, etc. for each part of the body based on the relative table (Rizkya et al., 2018).

In the second article, musculoskeletal work-related diseases and disorders and the contributing risk factors are examined with the help of standard questionnaires; Nordic and RULA among dentists in the north of Iran. The questionnaire consists of two sections and the first section of the questionnaire is about demographic information and job satisfaction. Then, the Nordic Musculoskeletal Questionnaire (NMQ) has been conducted for the identification and the determination of the potential risk factors and their severity. In total, 92 dental workers, 69 of the participants are a dentist and 23 of them are specialists, have been participating in the questionnaire for the study. Visual Analog Scale (VAS) has been used for the purpose of assessment of the pain severity and RULA (Rapid Upper Limb Disorder Assessment) has been conducted in the third section of the study to detect the adopted awkward posture during the work. At the end of the study, it has been found that more than half of the participants (73 %) of the participants were suffering from musculoskeletal disorders (Rabiei et al., 2015).

In the third article, the cross-sectional study has been carried out in order to determine the level of exposure to physical risk factors that are related to the upper limbs among the artisans in Isfahan. The Nordic Questionnaire and OCRA index (occupational repetitive actions index) have been conducted as a tool for the assessment of the physical ergonomic risk factors to the 94 workers in Artisan production. The effects of repetitive movements on upper limbs were separated as right and left hands for the evaluation. All the 94 participants were selected from different artisans such as embossing, etching, reticular, etc. Besides, the participants who have historical surgery in the limbs were excluded from the study. The statistical analysis of the study has been analyzed by Chi-square, Kruskal Wallis, and one-way variance analysis. The result of the Nordic Questionnaire shows that almost half of the workers suffered from upper limb pain and discomfort in the last 1-year period (Habibi et al., 2013).

In the fourth article, the main purpose of the study is to investigate the prevalence rate of musculoskeletal disorders and discomforts depending on its severity between the office workers. Thus, 753 subjects, within the age group of 20-50 years, from several areas are sampled and selected from a population of 20,000 Malaysian office workers in order to assess the musculoskeletal disorder rate based on severity. For that reason, a form of structured Cornell questionnaire has been carried out to sample population which is 753 office workers. According to the analysis of the Cornell questionnaire, it has been revealed that 69.7% of the workers suffered from severe pain in the neck, shoulder, or lower back (Shariat et al., 2016).

In the fifth article, the focus of the study is to reveal the prevalence of the WMSDs risk factors between school teachers in the Eastern and North-Eastern part of India and so that, supporting and justifying that teaching work leads to musculoskeletal disorders among teachers. For this purpose, 100 questionnaires have been sent to various schools that range from primary to higher secondary schools and 72 schoolteachers have responded to the Dutch Musculoskeletal Questionnaire (DMQ). The data were summarized by using descriptive statistics of mean, standard deviation, and percentages, and SPSS has been used in order to data analysis. As a result of that, in the last 12 months, most of the musculoskeletal complaints were in the neck, shoulder, back, and knees. So that, neck pain is revealed as the most common complaint among the other complaints with the percent of 53.52% (Damayanti et al., 2017).
In the sixth study, the aim of the study was to reduce the schoolteachers' career-threatening injuries and propose evidence-based intervention strategies. Thus, 500 teachers are randomly sampled and selected from four schools out of 1055 schools by using a random cluster sampling method. The design of the questionnaire depends on the job characteristics of the teachers. Therefore, standardized Dutch Musculoskeletal Questionnaire (DMQ) and standardized Nordic Musculoskeletal Questionnaire (NMQ) have been used for this domain. In the analysis of the questionnaires R software has been used and in the analysis of the statistical data descriptive statistics and chi-square tests have been applied. After the 12 months lasting interventions, a decline in the neck, shoulder, low back, and waist has been observed which are the main suffers and pain of the teacher (Shuai et al., 2014).

4.2.4. Observational Assessment

Observational assessment methods can be described as an evaluation of the workers' posture and movement while they are performing the jobs to analyze and measure the ergonomic risk factors and risk ratings by an external rater apart from the company in a predefined format and criteria. Due to it relies on external rater's judgment, the experience of the rater gains importance in order to collect information about the work methods, body posture, etc. Observation-based assessment methods have great importance because it lends to observe the current ergonomic condition of the company from the third perspective apart from the company and worker. Therefore, it may reveal many unnoticed and ignored risk factors that the workers faced with consistently.

Observational assessments are consisting of ergonomic risk assessment checklist and ergonomic evaluation tools. An ergonomic risk assessment checklist, the rater observes the working environment, the postures of the worker, etc. and responds to the questions in the checklist. Also, these ergonomic risk assessment checklists are very applicable and easy to use because the checklist contains only “yes” and “no” questions. In case of requirement of extra and specific feedback, checklists involve sections to write specific comments and insights about the questions one by one. Examples of the ergonomic risk assessment checklists are as follows: Nordic Musculoskeletal Questionnaire (NMQ), Dutch Musculoskeletal Questionnaire (DMQ), Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), and so on. Ergonomic evaluation tools are used for the determination of the risk ratings of the risk factors depending on the observations. There are various ergonomic evaluation tools that focus on different body sections. Ovako Working Posture Analysis System (OWAS), Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), Quick Exposure Check (QEC) are some of the examples of ergonomic evaluation tools.

Table 4.3 presents and summarizes the literature review of observational assessment methods and tools by using ergonomic risk assessment checklists and ergonomic evaluation tools.

Table 4.3. Literature Review of Observational Assessment Methods

Number	**Year**	**Name of the Authors**	**Name of The Study**	**Participant/s**	**Methods**
1	2017	Calzavara et al.	Picking from pallet and picking from boxes: a time and ergonomic study.	1 operator	- OWAS (Ovako Working posture Analysis System) index - Specific motion capturing system
2	2008	Pourmahabadian et al.	Investigation of risk factors of work-related upper-limb musculoskeletal disorders in a pharmaceutical industry.	84	- RULA (Rapid Upper Limb Assessment)
3	2014	Garkaz et al	Ergonomic assessment of Sina car montage industry workers' working positions by REBA (Rapid entire body assessment).	120	- REBA (Rapid Entire Body Assessment)
4	2017	Taghavi et al.	Risk factors for developing work-related musculoskeletal disorders during dairy farming.	Not specified.	- REBA (Rapid Entire Body Assessment)

5	2013	Nadri et al.	Comparison of ergonomic risk assessment results from Quick Exposure Check and Rapid Entire Body Assessment in an anodizing industry of Tehran, Iran	82	- REBA (Rapid Entire Body Assessment) - QEC (Quick Exposure Check)
6	2013	Lasota	Packer's workload assessment, using the OWAS method	Not specified.	- OWAS (Ovako Working Posture Analysis System)

In the first article, the paper aims to present strategies for different storing configurations for the manual assembly system parts. So, the focus of the paper is a prediction of the time that is needed to pick a part and required ergonomic interventions according to the different storing configurations. Thus, some laboratory tests, which include 10 different picking positions, have been performed for the prediction of the required time for picking activities. All these tests have been recorded and captured with the help of a specific motion capturing system which the operator needs to wear. As a result of the observation of the current system, OWAS (Ovako Working posture Analysis System) index has been decided to use in the study in order to evaluate these different storing configurations from an ergonomic point of view. At the end of the study, the findings show that the OWAS index has been seen as more favorable for the tilted pallets when it has been compared with the horizontal ones (Calzavara et al., 2017).

In the second article, the main purpose of the paper is to present an understanding of the WRMDs prevalence rate in the Iranian pharmaceutical industry. Therefore, the modified Nordic Musculoskeletal Questionnaire (NMQ) has been chosen to apply to the packing workers who work in antibiotics, tablets, syrup, ampoule, and Povidione packing. In this cross-sectional study, 84 workers are sampled as a participant which are randomly selected from five packing operations. Then, the RULA method has been used in order to assess the level of workers' exposure level to the risk factors related to upper limb musculoskeletal disorders. Result of the study shows that RULA method is a fairly suitable evaluation tool for the assessment of the WRMDs among the packing workers in the pharmaceutical industry and the major risks that are performed during these kinds of jobs are largely on back, neck, lower arm and postural problems which can be caused by inappropriate furniture design of the workstation (Pourmahabadian et al., 2008).

In the third article, the study focuses on the determination of the risk levels of workers in-car montage industry in Hamedan so that, propose an intervention for the development in the working positions of the workers. 120 workers from 60 occupational duties and different sections are sampled and selected in order to conduct a descriptive-analytical study in 2013. REBA (Rapid Entire Body Assessment) technique has been carried out for the evaluation of the musculoskeletal load on workers in terms of their postures, repetition, and force. For this purpose, the Nordic musculoskeletal questionnaire (NMQ) has been applied to the workers to obtain the prevalence of entire body disorders and the data were analyzed with the help of statistical tests. The reason why the REBA technique has been used in this study is that this technique examines the whole-body parts in two sections (groups A and B). Group A consist of neck, legs, and truck, and group B contains lower-upper arms and wrist. Therefore, scores from each part of the body have been obtained based on the movements, work positions, and gestures of each body part. As a result, this study represents that to prevent musculoskeletal disorders in-car montage industries, there is a need to apply for a program by using ergonomic concepts (Garkaz et al., 2014).

In the fourth article, the study points out the need for posture assessment in dairy farming works in Iran. Because the work activities of the dairy farm consist of many poor postures and these poor postures can lead to the risk of developing musculoskeletal disorders in dairy workers. Thus, the postural loads of the workers who work on dairy farming are observed and a cross-sectional study has been conducted to identify the related risk factors depending on the work activities. Dairy farming activities were divided into 3 groups (e.g., feeding, milking, and manure disposal) in order to observe the work activities much easier. Then, each task was divided into subgroups into itself, and REBA (Rapid Entire Body Assessment) has been conducted for the evaluation of each subgroup for each task. Based on the REBA scores, the poorest risk scores were determined as risk level 4 which consists of the following task: 1) manure disposal, 2) filling feed bags, and 3) pouring milk into a bucket. Hereby, the evaluation of the posture scores has substantial for the agriculture industry in order to assess different body regions that belong to many different work activities. Moreover, other tasks such as filling corn containers, pouring corn into the milling machine, preparing the feed, pouring food into mangers, attaching the milking ma-chine, and pouring milk from a bucket into a tank were classified as risk level 3 (Taghavi et al., 2017).

In the fifth article, the paper is examining and comparing the ergonomic risk assessment results as an entire body evaluation by using REBA (Rapid Entire Body Assessment) and QEC (Quick Exposure Check) scores and action levels in an anodizing and aluminum profiles producing industry in Tehran, Iran. For this purpose, these ergonomic risk assessment techniques have been used for detecting different risk factors. While REBA focuses on the posture of trunk, neck, and legs (in combination with force/load score) and upper arms, lower arms, and wrists (in combination with coupling score), the QEC points out to the posture of back, shoulder/upper arm, wrist/hand, and neck combined with the score of task duration, weight handled, hand force exertion, vibration exposure, and visual task demands which are obtained from the workers. Besides, Nordic Musculoskeletal Questionnaire (NMQ) has been carried out to 82 workers that engaged with different and various tasks and work activities in order to evaluate the correlation among the results of these two methods and examine the prevalence rate of the musculoskeletal disorders. At the end of the study, obtained data from the QEC and REBA final scores and actions were analyzed to compare the ergonomic risk assessment between these two methods and the correlation among the prevalence rate has been evaluated (Nadri et al., 2013)

In the sixth article, Lasota (2013) studied the workload assessment of the logistics-packers by applying the OWAS (Ovako Working Posture Analysis System) method in order to analyze the risk factors that can cause MSDs. The complex approach is being adopted to observe the workers while they are performing their job activities and the following segments have highlighted such as the trunk (back), arms, legs, and external load in kilograms. A computerized version of the OWAS technique has been used to conduct an assessment. For this purpose, the packaging process of the work is divided into 10 steps and each of these steps is assessed. As a result of the analysis of the risk factors by using WinOWAS. Therefore, "Obtaining items" and "Transfer" segments which refer to respectively segment 4 and 9 were classified as high risk of MSDs and needs to take care as soon as possible.

CHAPTER 5
PROBLEM STATEMENT, MATERIAL, TOOLS AND METHODOLOGY

5.1. Problem Statement

Before starting the research, the problem needs to be stated in a clearly defined, precise, specific and, well-understood format in order to propose a better understanding of the problem and contextualize the importance and need for the research in a related field. A well-written problem statement should contain research questions, purpose, limitations, and assumptions of the study because many materials, methods, and tools that are going to be used during ergonomic risk assessment studies will be shaped from the problem statement. According to Takala et al., (2010), the purpose of usage, features of the work to be assessed, the researcher(s) who will use the material and methods and, resources that are going to be used for gathering and analyzing the data are important criterion and indicator for the selection of the method(s) to be conducted. Therefore, a better implementation of the ergonomic risk assessment and more clear, accurate, and applicable solutions for the problem can be possible with the determination of the appropriate tools, material, and methods that depend on the problem statement.

In this context, the problem statement of the present study as follows: Despite the developments in the field of ergonomics studies, the logistics sector is one of the neglected fields in this regard. Especially, courier companies, which have one of the highest rates for work-related disorders, injuries and, long-term WMSDs, involve many ergonomic risk factors in nature and pose a danger to the workers' health. Hereby, this study aims to focus on identifying the ergonomic risk factors that present in Company A, which is a courier firm, by using ergonomic risk assessment methods and tools for eliminating the determined risk factors and make the working environment safe for the worker. For this purpose, it is aimed to present ergonomic interventions such as remediation actions and implementations at the end of the study. Moreover, this study also examines the way how the cargo or parcel packages are lifted by the workers, the postures such as pulling, pushing, twisting, bending, etc. while performing the job and, other risk factors that present in the working environment. Also, there are very few studies that concern the cargo workers' work-related activities, postures, etc. in terms of ergonomic perspective. Hence, this study points out the important problem and area of the logistics sector, cargo, or parcel packages activities (loading, unloading, sorting, etc.), and the ergonomic risk factors that contain the job.

5.1.1. Purpose of the Study and Research Questions (RQs)

The purpose of this study is to use ergonomic risk assessment for the detection of the root causes underneath of the occupational diseases, work-related disorders, and injuries during the loading, unloading, sorting, etc. processes inside the cargo transfer center, for making ergonomic improvements and to implement these activities in order to identify and minimize the risk factors that cause these WMSDs. According to the root cause analysis, required ergonomic remediation actions and ergonomic interventions will be derived to address the problems in Company A.

5.1.1.1. Descriptive Research Question 1

What is the prevalence of WMSDs in terms of severity in the body parts, frequency, and prevention doing work? (related to demographic data such as age, working time, department, and so on.).

5.1.1.1.1. Relational Hypotheses

- H_1: Personal risk factors have an impact on the physical risk score.
- H_2: Personal risk factors have an impact on psychosocial risk score.

5.1.1.2. Descriptive Research Question 2

What is the prevalence of WMSDs in terms of severity in the body parts, frequency, and prevention doing work? (related to environmental data such as vibration, noise, temperature, lighting, etc.).

5.1.1.2.1. Relational Hypotheses

- H_3: Environmental risk factors have an impact on physical risk score.
- H4: Environmental risk factors have an impact on psychosocial risk score.

5.1.2. Limitations of the Study

This study only focuses on the work-activities such as loading, unloading the truck, sorting the cargo packages, etc. inside an İzmir branch of a courier firm. The drivers of the trucks and office workers (white collars) are excluded from the study. Also, data such as infirmary records and lost working days have not been included in the ergonomic assessment stage because of the confidential issues of the workers. However, most of the workers stated that they usually don't inform the company and confirm their illnesses and work-related pain to the infirmary.

5.1.3. Assumptions of the Study

The absence of an infirmary and lost working day records may affect the results of the ergonomic risk assessment for the study. Also, busy days such as before and after religious and official holidays, weekends, etc. may change the workers' normal work practices and habits because of the limited time. Besides, workers may be careful when they performing their job on an observed day. Thus, the usual working habits and behaviors of the worker can be reached more clearly, when the observation is made without the knowledge of the worker. Lastly, the willingness to attend and the degree of consideration of the worker to the research study can change the outcome of the study.

5.2. Material

Company A is one of the leading companies of package and cargo transportation in the logistics sector worldwide. They actively serve many services in logistics and distribution such as transportation and freight (air, sea, ground, rail), freight forwarding, storage, and after-sales service. This ergonomic risk assessment study was implemented in the Izmir cargo transfer center of Company A on blue-collar workers except for the drivers. The reason why this study is only implemented on blue-collar workers is that exposure to heavy loading, duration, frequency, etc. is very common among logistics workers. For this purpose, it is aimed to make ergonomic improvements to the related operations in order to determine the risk factors that blue-collar workers are exposed to during cargo loading and unloading and to solve these problems. Therefore, the layout of the workstations, processes, workflows, departments, sections, and shifts are identified to have a general opinion about the system of the company. First of all, blue-collar workers work in a two-shift (night shift and day shift). The day shift starts at 5 a.m. and finishes at 9 a.m. On the other side, the night shift is between 5 p.m. and 10 p.m. Approximately 55-60 people are working in the night shift however, this number decreases even more in the day shift. In addition, there is an intensity in the morning operation due to less working hours and fewer workers when compared with the night shift. Also, the job performed during the two shifts differs from each other. For example, while cargo packages are classified and sorted according to the cities in the night shift, cargo packages are classified depending on the districts of İzmir in the day shift. The main operations in the cargo transfer center are defined as unloading, separation, DWS measurement, sorting, and, loading. The unloading operations involve unloading the cargo from the truck and putting the cargo to the belt conveyor which is directing the cargo to the DWS where the dimension, weight, and scanning of the cargo will be measured. DWS system collects and analyzes the volume, weight, and barcode information of the cargo packages for track and tracing. After this stage, the cargo packages are directed into the sorting operation where cargo packages will be classified according to city, region, etc. Then, the classified cargo packages move along the belt conveyor to be loaded onto the destination truck. The sorting operations of the company are generally positioned on the second floor (mezzanine floor). For that reason, the operations are divided into first and second floors to make the area observed more easily on the checklists. Depending on that, unloading and loading operations and DWS measurements of the large and shapeless cargos are located on the first floor. On the contrary, most of the sorting operations (3 out of 4) are located on the second floor. In addition to that, there is a section of the first floor that deals with the cargo packages to be sent abroad. Lastly, there is a small sorting area for small packages on the first floor.

5.2.1. Structural Framework for the Application of the Methodologies and Instruments

In the below-presented scheme, Figure 5.1 displays the proposed methodology and instruments to be used throughout the study.

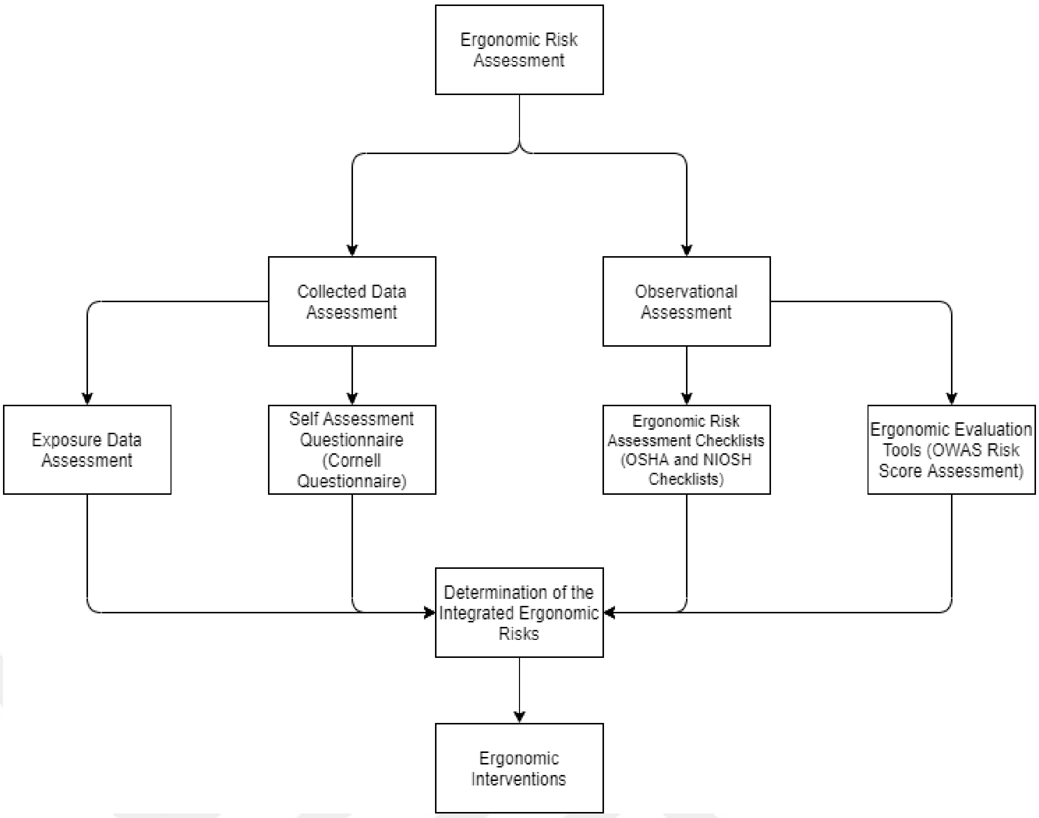


Figure 5.1. Structural Framework of the Proposed Methodology and Instruments

5.3. Proposed Methodology

The materials, tools, and methodologies that are going to be conducted during the study need to be chosen according to the factors such as features of the firms, work characteristics, worker attitudes, behavior and habits, and risk factors present in the work environment, etc. Thereby, the purpose of selected material, tools, and methodologies, are identified in this section of the study. For further understanding of the concept, the proposed methodology has divided into five stages as follows: (1) general system assessment, (2) preliminary ergonomic assessment, (3) integrated ergonomic risk assessment, (4) ergonomic interventions for operations with a high ergonomic risk level and (5) development of a plan for controlling and monitoring ergonomic risk factors. These five stages are examined in detail one by one and schematized as below.

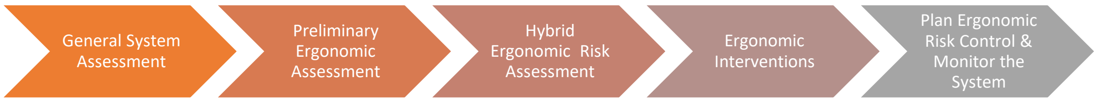


Figure 5.2. Five Stages of Proposed Methodology

It can be deducted from Figure 5.2 that the application of the proposed approach starts with the general system analysis which contains general information such as the layout, works, workflows, departments, worker number, shift number, and hours of the firms. This general information about the firms assists the researcher to understand and identify the processes and firm more detailly before starting the detailed analyses. Secondly, the preliminary ergonomic assessment provides the identification of risks that may occur within the enterprise by analyzing loading, unloading, sorting operations via a checklist. Thirdly, integrated ergonomic risk assessment involves questionnaires to apply to workers, evaluation to observe, measurement of environmental risk factors e.g., chemical substances, harmful gases, and so on. In the fourth stage, ergonomic interventions for the operation which contains high ergonomic risk level. For this purpose, ergonomic risk factors should be classified according to their degree, and factors with high ergonomic risk should be determined in this stage. After that, ergonomic interventions (behavioral, engineering, and organizational interventions) need to be presented for the high-risk factors. Lastly, planning the ergonomic risk control and monitoring the system comes. This stage includes the identification of the ergonomic risk control measures and the re-analysis of the operations.

5.3.1. General System Assessment

In the first stage of the study, general system analysis will be carried out at Company A İzmir cargo transfer center. The researcher will make observations in the relevant cargo transfer center in order to get insights about the processes, overall workflow, layout, works, departments, number of workers, working hours, shift numbers and hours, etc. to know the company. This information is necessary for generating an understanding of the company in terms of the characteristic of the work. Also, these assessments about the general system of the company are needed for the detection of the problem and accordingly the methods to be used during the study in order to solve the problem. Because it is crucial to plan the next moves of the study e.g., where to start, which method to use, etc. in a systematic and structured framework that assisting the problem. For the next stages of the assessment, the managers of the department, worker health unit managers (ergonomic specialist) need to be informed about the importance and effects of WMSDs. Moreover, the observer who will collect data during the study needs to be informed in detail about the processes of the assessment. For this purpose, general information about Company A, where the operations (loading/unloading) are conducted will be analyzed for the identification and determination of the problem.

5.3.2. Preliminary Ergonomic Assessment

A preliminary ergonomic assessment is an analysis of the degree of the potential risk variables and hazards present in the workstations and working environment. The aim of conducting a preliminary ergonomic assessment is a too detailed investigation of the working environment in terms of departments, operations, tasks, etc. to detect the possible risk factors and their degree. Basically, preliminary ergonomic assessment is the stage where the risk identification in the company is performed. Thus, firstly, information about the operations needs to be collected and analyzed in order to determine which methods to be used. For this part of the study, the literature of WMSDs and validation of the methods should be investigated in detail and taken into consideration to see the performance of the method for specific WMSDs. The selection of the method to be used can be compelling in many ways because of the diversity of the methods in user needs (Takala et al., 2010). The decision-making of the methods to be used through the research study needs to be chosen carefully depending on the combination of factors such as observed operations, workflows via checklist, postures, movements of the worker and exposure values of the working environment.

In this context, after the general system analysis of Company A, the Ergonomic Assessment Checklist of OSHA has been used to determine the risks related to the work-related activities of the workers. In addition to that, NIOSH workstation and material handling checklists have been conducted in the company in terms of examining the likelihood of hazardous occurrences because of equipment and tool handling and workstation-related reasons. The whole operations of Company A are divided into two parts as the first floor and the second floor. On the first floor, unloading/ loading of the trucks and DWS measurement (dimension, weight, and scanning) of the shapeless and large cargos have been made. On the second floor, the cargos are separated according to the country, region, and city distribution to which the cargo will be sent (sorting operation).

5.3.3. Hybrid Ergonomic Risk Assessment

Hybrid ergonomic risk assessment is the combination of the methods in order to analyze the risk factors in the working environment. The reason why more than one method needs to be used is that the usage of one method may not be required for the analysis of the risk factors. The severity of the available methods in the literature is large, however, no single one of them can be used for all purposes. Each of the methods supplies different requirements and accordingly, different approaches need to be used for different purposes (Takala et al., 2010). Besides, while selecting the methods to be used, the validity of the method needs to take into consideration for the purpose of the study. Therefore, the hybrid model, which is the integration of multiple methods, is preferred for this study in order to conduct more reliable and valid results from the study. Therefore, a two-stage analysis will be performed during this ergonomic risk assessment. Elaboration of this two-stage analysis can be named as follows: collected data assessment, and observational assessment.

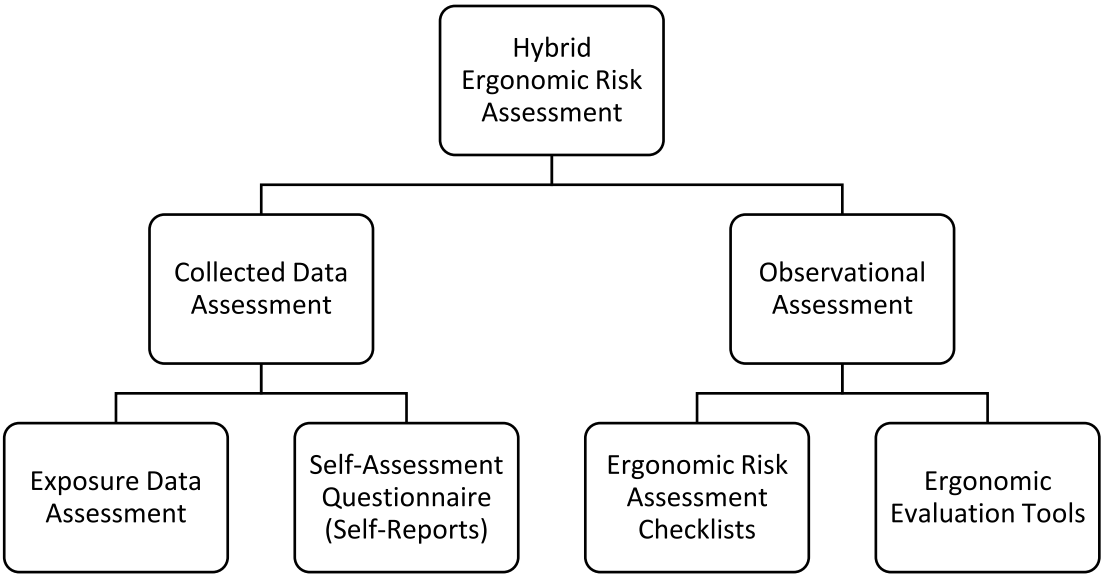


Figure 5.3. Two-Stage Hybrid Ergonomic Risk Assessment

Two-stage hybrid ergonomic risk assessment has been practiced for the identification and detection of the potential risk factors: 1) collected data assessment, which involves exposure data assessment and self-assessment questionnaire, 2) observational assessment which contain ergonomic risk assessment checklists and ergonomic evaluation tools.

5.3.3.1. Collected Data Assessment

Collected data assessment is the first stage of ergonomic risk assessment that depends on the collection of data from workers and the working environment. Therefore, by applying different methods, it aimed to understand and examine the current situation of the organization from the perspective of both workers and the company. In this study, exposure data assessment and self-assessment questionnaires (self-reports) have been planned to use. In exposure data assessment, the environmental factors (i.e., chemical substances, vibration, temperature, lighting, etc.) of the company are measured with the help of using some instruments in order to detect the health risks of the workers. The purpose is to measure the levels of the substances in the workstation and the working environment and accordingly to determine the damages and risks that may arise from the excessive presence of substances. According to the measurements, possible risk factors and the risk levels of the factors are determined. In this study, the measurement report of the company has been used for this purpose.

A self-assessment questionnaire (self-reports) is a form that is filled into workers in order to determine the risk factors and the risk levels for their own work-related activities. Data are collected via interviews and questionnaires on both physical and psychosocial factors in the self-assessment approach (Nath et al., 2017; David, 2005). Therefore, this approach has considerable benefits such as easy to use and accessible to a wide variety of workplace conditions with low initial cost (Nath et al., 2017; David, 2005). In this part of the study, the questionnaires to be used are also becoming a prominent factor for the quality of the assessment because the validity, adaptation, and reliability of the questionnaire and the suitability of the questionnaire to the research affect the findings and accordingly implementations of the study. Because, the applicability, validity, and reliability of the tools that are employed during the collection of the symptom data, are substantial to perform effective and accurate assessment (Erdinc et al., 2011; Forcier et al., 2008; Fjell et al., 2007; Annett, 2002; Hedge, 2004; Li & Buckle, 1999; Kuorinka et al., 1987). For that reason, Cornell

Musculoskeletal Discomfort Questionnaire (CMDQ) has been decided to be used in the study as a self-report because it has many benefits such as easy to apply, which involves one page, a well understood, and clear format, and so on. CMDQ is a questionnaire that is developed by DR. Alan Hedge and his graduate students of ergonomics at Cornell University and this questionnaire is depending on the formerly published research studies about musculoskeletal discomfort and disorders among office workers (CUergo, n.d.). The Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) sample is attached to the Appendix-5.

5.3.3.3. Observational Assessment

Observational assessment is a type of ergonomic risk assessment method that is used for the measurement of the work associated risk factors in the working environment by observation in real-time or via recorded video of the work activities by a job analyst. For this purpose, a variety of simplified approaches have been established for monitoring and recording exposures in the workplace on Pro-forma sheets (David, 2005) however this approach needs to be made by an external observer or ergonomist who fills the scoring of the work-related activities' observations in a predefined sheet (Andreas & Johanssons, 2018). Despite these methods are time-consuming, their reliability and validity are satisfactory (Andreas & Johanssons, 2018; Takala et al., 2010). Therefore, there are many different observational methods for ergonomic risk assessment available in the literature in spite of no consistent way to guide researchers about how to choose among the methods (Andreas & Johanssons, 2018). The selection of the appropriate observational method can be done according to the body region to be assessed, types of exposures in the workplace, and characteristics of the job itself. So, in this stage of the study, data will be collected including ergonomic risk assessment checklists and ergonomic evaluation tools for integrated ergonomic risk assessment. OSHA musculoskeletal system risk assessment checklist has been chosen as a checklist for the detection of the physical risk factors. Besides, NIOSH workstation and materials handling checklists have been used for the determination of the risk factors related to the working tool, equipment, and layout of the workstation. The OSHA Ergonomic Assessment Checklist (Appendix-2), NIOSH Workstation Checklist (Appendix-3), and Materials Handling Checklist (Appendix-4) sample form are in the Appendix section at the end of the paper.

Ergonomic evaluation tools are postural assessments that are used to assess the physical workload of the worker. There are many different ergonomic evaluation tools in the literature depending on the intended purpose and various body regions or parts. In this study, the Ovako working posture assessment system (OWAS) has been chosen as a tool. The generation of the OWAS method depends on defining the workloads during the overhauling of iron smelting ovens in the steel industry company (Takala et al., 2010; Karhu et al., 1977). The reason underneath for the use of this method in this study is because OWAS method categorizes three common work postures which are back (four back postures), lower extremities (three arms postures), and legs (seven legs postures) along with the weight of the load handled (three categories) and classifies these possible 252 combinations into four action categories (Takala et al., 2010; Andreas & Johanssons, 2018).

CHAPTER 6
GENERAL SYSTEM AND PRELIMINARY ASSESSMENT OF THE COMPANY

The first stage of the ergonomic risk assessment is the general system assessment which enables the researcher to have an idea about the company' s general system and operations such as layout, workflow, processes, sub-processes, main operations, and so on. At this stage, the company's general processes and sub-processes are determined and examined through observation. Then, a preliminary assessment is performed to identify the risks of the processes and sub-processes of the company via a checklist. In this context, general system assessment, flowchart, workflow analysis will be discussed in detail in the following sections.

6.1. General System Assessment

General system assessment starts with obtaining information about the company' s ergonomic activities. There is a department that includes experts in the field of occupational health and safety in the company. This department carries out various ergonomic activities on the occupational health and safety of the workers. For example, before the workers are hired, each of them is given vocational education and occupational safety instructions on how to carry the cargo packages and which postures should be used. Generally, these vocational training are repeated once a year. However, this trainings can be repeated in case of any occupational accident or in cases where the workers cannot perform the posture shown at the end of the training. At the end of this training, each worker is checked separately and the application of the training is checked by filling the observation paper. Besides, exams covering training subjects are regularly held for workers. After obtaining information about the company's ergonomic activities, the workspace needs to be observed by the researcher. In this context, the layout of the company and the work stations where the operations take place were examined. The loading/unloading operation, which is the operation that an ergonomic risk assessment will be applied, works in two shifts (morning and night shift). Main processes and sub-processes in the loading/unloading operation were classified and converted into a flowchart for a more systematic review. As a result, the main processes are divided into 5 sections which are unloading, separation, DWS measurement, sorting, and, loading.

With trucks arrival, cargo packages are unloaded and placed into the conveyor belt. While the conveyor belt transports the cargo packages to the next station, which is the DWS measurement, the shapeless/large cargo packages among the loads on the belt are unloaded from the belt and held aside to be measured in another DWS machine. Meanwhile, these shapeless/large cargo packages are loaded on the pallet jack and directed towards the shapeless DWS where the shapeless/large cargo packages will be measured. Furthermore, foreign and small cargo packages are also transported to different workstations where different operations are performed. After the DWS measurement, the cargo packages are transported into the next station, which is the sorting station. The first sorting station is the classification of the loads to be sent to the Central Anatolia region and its surroundings. Also, these cargo packages are classified in themselves as Ankara and other Central Anatolia region loads. The remaining cargo packages are directed into the next sorting station which is classifying loads to be sent to İstanbul and its surroundings. In this station, the cargo packages are classified into three sections which are İstanbul Anatolian side, İstanbul European side, and Bursa loads. After this station, the remaining cargo packages belonging to İzmir and its surroundings are retained for the next day's operations. After the loads are classified according to the regions, the cargo packages are scanned by the hand terminal and the information to be loaded on the relevant trucks is processed and loaded onto the truck. After the loading process is finished, the truck is locked and closed with a plastic security seal. After this process, no loading is made to the truck and the vehicle sets off.

Small sorting operation is another process that includes different sub-processes than normal loads. In this section, small packages are classified into separators which consist of 24 compartments in itself and each of these compartments represents cities and surrounding areas to be sent. Afterward, the barcode of these small packages placed in these compartments is scanned through the hand terminal and placed in a resealable bag. This process is done separately for each compartment and a different resealable bag is opened for each compartment. Resealable bags are locked and scanned after they are filled. This final barcode scan is done to inform that no more small packages will be loaded into the bag. After the bags are locked, they are directed towards the truck they will go and loaded into the truck. Also, foreign cargo packages have a different workspace than the other loads. In the same way, the shapeless/large cargo packages are separated into foreign cargoes and their DWS measurement is made separately. Document transactions of cargo packages to be sent abroad are made immediately after DWS measurement.

During the day shift, the nighttime processes are done in reverse. In other words, the unloading process is carried out at the station where the loading is made and the process works in the opposite way. The only difference in the day shift, cargo packages are sorting according to the districts, not cities. For further information about the main processes and sub-processes of the operations, Figure 6.1 is presented as follows.

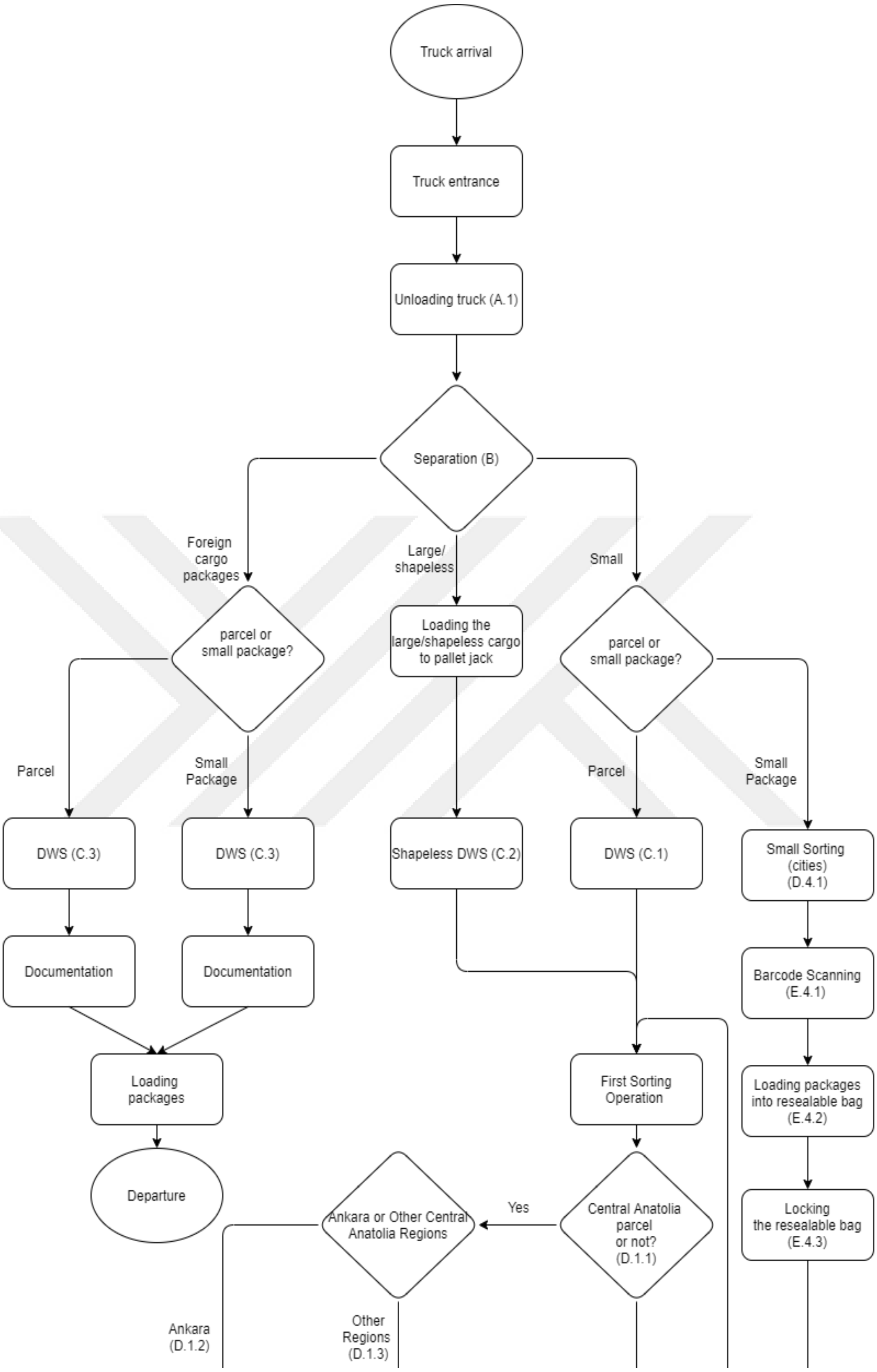


Figure 6.1. Flowchart of the Company's Operations

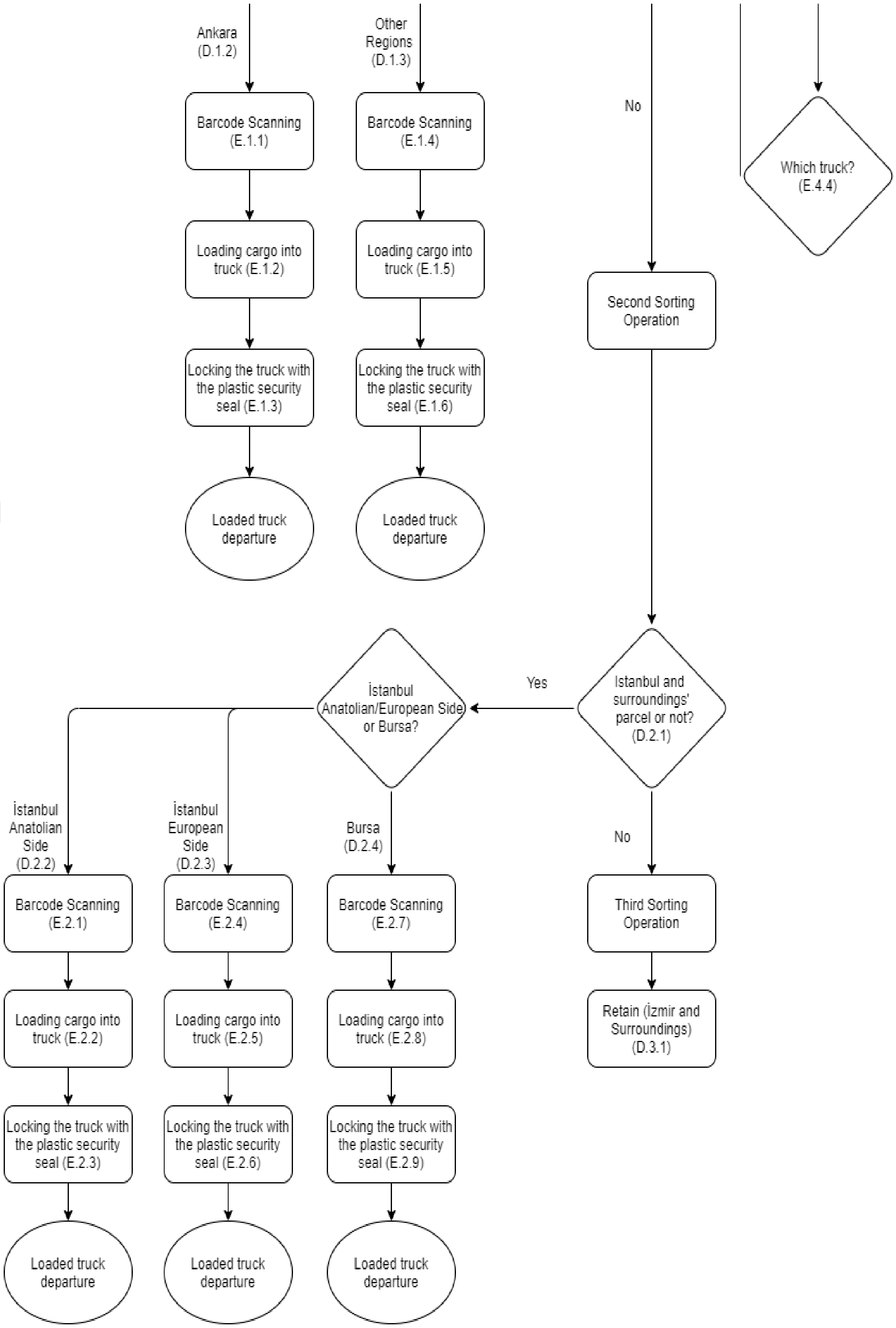


Figure 6.1. Flowchart of the Company's Operations (continues)

For detail insight about the main operation's sub-processes, the codes, names, and brief definitions are presented in Table 6.1.

Table 6.1. Codes, Names, and Descriptions of the Sub-processes

Sub-process Code	Operation Name		Description of the Operations
A	Unloading Operation		Cargo package is taken from the truck and placed on the conveyor belt.
B	Separation Operation		Cargo packages are divided into their features (foreign, large/shapeless, and small packages).
C	DWS Measurement		The insertion of cargo packages into the device that measures the cargo packages' dimension and weight by scanning.
D	Sorting Operation	First Sorting (D.1)	Classification of cargo packages according to their destination. The first sorting station belongs to the Central Anatolia region and its surroundings.
		Second Sorting (D.2)	Cargo packages remaining after the first classification station are directed to the second classification station and the cargo packages of Istanbul and its surroundings are separated.
		Retain (D.3)	The remaining cargo packages belonging to Izmir and its surroundings are kept for next day distribution.
		Small Sorting (D.4)	Small packages are sorted into separators consisting of 24 compartments containing the cities and surrounding areas to be sent.
E	Barcode Scanning and Loading Operation	Barcode Scanning and Loading for Ankara and Its Surroundings (E.1)	Cargo packages to be sent to Ankara and its surroundings are loaded onto the truck after barcode scanning. After the loading is finished, the truck is locked with a plastic security seal and leaves to set off.
		Barcode Scanning and Loading for İstanbul and Its Surroundings (E.2)	Cargo packages to be sent to İstanbul and its surroundings are loaded onto the truck after barcode scanning. After the loading is finished, the truck is locked with a plastic security seal and leaves to set off.

Sub-process Code	Operation Name		Description of the Operations
		Barcode Scanning and Loading for İzmir (E.3)	Remaining cargo packages, which belongs to İzmir and its surroundings, are loaded onto the truck after barcode scanning. After the loading is finished, the truck is locked with a plastic security seal and kept for the next day distribution.
		Barcode Scanning and Loading for Small Packages (E.4)	After the barcode scanning of the small packages, which sorted into separators consisting of 24 compartments, the small packages are placed inside of the resealable bag. After the resealable bag is filled, the bag is locked, and the barcode of the bag is scanned and transferred to the truck to which it will be sent.

6.2. Preliminary Assessment

The preliminary assessment is performed after the general system assessment of the company to identify risk factors of the operations, processes, and sub-processes. In order to perform this analysis, the checklists to be used during the study needs to be determined first. Then, the relevant parts are observed in order to answer the questions in the checklists. After this stage, risk factors are determined according to the answers to the checklist. The reason underneath for this preliminary assessment is because these data will be a guide to choose our ergonomic risk assessment method. Furthermore, OSHA Ergonomic Assessment Checklist is chosen for the detection of the physical ergonomic risk factors (musculoskeletal factors). On the other side, NIOSH Workstation Checklist and NIOSH Materials Handling Checklist have been used for the identification of the risk factors that depend on the working tool, equipment, and layout risk factors. According to the results obtained from these checklists, the mind map shown (Figure 6.2) below was prepared.

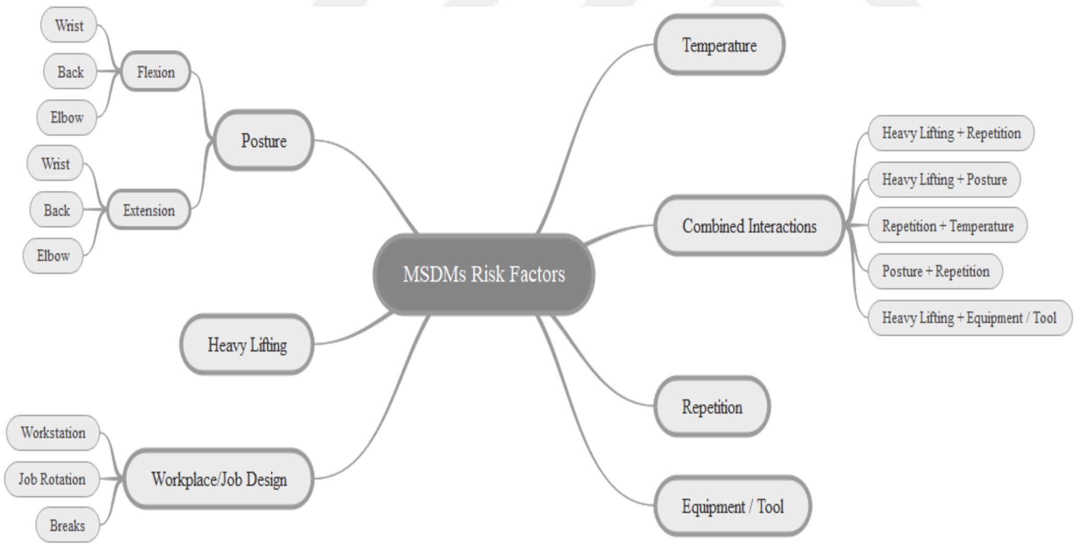


Figure 6.2. Mind Map of the Ergonomic Risk Factors for the Company A

It can be deducted from the figure that, posture, heavy lifting, workplace/job design, temperature, combined interaction of the risk factors, repetition, and equipment/tool are risk factors that need to be focused on first. The postures of the workers were divided into two main groups as flexion and extension and risky postures such as wrist, back, and elbows were added in both groups. In addition, unilateral and bilateral postures were not observed during observation. Workplace and job design were included in the mind map as a risk factor, and the height of some workstations, incorrect design, job rotation, and breaks was grouped under this group title. Under the title of equipment and tool, it is meant the ladder used to access the upper parts of the truck during truck loading, the hand terminal, the portable equipment that is placed inside the trucks and used to direct the cargo packages to the DWS which do not have a handgrip. Apart from this, the risk factors caused by the extreme heat in the summer and cold in the winter were evaluated under the temperature heading. As a result of these temperature risk factors, the workers on the 2nd floor, who are the most affected by these temperatures, were putting cardboard under their feet to prevent the cold from passing through and there was no insulating material on the floor. Therefore, these circumstances were evaluated as an environmental risk factor. OWAS method was chosen for exposure assessment by looking at these risk factors determined by the observation method at the end of the preliminary assessment.

CHAPTER 7
THE HYBRID MODEL FOR THE ASSESSMENT OF THE ERGONOMIC RISK FACTORS

The hybrid model for the ergonomic risk assessment is the integration and use of multiple methods to analyze risk factors in the working environment. In this context, it is a better alternative to use multiple methods rather than using a single method in terms of validity. Because it is necessary to examine risk factors from many angles to evaluate ergonomic risk factors, and a single method may be difficult to do so. For this purpose, different methods should be chosen to meet different purposes and there are various methods in the literature that serve many purposes. However, these methods have different limitations, requirements, structure, and purpose. Thus, it is important to choose a method suitable for the purpose. On the other hand, the validity of the method used is important in terms of showing how accurately the results found are measured and how close they are to real-life examples. Also, while choosing the method to be used in the study, many variables such as the structure of the company, character, operation, processes, business environment, existing risk factors, etc. should be taken into consideration. Hence, method selection is also a complex process because it contains many variables.

In this study, a hybrid model was conducted in order to obtain more accurate, reliable, and valid results. In this hybrid model, collected data assessment, exposure values analysis, and observational assessment have been used. By doing these analyzes, it is aimed to collect and analyze data from three different angles through the company (exposure values analysis), worker (via questionnaire), and an external observer. Therefore, a Self-Assessment Questionnaire Using NORDIC was chosen as a questionnaire to be applied to workers to obtain information and data on musculoskeletal disorders. On the other side, OWAS has been chosen as an observational assessment method in order to observe workers' work-related movements, postures, etc. to create meaningful data to analyze. The reason why the OWAS method has been chosen is that it contains questions that investigate different body regions and parts. So, it assists the researcher to detect the problem and focus on it. In this context, the results obtained by applying these hybrid methods will be presented in this section of the study as follows.

7.1. Collected Data Assessment

Collected data assessment is the first step in ergonomic risk assessment, which requires collecting data from both workers and the work environment about the WMSDs and the current ergonomic state of the company. In this stage of the study, detection of the risk factors in shaping the study's development. For that reason, exposure values assessment and self-assessment questionnaire (self-reports) assessments were presented in detail in the upcoming sections.

7.1.1. Exposure Values Assessment

Exposure values assessment can be defined as the detection and analysis of hazardous substances arising from the environmental conditions of the company that put the health and safety of workers at risk through exposure. These environmental exposure values can be chemical, physical, and biological agents and can be measured by using some special instruments and equipment. The main aim of this evaluation is to measure the level of hazardous substances in the working environment and to compare it with the limit value that the environment should have. At the end of this assessment, it is necessary to focus on higher values than they should be and the damage that arises from the excessive presence of these substances to make improvements in this regard. In this context, the below-mentioned tables are retrieved from the company's measurement reports. According to these measurement reports, exposure types are divided into four sections which are lightning, noise, temperature, and chemical agents. For further information, each of these metrics is presented separately for a different location.

Table 7.1. Lightning Exposure Values Assessment Results of the Company

Exposure Type: Lightning		
Measurement Location	**Measurement Results (Lux)**	**Limit Value (Lux)**
Uploading platform 1	487	100
Uploading platform 2	1343	100
Uploading platform 3	427	100
Shapeless / Large cargo sorting space	56	100
DWS Machine	237	200
Small sorting	241	100
First loading region (Door 2)	201	100
First loading region (Door 4)	216	100
Second loading region (Door 3)	229	100
Second loading region (Door 1)	171	100

Table 7.2. Noise Exposure Values Assessment Results of the Company

Exposure Type: Noise				
Measurement Location	L_{eq} **dB A**	L_{max}**dB A**	L_{min}**dB A**	**Limit Value dB A**
Uploading platform 1	73,5	82,6	69,6	80
Uploading platform 2	73,9	77,5	70,6	80
Uploading platform 3	69,7	71,3	65,3	80
Shapeless / Large cargo sorting space	73,9	80,2	64,9	80
DWS Machine	75,9	80,0	74,8	80
Small sorting	71,7	72,9	70,8	80
First loading region (Door 2)	71,1	74,9	69,2	80
First loading region (Door 4)	73,9	79,9	69,6	80
Second loading region (Door 3)	74,3	80,5	71,2	80
Second loading region (Door 1)	75,9	81,3	73,3	80

Table 7.3. Temperature Exposure Values Assessment Results of the Company

Exposure Type: Temperature		
Measurement Location	**Measurement Results (°C)**	**Temperature Measurement Ranges (°C) (15 °C-30 °C)**
Uploading platform 1	22,8	15-30
Uploading platform 2	22,7	15-30
Uploading platform 3	22,8	15-30
Shapeless / Large cargo sorting space	23,1	15-30
DWS Machine	23,3	15-30
Small sorting	23,0	15-30
First loading region (Door 2)	23,7	15-30
First loading region (Door 4)	23,6	15-30
Second loading region (Door 3)	23,5	15-30
Second loading region (Door 1)	23,4	15-30

Table 7.4. Chemical Agents Exposure Values Assessment Results of the Company

Exposure Type: Chemical Agents						
	Measurement Results (mg/m3)			**Limit Value (mg/m3)**		
Measurement Location	**Total Particle**	**CONS**	**TWA**	**Flammable, Explosive, Hazardous and Harmful Material**	**OSHA**	**NIOSH**
Uploading platform 1	0,055	-	-	-	15	10
Uploading platform 2	0,022	-	-	-	15	10
Uploading	0,015	-	-	-	15	10

platform 3						
Shapeless / Large cargo sorting space	0,157	-	-	-	15	10
DWS Machine	0,020	-	-	-	15	10
Small sorting	0,034	-	-	-	15	10
First loading region (Door 2)	0,014	-	-	-	15	10
First loading region (Door 4)	0,013	-	-	-	15	10
Second loading region (Door 3)	0,023	-	-	-	15	10
Second loading region (Door 1)	0,064	-	-	-	15	10

7.1.2. Self-Assessment Questionnaire (Self-Reports)

Using a single method of ergonomic risk assessment may be insufficient to obtain meaningful data. Also, obtaining data from a single perspective of the company is not sufficient to interpret the results correctly. For that reason, while exposure values assessment provides data from the company side, a self-assessment questionnaire provides data from the worker's perspective. Self-Assessment Questionnaire can be defined as a form consisting of a series of questions related to the subject to be researched in order to have the participant fill out. The Nordic Musculoskeletal Questionnaire (NMQ) was decided to be used in this study to determine the risk factors and their risk levels about worker's work-related activities. The reason for applying the Nordic Musculoskeletal Questionnaire in this study is because of its accessibility, validity, and easy to use. In addition, this questionnaire is designed to determine whether workers have ache, pain, and discomfort in various body parts, and to collect data on the frequency of pain and its effects on performing work activities. Below in Figure 7.1., each specific body part that the questionnaire contains, and the scales of the Nordic questionnaire assesses is presented.

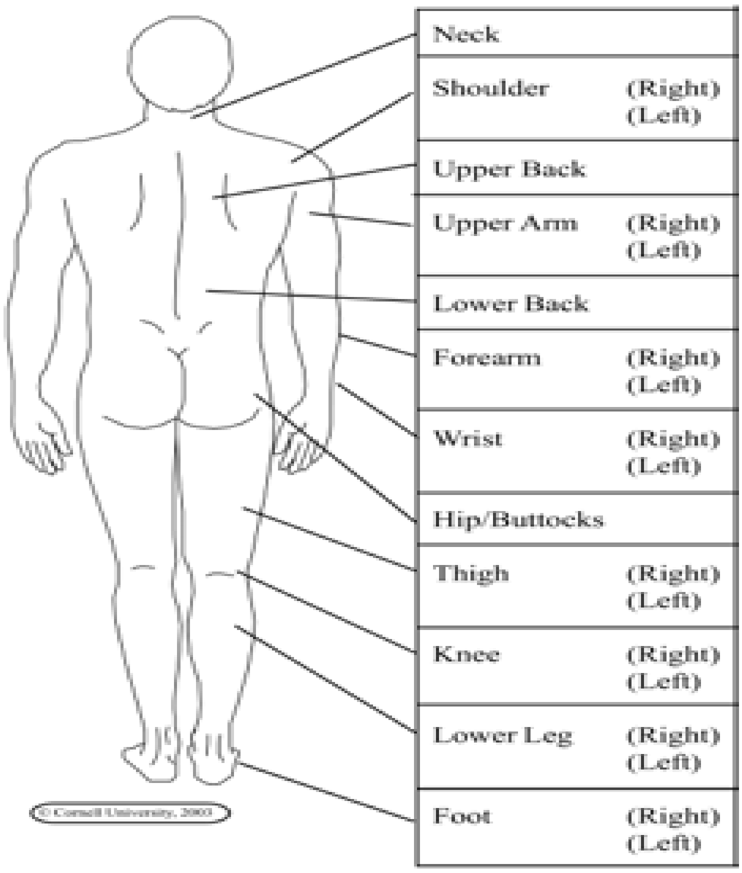


Figure 7.1. Body Parts Symptoms and Scales of the Nordic Questionnaire

The Nordic questionnaire starts with demographic questions at first such as name (optional), age, weight, height, the time worked in the company. By asking these demographic questions, it has been aimed to obtain information such as the average age at which the musculoskeletal pain starts, whether time worked in the company affects work-related pain. Then there are questions about body part symptoms including neck, shoulder, upper back, upper arm, lower back, forearm, wrist, hip, thigh, knee, lower leg, and foot. Also, there are 3 main questions that must be answered separately for each body part in this questionnaire. The first question is "During the last work week how often did you experience ache, pain, discomfort in?" In the answers, five scales have been used which are: never, 1-2 times last week, 3-4 times last week, once every day, and several times every day. This question aims to obtain data on which part of the body the worker has ache, pain, and discomfort during work and the frequency of these pains. On the other side, the second question is “If you experiences ache, pain, discomfort, how uncomfortable was this?” There are three scales in the responses: slightly uncomfortable, moderately uncomfortable, and very uncomfortable, aiming to measure the frequency and degree of pain. The third and last question is “If you experienced ache, pain, discomfort, did this interfere with your ability to work?” which has three scales (not at all, slightly interfered, and substantially interfered). By asking this question, it has been tried to find out whether the pain experienced by the workers affects their job or not.

Before the questionnaire is applied to workers, every worker is informed about the questionnaire and the volunteerism principle. Among the workers who are working in the operations (approximate 50-55 workers), the drivers of the vehicles are excluded from the sample. Hereat, this questionnaire was applied to 16 workers from different operations and workstations. The questions were asked one by one to workers who accepted to participate in the survey and the answers were filled out one by one by the pollster. The answers given were entered in SPSS and the percentages of the answers given by the workers are presented as in the table below.

Table 7.5. Table of workers' answer to the Nordic questionnaire (in percentage)

Nordic Questionnaire SPSS Results (in percentage)		Q1: During the last work week how often did you experience ache, pain, discomfort in:					Q2: If you experienced ache, pain, discomfort, how uncomfortable was this?			Q3: If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
		Never	1-2 times last week	3-4 times last week	Once every day	Several times	Slightly uncomfort	Moderately	Very uncomfort	Not at all	Slightly interfered	Substantially
Neck		56.25	25.00	12.50	0.00	6.25	68.75	25.00	6.25	87.50	12.50%	0.00%
Shoulder	Right	81.25	6.25	0.00	0.00	12.50	93.75	6.25	0.00	93.75	6.25	0.00
	Left	81.25	12.50	0.00	0.00	6.25	93.75	6.25	0.00	93.75	6.25	0.00
Upperback		56.25	12.50	6.25	6.25	18.75	75.00	18.75	6.25	81.25	12.50	6.25
Upperarm	Right	75.00	0.00	6.25	12.50	6.25	75.00	25.00	0.00	87.50	12.50	0.00
	Left	68.75	6.25	12.50	12.50	0.00	68.75	31.25	0.00	81.25	18.75	0.00
Lowerback		31.25	18.75	25.00	6.25	18.75	37.50	50.00	12.50	50.00	37.50	12.50
Forearm	Right	56.25	18.75	12.50	0.00	12.50	62.50	31.25	6.25	81.25	12.50	6.25
	Left	56.25	25.00	12.50	0.00	6.25	62.50	31.25	6.25	81.25	12.50	6.25
Wrist	Right	62.50	25.00	0.00	0.00	12.50	68.75	31.25	0.00	81.25	6.25	12.50
	Left	81.25	12.50	0.00	0.00	6.25	87.50	6.25	6.25	81.25	12.50	6.25
Hip		75.00	12.50	6.25	0.00	6.25	81.25	12.50	6.25	81.25	18.75	0.00
Thigh	Right	87.50	12.50	0.00	0.00	0.00	93.75	6.25	0.00	87.50	12.50	0.00
	Left	87.50	6.25	0.00	0.00	6.25	87.50	12.50	0.00	87.50	12.50	0.00
Knee	Right	93.75	6.25	0.00	0.00	0.00	93.75	6.25	0.00	93.75	6.25	0.00
	Left	81.25	12.50	0.00	0.00	6.25	87.50	6.25	6.25	87.50	12.50	0.00
Lowerleg	Right	87.50	12.50	0.00	0.00	0.00	93.75	6.25	0.0	93.75	6.25	0.00
	Left	81.25	18.75	0.00	0.00	0.00	93.75	6.25	0.00	87.50	12.50	0.00
Foot	Right	56.25	18.75	6.25	12.50	6.25	62.50	31.25	6.25	87.50	12.50	0.00
	Left	50.00	25.00	6.25	12.50	6.25	56.25	37.50	6.25	81.25	18.75	0.00

7.1.3. Weighted Ergonomic Risk Assessment by Using OWAS Method

OWAS is an observational and analytical ergonomic risk assessment method that assists ergonomists to estimate the worker's static load level at the workstation via observing and analyzing the work-related postures (Grzybowska, 2010). The method considers a total of 252 combinations of various and common working postures, including four back positions, three lower extremities and seven postures along with the three different weight of the load (Takala et al., 2010; Andreas & Johanssons, 2018). In addition to that, it contains different codes for the various postures and external load volumes. In figure 7.2, four back posture codes, three forearms position codes, seven legs work codes, and three external load volume codes are presented.

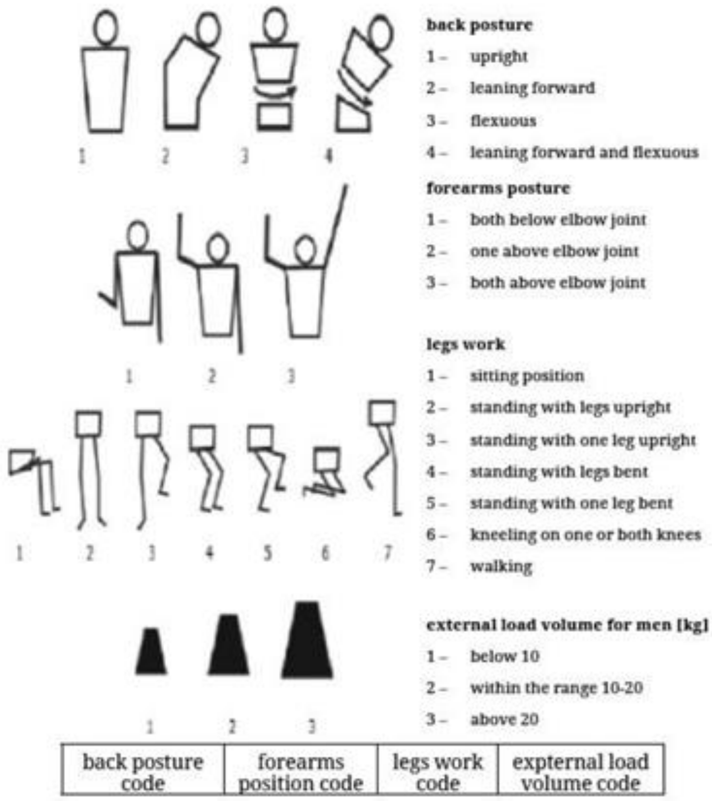


Figure 7.2. OWAS Method Postures and Load Volume Codes

Figure 7.3 displays the action categories of postures and loads with codes in a matrix for the evaluation of the work-related postures and positions.

Back	Arms	Legs																				
		1			2			3			4			5			6			7		
		Load			Load			Load			Load			Load			Load			Load		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	3	1	1	1	1	1	1	1	1	1	2	2	3	2	2	3	1	1	1	1	1	2
2	1	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	2	2	2	2	3	3
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	4	3	3	4	2	3	4
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4
	2	3	3	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4
	3	4	4	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4

Figure 7.3. OWAS Action Categories of Postures and Loads

Table 7.5 shows the OWAS method action categories and risk scores table which are divided into four categories as follows:

Table 7.6. Table of Action Categories and Risk Scores

Action Category	Explanation
1	Normal and natural postures with no harmful effect on the musculoskeletal system - No action required
2	Posture with some some harmful effect on the musculoskeletal system - Corrective actions required in the near future
3	Postures have a harmful effect on the musculoskeletal system - Correction actions should be done as soon as possible
4	The load caused by these postures has a very harmful effect on the musculoskeletal system - Corrective actions for improvement required immediately

Figure 7.4 presents the computerized evaluation screen of the OWAS method for the assessment of the postures and loads.

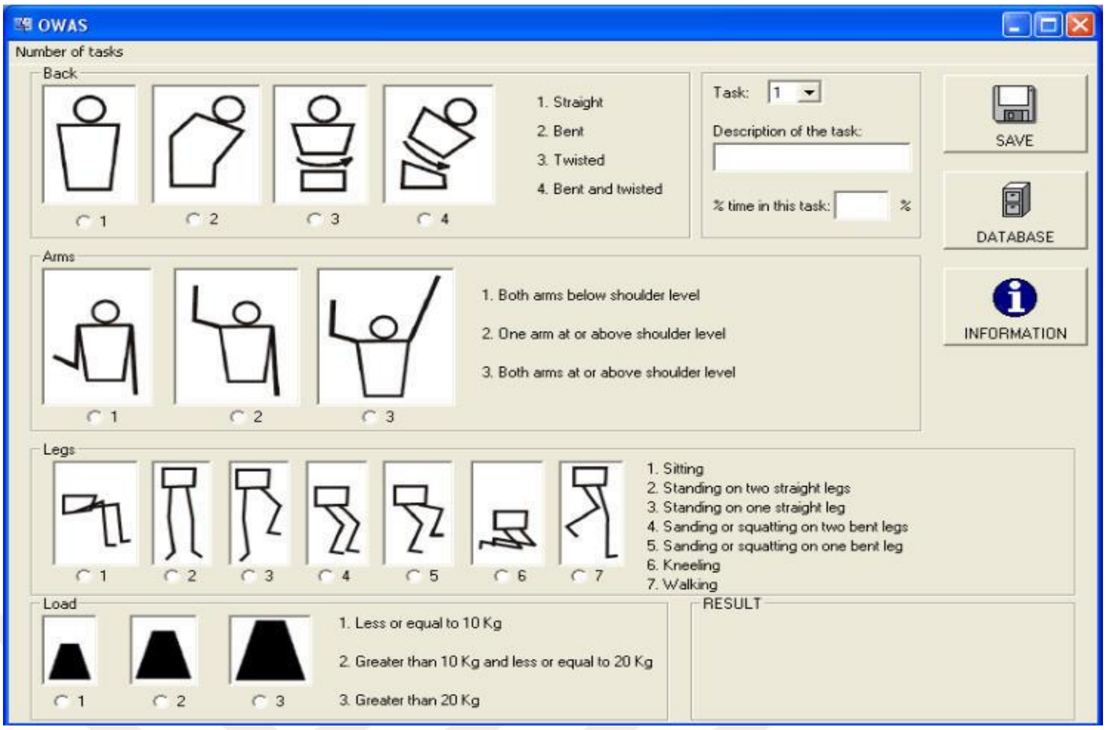


Figure 7.4. Computerized Analysis of the OWAS Method

7.1.3.1. Unloading the Cargo Packages

The first process is unloading the cargo packages which was carried out by observing the worker’ s postures and positions while unloading the truck and placing the cargo packages to the conveyor belt. Observed postures and positions are noted in the paper and analyzed by using the ErgoFellow 3.0 program. As a result of this analysis performed by the OWAS method, the time result of the unloading cargo packages process is presented below in Figure 7.5.

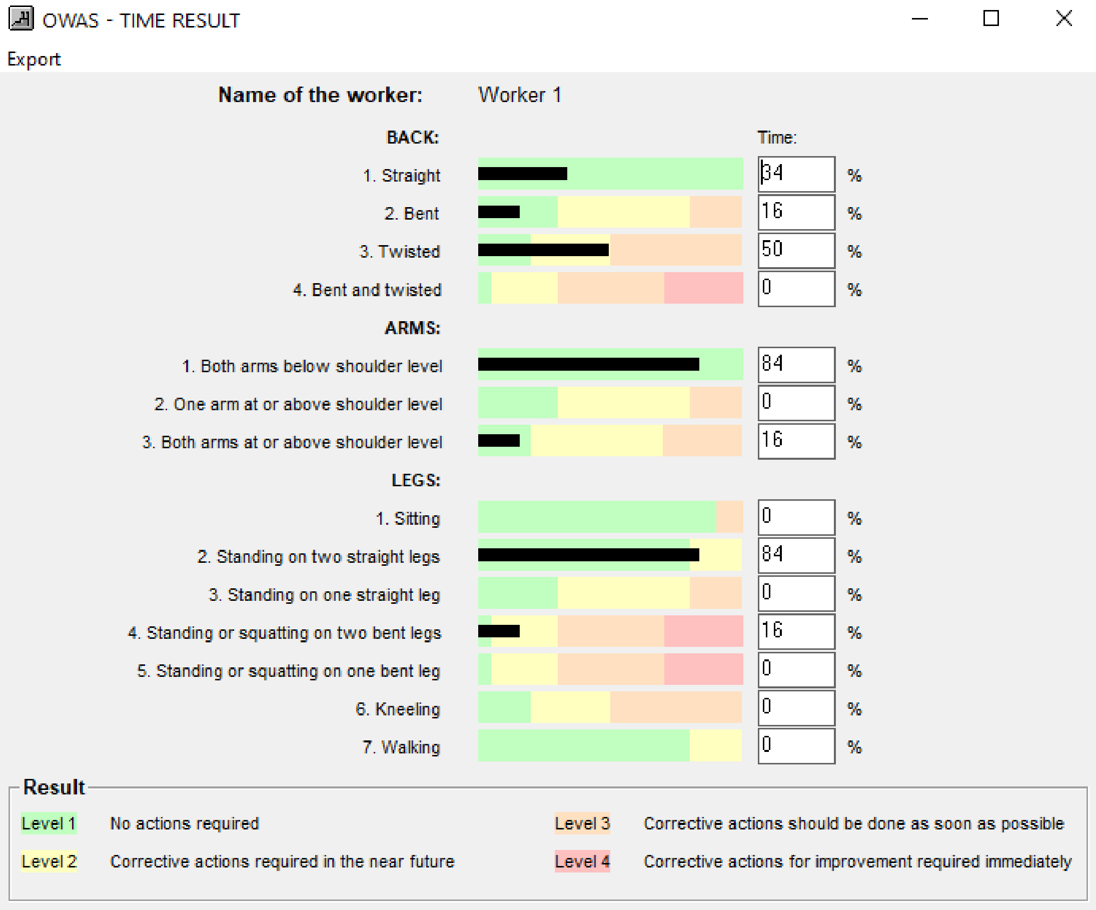


Figure 7.5. OWAS Time Result of the Unloading Cargo Packages

It can be deducted from Figure 7.5 that the worker’s back is 34% straight, 16% bent, 50% twisted while in the duration of the process. In addition to that, the level of worker’s arms level is presented. According to the figure, the worker’s arms level below the shoulder is 84% and the worker’s arms level above the shoulder is 16% while in the duration of the process. Also, it was observed that the worker’s percentage of standing on two straight legs is 84 and the percentage of standing or squatting on two bent legs is 16 while in the duration of the process.

7.1.3.2. Separation of the Foreign Cargo Packages

The second process is the separation of the cargo packages depending on their dimensions and features. For example, foreign cargo packages must be divided from the other cargoes and documented differently. Also, the DWS measurement of the large/shapeless cargo packages are in the different workstations and it has a different conveyor belt. For that reason, these cargo packages which have different workstations must be separated. As a result of this analysis performed by the OWAS method, the time result of the separation of the foreign cargo packages process is presented below in Figure 7.6.

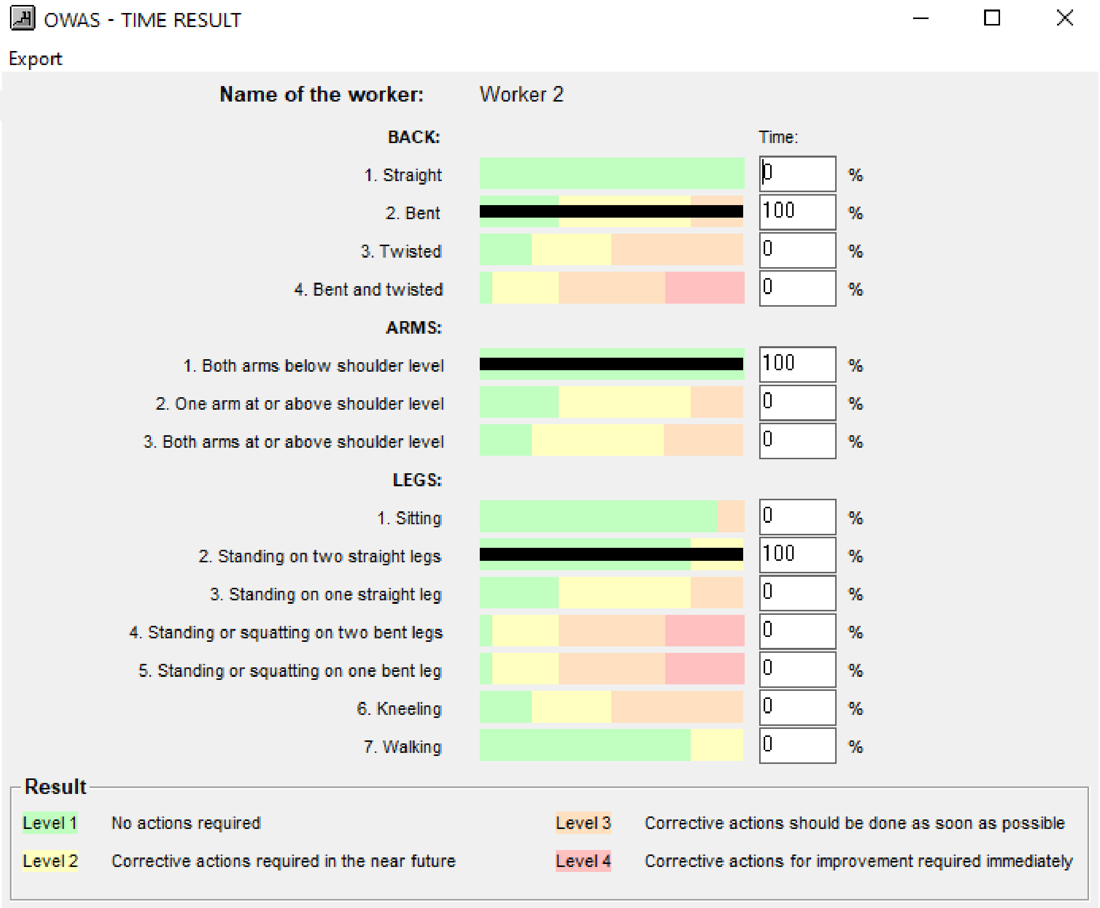


Figure 7.6. OWAS Time Result of the Separation of the Foreign Cargo Packages

It can be deducted from Figure 7.6 that the worker's back is 100% bent while in the duration of the process. According to the figure, workers' both arms level below the shoulder is 100% while in the duration of the process. Also, it was observed that the worker's percentage of standing on two straight legs is 100 while in the duration of the process.

7.1.3.3. Separation of the Large/Shapeless Cargo Packages

The second sub-process of the separation operation is the separation of the large/shapeless cargo packages. As a result of this analysis performed by the OWAS method, the time result of the separation of the large/shapeless cargo packages process is presented below in Figure 7.7.

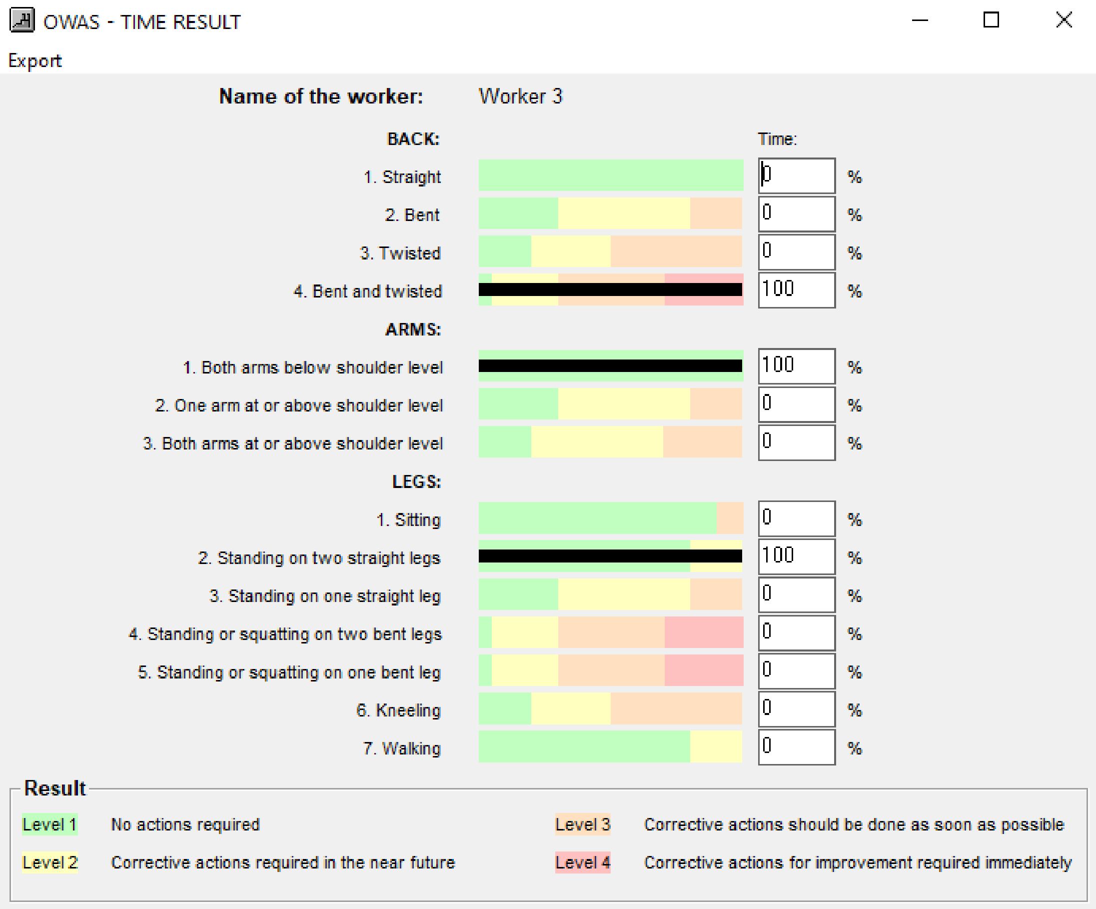


Figure 7.7. OWAS Time Result of the Separation of the Large/Shapeless Cargo Packages

It can be deducted from Figure 7.7 that the worker's back is 100% bent and twisted while in the duration of the process. In addition to that worker's arms level below the shoulder is 100% while in the duration of the process. Also, it was observed that the worker's percentage of standing on two straight legs is 100 while in the duration of the process.

7.1.3.4. Separation of the Small Packages

The third process of the separation operation is the separation of the small packages. As a result of this analysis performed by the OWAS method, the time result of the separation of the small packages process is presented below in Figure 7.8.

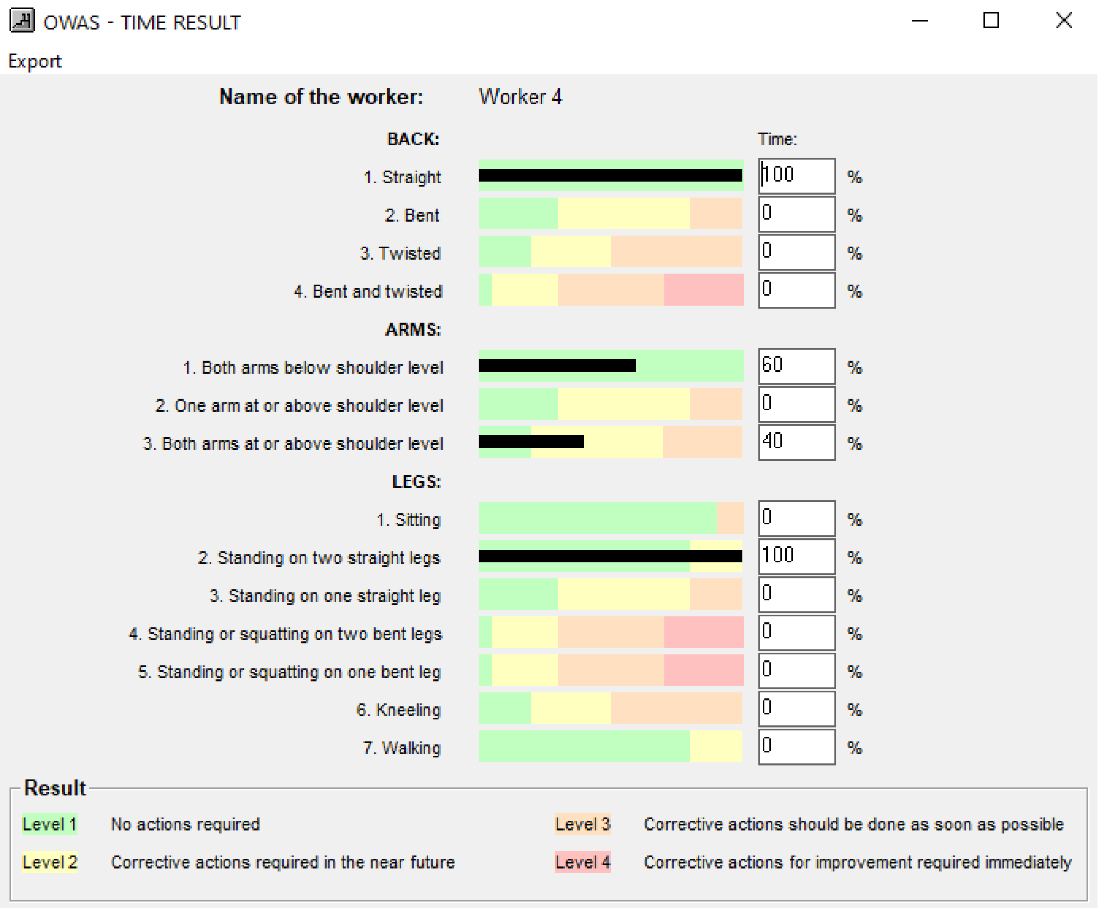


Figure 7.8. OWAS Time Result of the Separation of the Small Packages

It can be deducted from Figure 7.8 that the worker's back is 100% straight while in the duration of the process. In addition to that worker's arms level below the shoulder is 60% and the worker's arms level above the shoulder is 40% while in the duration of the process. Also, it was observed that the worker's percentage of standing on two straight legs is 100 while in the duration of the process.

7.1.3.5. DWS Measurement of the Cargo Packages

The third process is the DWS measurement of the cargo packages. This process has been divided into three sub-processes to examine different cargo types' DWS measurement. For instance, large/shapeless cargo packages have different DWS machine for the measurement process. Due to foreign cargo packages and normal packages have different workstations, they also have different DWS measurement process. For that reason, normal, foreign, and large/shapeless cargo packages are examined separately. As a result of this analysis performed by the OWAS method, the time result of the DWS measurement of the cargo packages process is presented below in Figure 7.9.

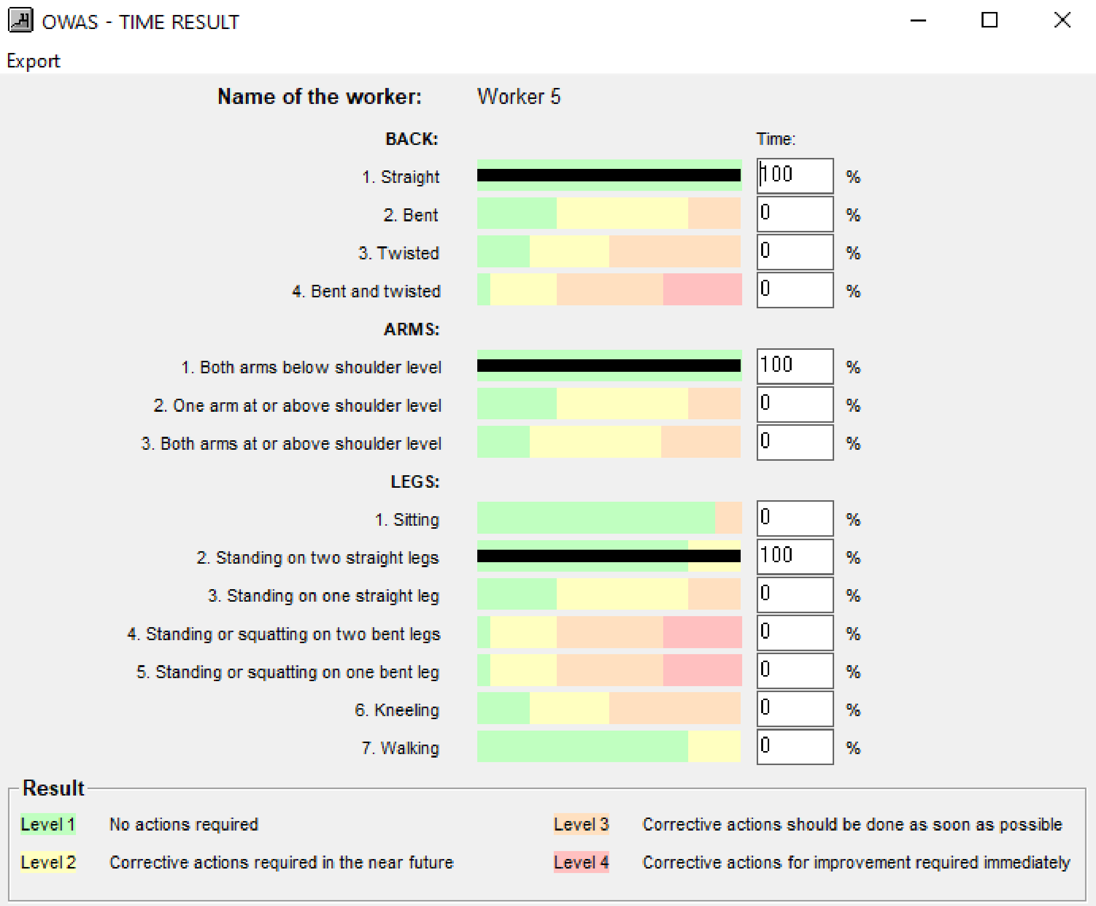


Figure 7.9. OWAS Time Result of the DWS Measurement of Cargo Packages

It can be deducted from Figure 7.9 that the worker's back is 100% straight while in the duration of the process. In addition to that worker's arms level below the shoulder is 100% while in the duration of the process. Also, it was observed that the worker's percentage of standing on two straight legs is 100 while in the duration of the process.

7.1.3.6. DWS Measurement of the Foreign Cargo Packages

The second sub-process of the DWS measurement operation is the DWS measurement of the foreign cargo packages. As a result of this analysis performed by the OWAS method, the time result of the DWS measurement of the foreign cargo packages process is presented below in Figure 7.10.

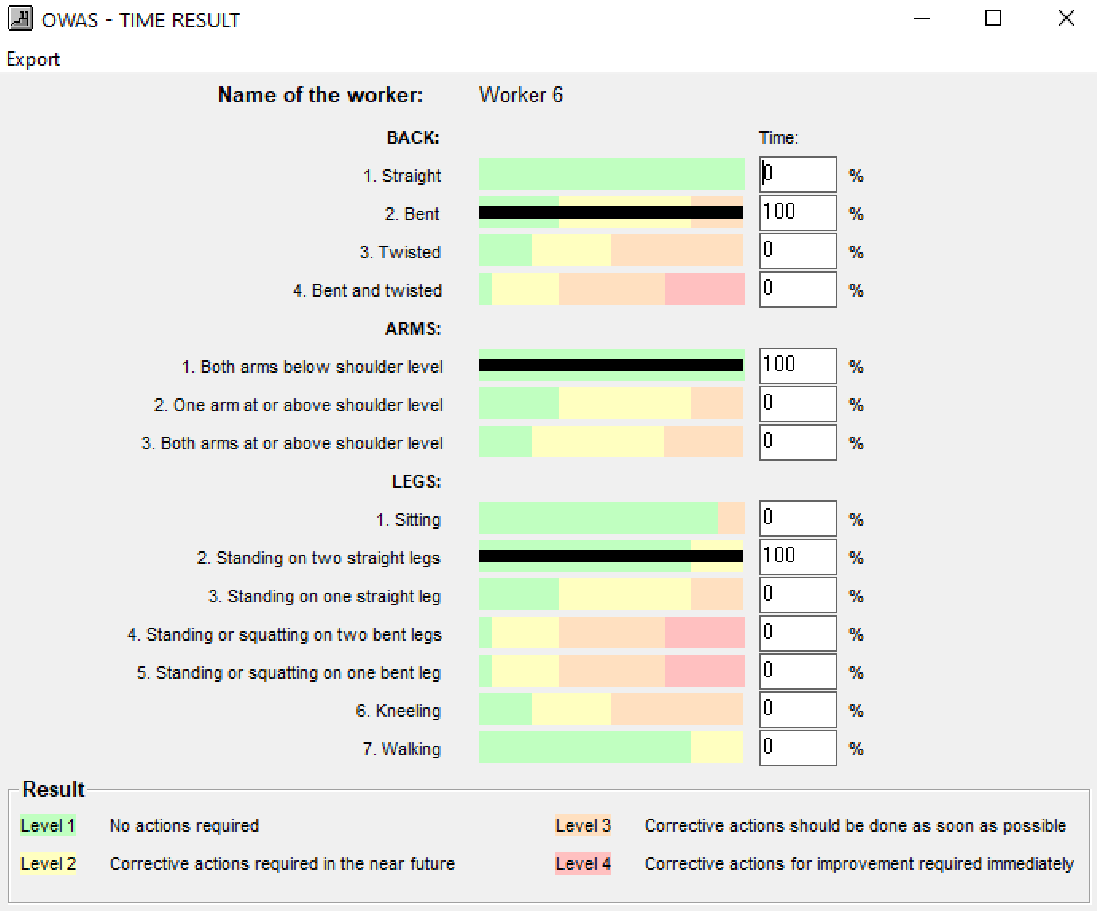


Figure 7.10. OWAS Time Result of the DWS Measurement of the Foreign Cargo Packages

It can be deducted from Figure 7.10 that the worker's back is 100% bent while in the duration of the process. In addition to that worker's arms level below the shoulder is 100% while in the duration of the process. Also, it was observed that the worker's percentage of standing on two straight legs is 100 while in the duration of the process.

7.1.3.7. DWS Measurement of the Large/Shapeless Cargo Packages

The third sub-process of the DWS measurement operation is the DWS measurement of the large/shapeless cargo packages. As a result of this analysis performed by the OWAS method, the time result of the DWS measurement of the large/shapeless cargo packages process is presented below in Figure 7.11.

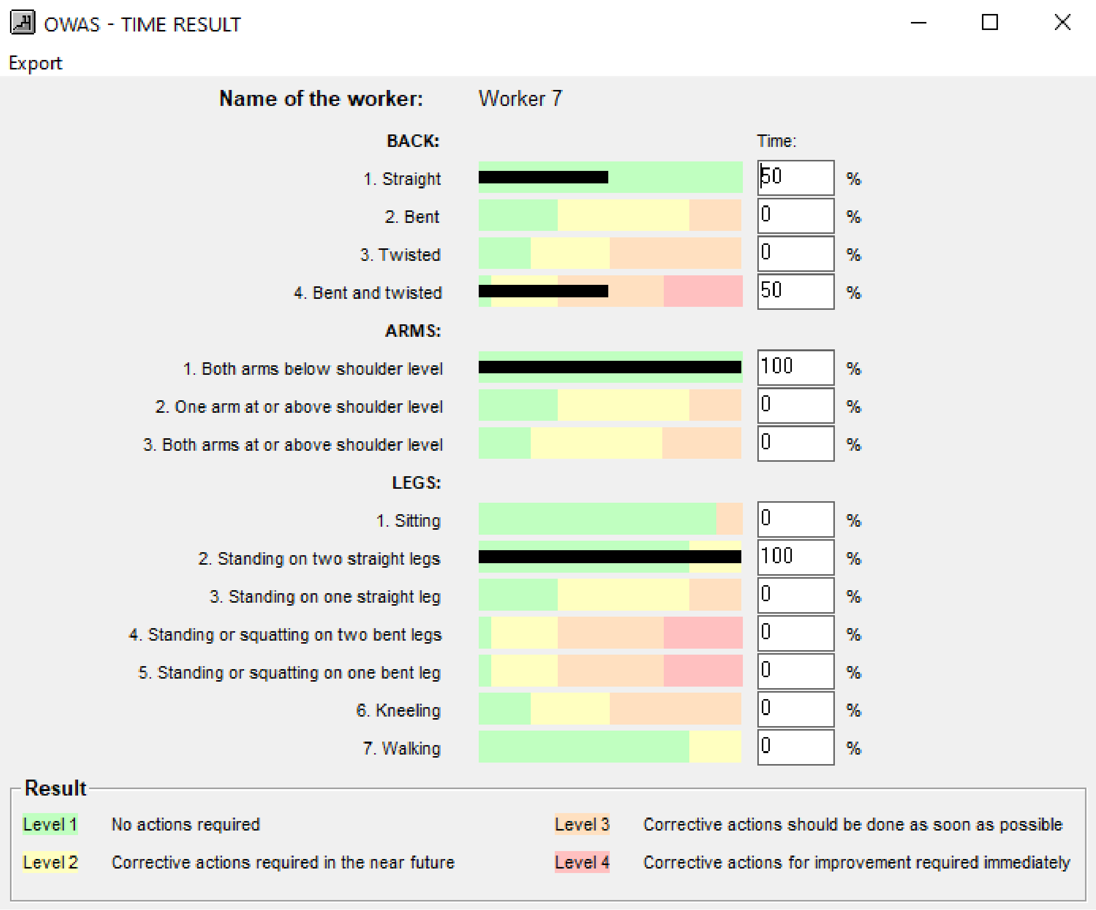


Figure 7.11. OWAS Time Result of the DWS Measurement of the Large/Shapeless Cargo Packages

It can be deducted from Figure 7.11 that the worker' s back is 50% straight, 50% bent and twisted while in the duration of the process. According to the figure, workers' both arms level below the shoulder is 100% while in the duration of the process. Also, it was observed that the worker's percentage of standing on two straight legs is 100 while in the duration of the process.

7.1.3.8. First Sorting Operation

The fourth process is the sorting process where cargo packages are separated according to the destination or city. For instance, there are four sorting stations (three normal & one small sorting) in the company. These sorting stations are arranged according to the regions where the cargo will be sent. In this context, the first sorting station is the Central Anatolia region cargo. The cargo packages directed to this station are also divided into Ankara and other inner Anatolian, eastern, and southeastern Anatolian regions cargoes. As a result of this analysis performed by the OWAS method, the time result of the first sorting operation process is presented below in Figure 7.12.

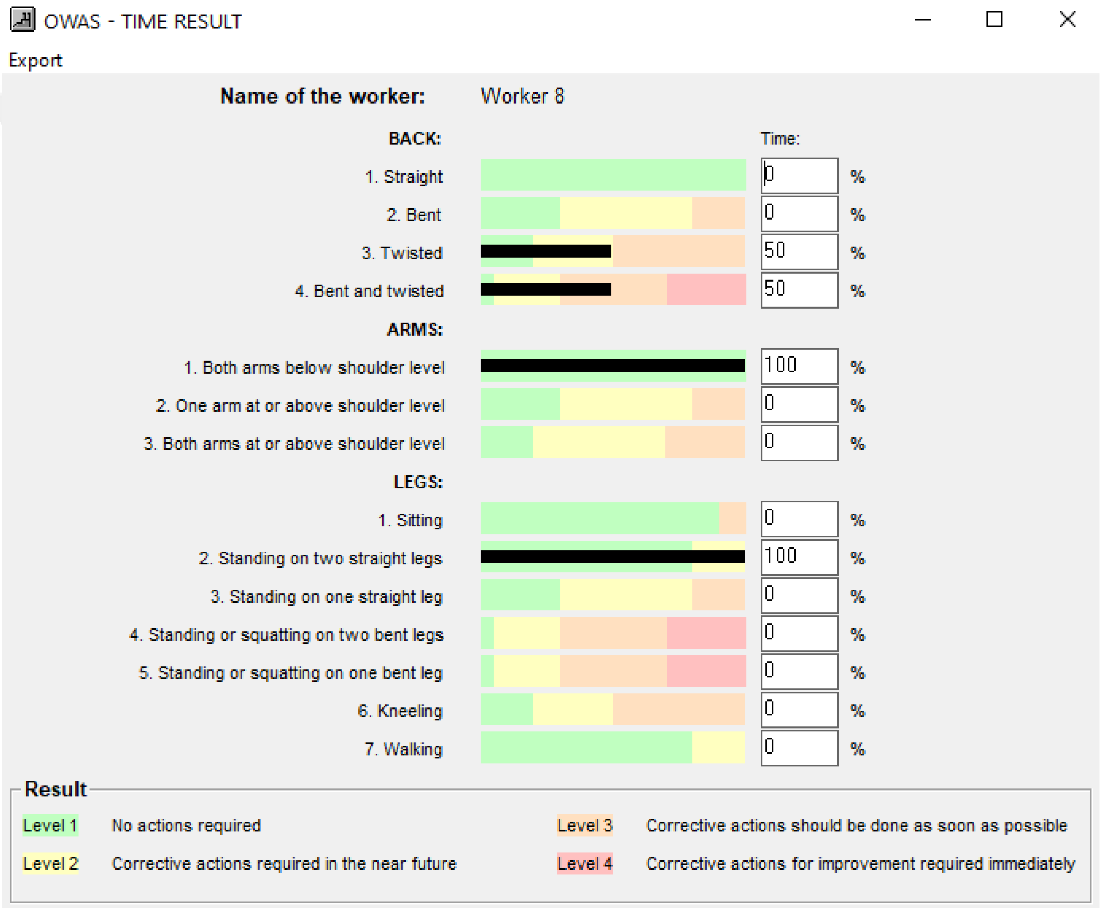


Figure 7.12. OWAS Time Result of First Sorting Operation

It can be deducted from Figure 7.12 that the worker’s back is 50% twisted, 50% bent and twisted while in the duration of the process. Also, the worker’s arms level below the shoulder is 100% while in the duration of the process. In addition, it was observed that the worker’s percentage of standing on two straight legs is 100 for this process.

7.1.3.9. The Second Sorting Operation

The second sub-process of the sorting operation is the sorting cargo packages for İstanbul and its surroundings. Therefore, the cargo packages which is leading to the İstanbul region are divided into three categories which are İstanbul Anatolian side, İstanbul European side and, Bursa region cargoes. As a result of this analysis performed by the OWAS method, the time result of the second sorting operation process is presented below in Figure 7.13.

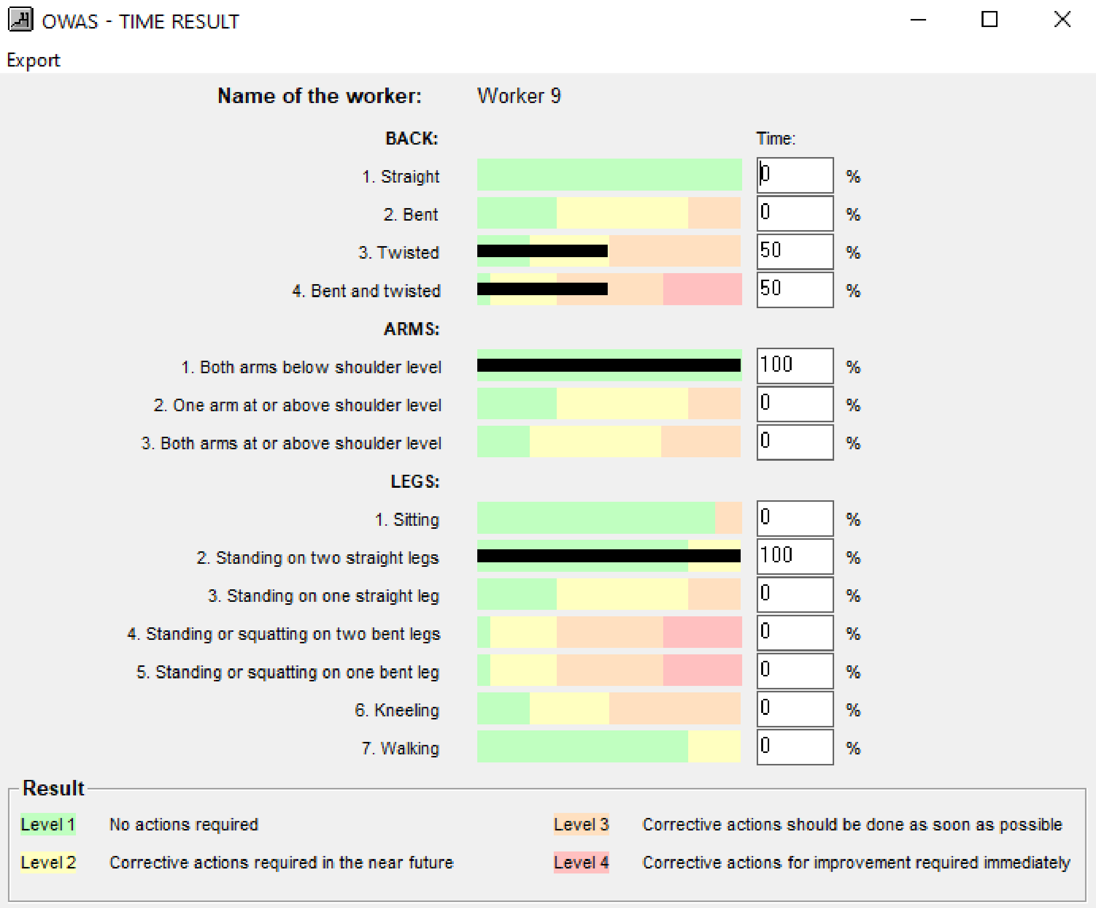


Figure 7.13. OWAS Time Result of the Second Sorting Operation

It can be deducted from Figure 7.13 that the worker's back is 50% twisted, 50% bent and twisted while in the duration of the process. According to the figure, workers' both arms level below the shoulder is 100% while in the duration of the process. Also, it was observed that the worker's percentage of standing on two straight legs is 100 for this process.

7.1.3.10. Retain Operation (İzmir Cargoes)

The third sub-process of the separation process is the station where the Izmir cargo, which will be classified according to the districts of Izmir the next day, is kept until the morning operation. The loads that will travel in Izmir and its surroundings at this station are loaded onto the truck after the sorting process and kept for the next day's processes. As a result of this analysis performed by the OWAS method, the time result of the retain operation process is presented below in Figure 7.14.

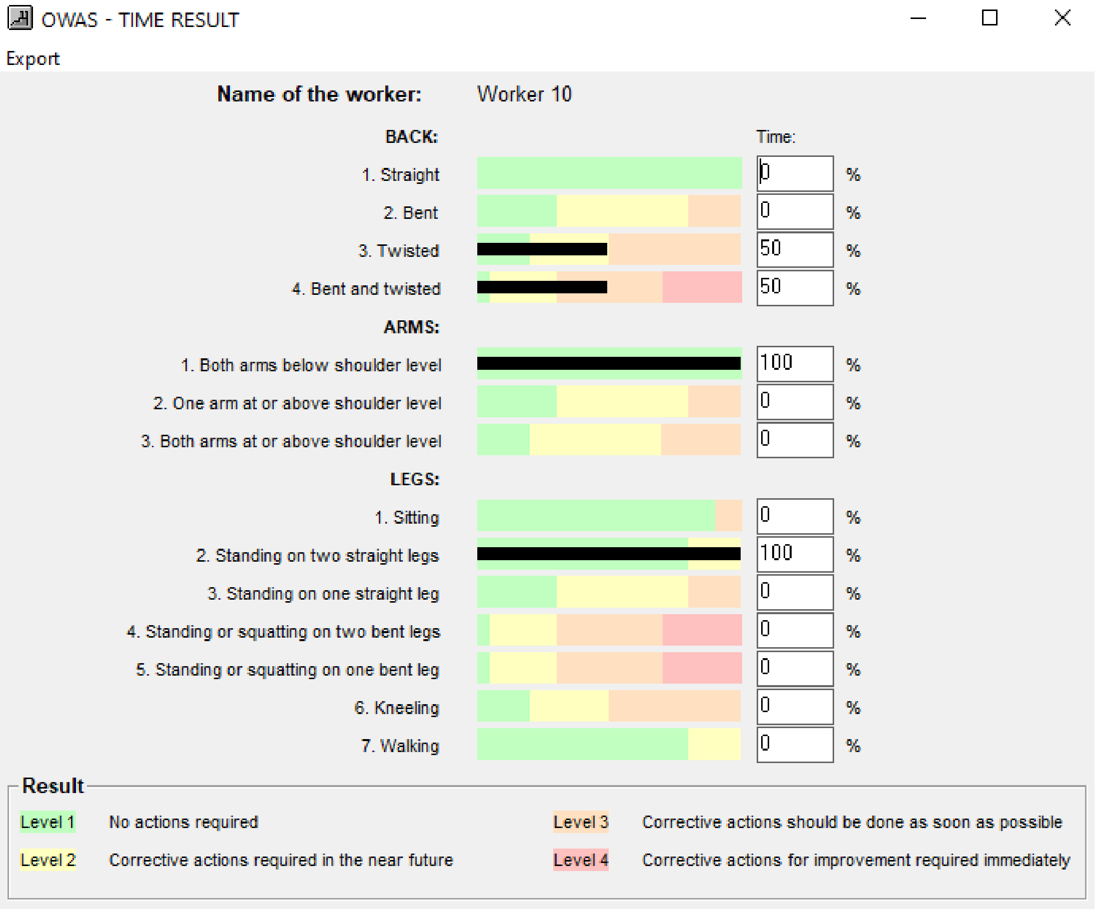


Figure 7.14. OWAS Time Result of the Retain Operation

It can be deducted from Figure 7.14 that the worker's back is 50% twisted, 50% bent and twisted while in the duration of the process. According to the figure, workers' both arms level below the shoulder is 100% while in the duration of the process. In addition, it was observed that the worker's percentage of standing on two straight legs is 100 for this process.

7.1.3.11. Small Sorting Operation

The fourth and last sorting sub-process is a small sorting operation. In this sub-process, small packages are classified into separators which consist of 24 compartments in themselves and each of these compartments represents cities and surrounding areas to be sent. As a result of this analysis performed by the OWAS method, the time result of the small sorting operation process is presented below in Figure 7.15.

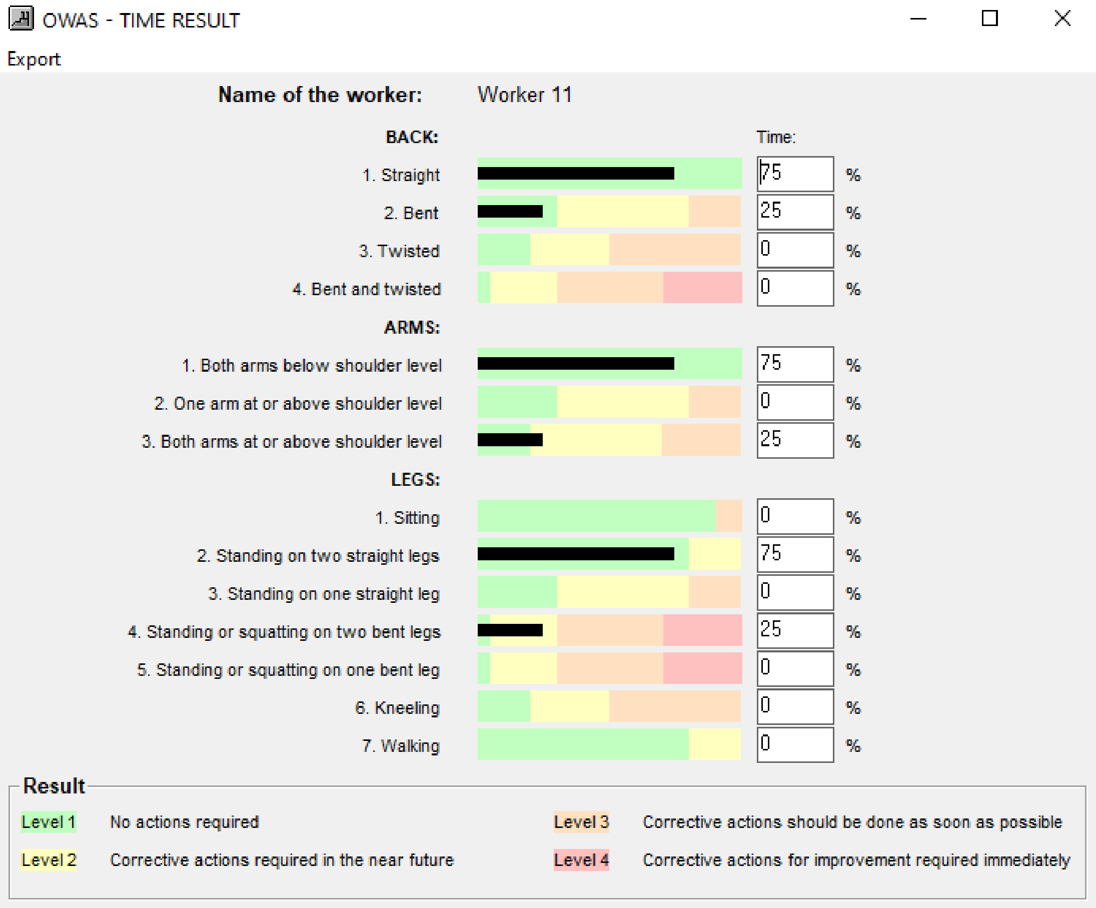


Figure 7.15. OWAS Time Result of the Small Sorting Operation

It can be deducted from Figure 7.15 that the worker's back is 75% straight, 25% bent while in the duration of the process. According to the figure, workers' both arms level below the shoulder is 75% and worker's both arms at or above shoulder level is 25% while in the duration of the process. In addition, it was observed that the worker's percentage of standing on two straight legs is 75 and the percentage of standing or squatting on two bent legs is 25 for this process.

7.1.3.12. Barcode Scanning and Loading Operation for Ankara

After the sorting operation, cargo packages are directed to the trucks. In this process, the barcodes of the cargo packages are scanned to be loaded on the truck or vehicle. This process is divided into six separate sub-processes for different regions such as Ankara, other Central Anatolia regions, Istanbul (Anatolian side), Istanbul (European side), Bursa, and Izmir. As a result of this analysis performed by the OWAS method, the time result of the barcode scanning and loading operation process for Ankara cargoes are presented below in Figure 7.16.

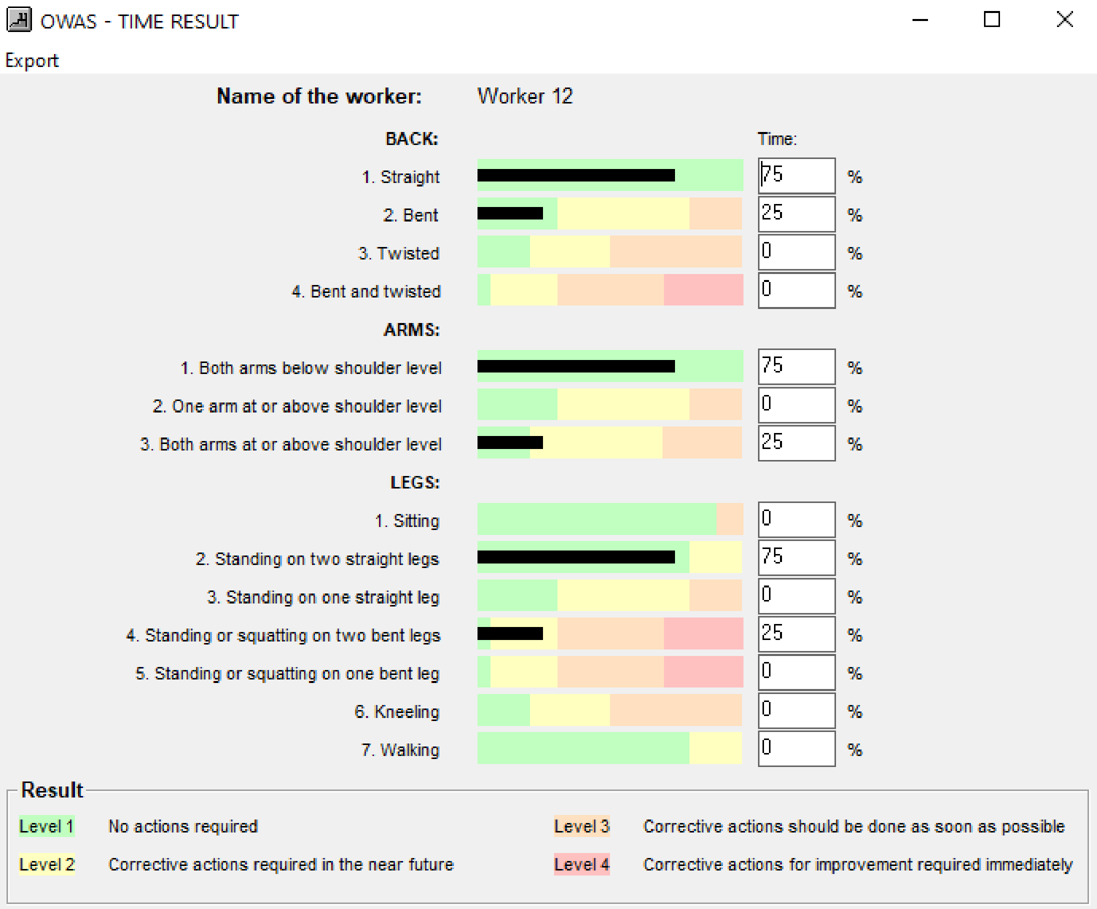


Figure 7.16. OWAS Time Result of the Barcode Scanning and Loading Operation for Ankara

Based on Figure 7.16, it can be deducted that the worker's back is 75% straight, 25% bent while performing the job. Also, the worker's arms level below the shoulder is 75% and the worker's both arms at or above shoulder level is 25% while in the duration of the process. In addition, it was observed that the worker's percentage of standing on two straight legs is 75 and the percentage of standing or squatting on two bent legs is 25 for this process.

7.1.3.13. Barcode Scanning and Loading Operation for Other Anatolian Regions

The second sub-process of this operation is barcode scanning and loading of the cargo packages into the vehicle which is going to be directed towards other Anatolian regions (Ankara’ s surroundings, Eastern Anatolia, and Southeastern Anatolia region). As a result of this analysis performed by the OWAS method, the time result of the barcode scanning and loading operation process for other Anatolian region cargoes are presented as below in Figure 7.17.

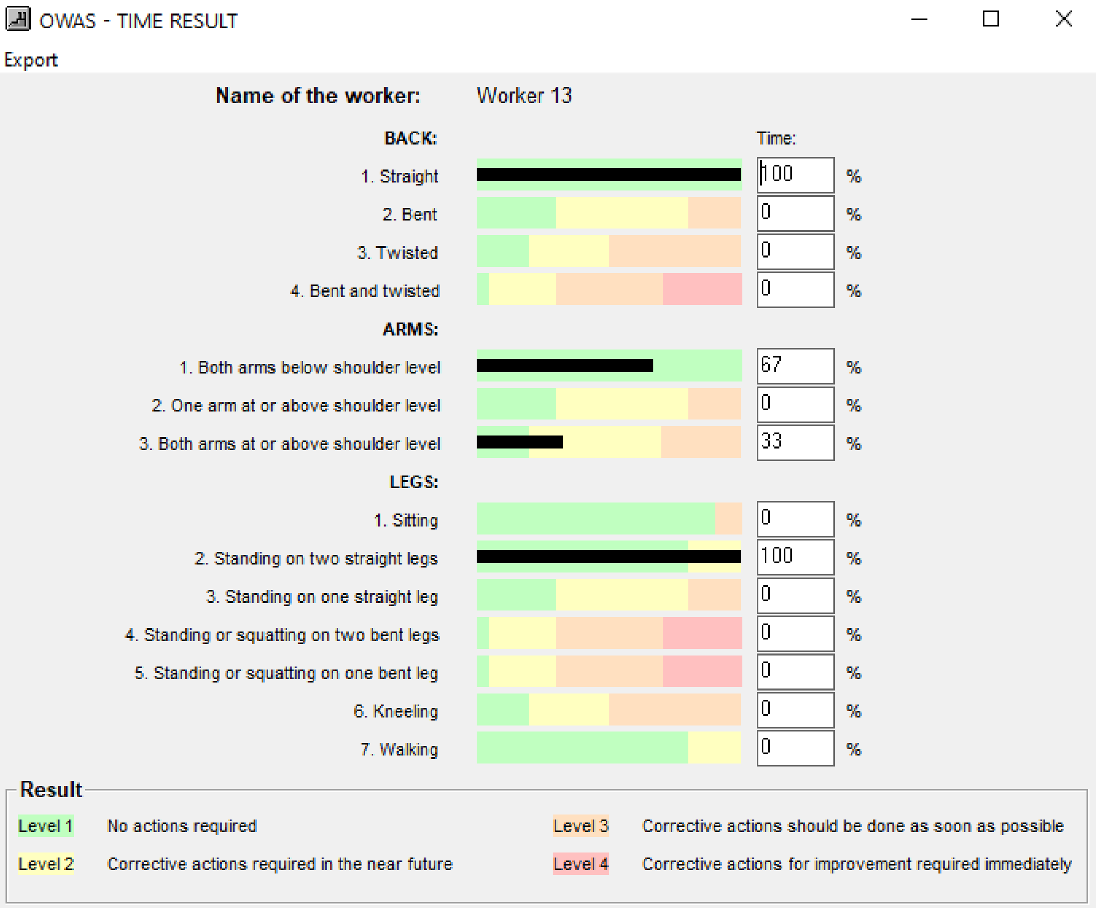


Figure 7.17. OWAS Time Result of the Barcode Scanning and Loading Operation for the Other Anatolian Regions

Based on Figure 7.17, it can be deducted that the worker’s back is 100% straight while performing the job. Also, the worker’s arms level below the shoulder is 67% and the worker’s both arms at or above shoulder level is 33% while in the duration of the process. In addition, it was observed that the worker’s percentage of standing on two straight legs is 100 for this process.

7.1.3.14. Barcode Scanning and Loading Operation for İstanbul (Anatolian Side)

The third sub-process of this operation is barcode scanning and loading of the cargo packages into the vehicle which is going to be directed towards İstanbul (Anatolian side). As a result of this analysis performed by the OWAS method, the time result of the barcode scanning and loading operation process for İstanbul (Anatolian side) cargoes are presented below in Figure 7.18.

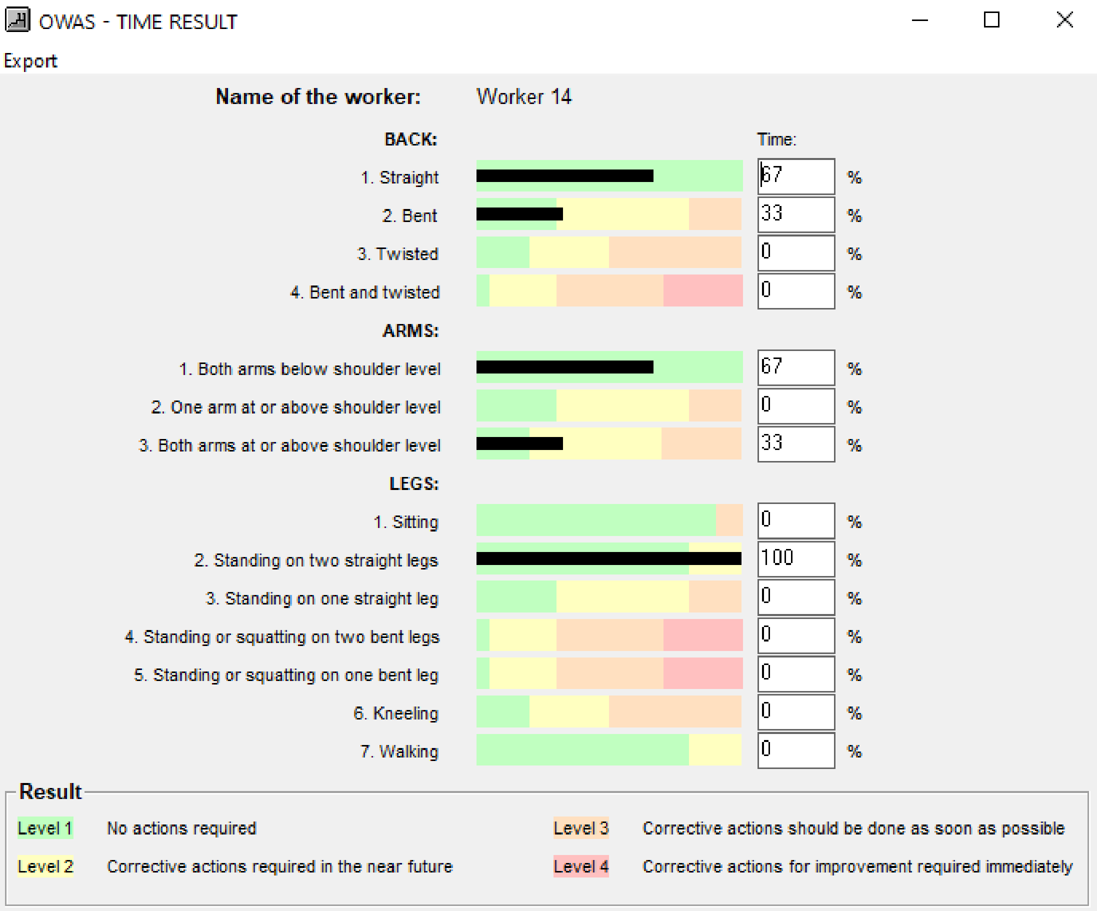


Figure 7.18. OWAS Time Result of the Barcode Scanning and Loading Operation for İstanbul (Anatolian Side)

Based on Figure 7.18, it can be deducted that the worker's back is 67% straight and 33% bent while performing the job. Also, the worker's arms level below the shoulder is 67% and the worker's both arms at or above shoulder level is 33% while in the duration of the process. In addition, it was observed that the worker's percentage of standing on two straight legs is 100 for this process.

7.1.3.15. Barcode Scanning and Loading Operation for İstanbul (European Side)

The fourth sub-process of this operation is barcode scanning and loading of the cargo packages into the vehicle which is going to be directed towards İstanbul (European side). As a result of this analysis performed by the OWAS method, the time result of the barcode scanning and loading operation process for İstanbul (European side) cargoes are presented as below in Figure 7.19.

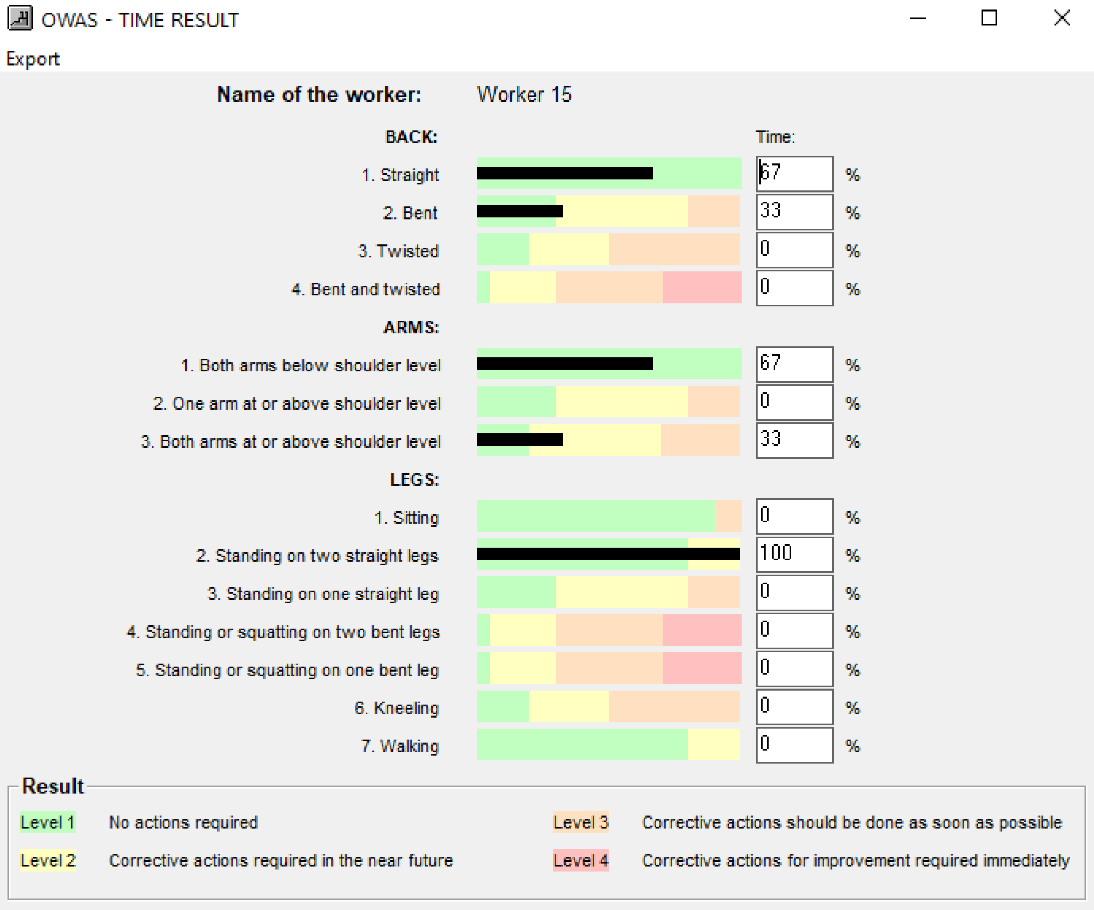


Figure 7.19. OWAS Time Result of the Barcode Scanning and Loading Operation for İstanbul (European Side)

Based on Figure 7.19, it can be deducted that the worker's back is 67% straight and 33% bent while performing the job. Also, the worker's arms level below the shoulder is 67% and the worker's both arms at or above shoulder level is 33% while in the duration of the process. In addition, it was observed that the worker's percentage of standing on two straight legs is 100 for this process.

7.1.3.16. Barcode Scanning and Loading Operation for Bursa

The fifth sub-process of this operation is barcode scanning and loading of the cargo packages into the vehicle which is going to be directed towards Bursa. As a result of this analysis performed by the OWAS method, the time result of the barcode scanning and loading operation process for Bursa cargoes are presented below in Figure 7.20.

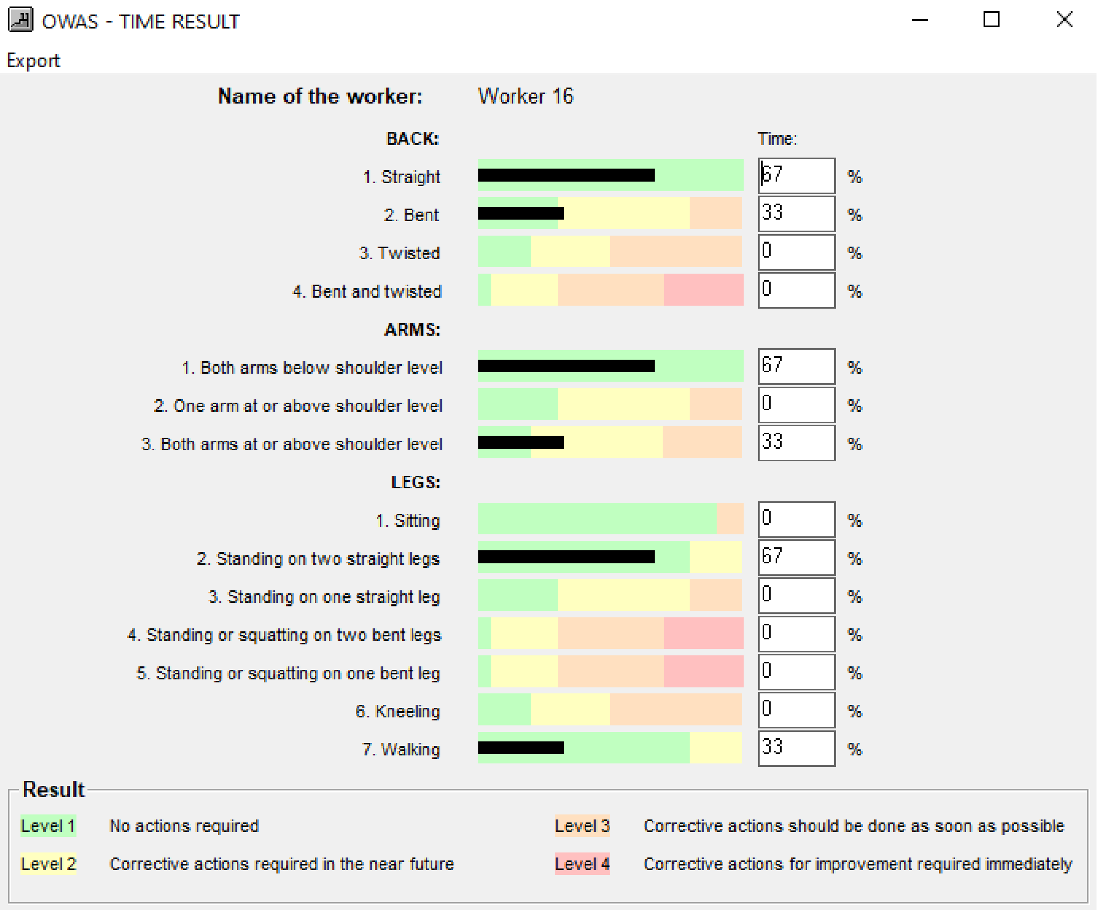


Figure 7.20. OWAS Time Result of the Barcode Scanning and Loading Operation for Bursa

Based on Figure 7.20, it can be deducted that the worker's back is 67% straight and 33% bent while performing the job. Also, the worker's arms level below the shoulder is 67% and the worker's both arms at or above shoulder level is 33% while in the duration of the process. In addition, it was observed that the worker's percentage of standing on two straight legs is 67 and the percentage of walking is 33 for this process.

7.1.3.17. Barcode Scanning and Loading Operation for İzmir

The sixth sub-process of this operation is barcode scanning and loading of the cargo packages into the vehicle which is going to be divided into different sections of the İzmir for the next day’ s operation. As a result of this analysis performed by the OWAS method, the time result of the barcode scanning and loading operation process for İzmir (Retain) cargoes are presented below in Figure 7.21.

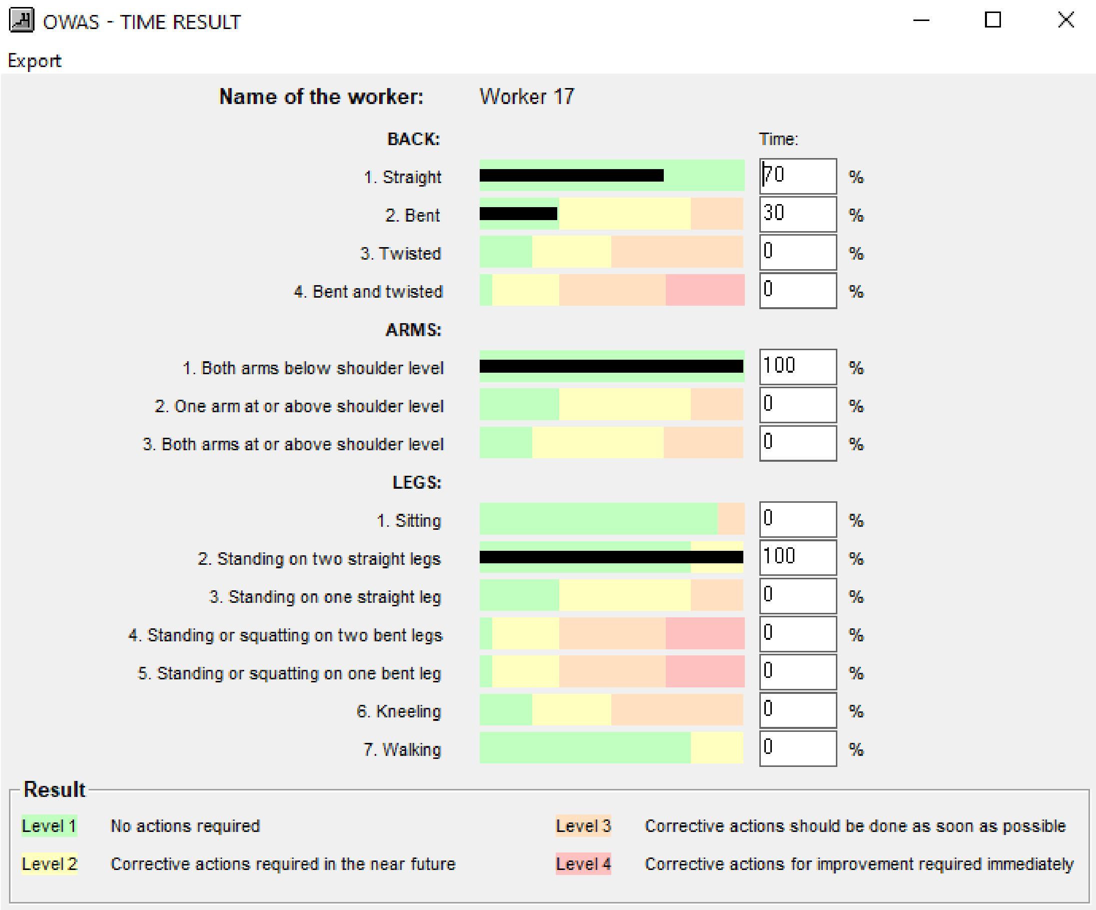


Figure 7.21. OWAS Time Result of the Barcode Scanning and Loading Operation for İzmir

Based on Figure 7.21, it can be deduced that the worker’s back is 70% straight and 30% bent while performing the job. Also, the worker’s arms level below the shoulder is 100% while in the duration of the process. In addition, it was observed that the worker’s percentage of standing on two straight legs is 100.

CHAPTER 8
ERGONOMIC INTERVENTIONS

After performing the hybrid ergonomic risk assessment, the observed results should be examined and required remediate actions should be made for the operations which involve high-risk. Otherwise, just assessment shows what the problem is or where it originates. If we characterize these risky operations as a disease, the assessment only reveals the symptoms of the disease and says what the disease is. However, ergonomic improvements go one step beyond diagnosing this disease, seeking, and improving its treatment. In this context, ergonomic interventions one of the main steps for the treatment and prevention of the damage due to WMSD (Kim & Junggi, 2013). Therefore, the main purpose of the ergonomic intervention is to eliminate the likelihood of exposure to risk factors in the work environment which may result in occupational accidents, diseases, and disorders.

In this part of the study, the risk levels observed as a result of the ergonomic assessment made so far will be examined in detail and the necessary improvement actions will be suggested. Necessary ergonomic improvements will be examined from reactive and proactive perspectives. Firstly, the reactive approach is an approach based on taking precautions after incidents such as accidents, injury, or exposure that occur in the current workplace in order to perform an improvement action. On the other side, a proactive approach can be defined as designing the workplace to prevent MSDs before they occur (PROergonomics, 2016), and therefore this approach is considered to provide cost-effective solutions. Because this approach focuses on predicting and eliminating any accident, occupational disease, or risk factor before it occurs. Many companies prefer to use the reactive approach in order to measure their ergonomic performance, despite the proactive approach is providing more desirable results and more statistically valid than a reactive approach (EHS Today, 2010). In this study, by focusing on the risk levels as a result of the ergonomic assessment, firstly, required remediation actions and ergonomic interventions and corrections recommendations will be made depending on a reactive approach for the operations which found to be risky. In the next section, ergonomic interventions and correction recommendations will be presented based on the proactive approach of future ergonomic problems and operations identified during the company's observation but not found risky in the assessment. For this purpose, OWAS action categories and risk levels of the assessed body region table is presented in Table 8.1 below.

Table 8.1 OWAS Action Categories and Risk Levels of the Assessed Body Regions

Level 1	No actions required	Level 3	Corrective actions should be done as soon as possible
Level 2	Corrective Actions Required in the Near Future	Level 4	Corrective actions for improvement required immediately

8.1 Reactive Approach

In this section, ergonomic suggestions, and improvements in accordance with the reactive approach will be presented for risky positions observed at workstations. In this context, the assessments made in the 7th section of the thesis are presented below as a table in order to examine them more easily and to focus on the risk levels. By analyzing these tables, required correction recommendations are presented for operations with risk levels 2, 3, and 4.

Table 8.2 OWAS Observed Level of Risks for Worker 1

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULT
WORKER 1	A	UNLOADING OPERATION	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 2
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 2
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the unloading operation, it is observed from Table 8.2 that worker 1 is standing on two straight legs and standing or squatting on two bent legs in most of the work and this position poses risk for the legs. In order to solve this problem, working postures that provide a neutral body position with a comfortable posture should be studied to complete tasks without stressful angles. Works that require standing and moving for a long time should be done occasionally by sitting. For this purpose, it is necessary to ensure that the worker needs to be seated from time to time. In addition, in the unloading operation, the worker must take the cargo below its level from the cargo transport vehicle in the correct position. To this end, standing or squatting on two bent legs is a wrong posture and can only be eliminated with proper training.

Table 8.3 OWAS Observed Level of Risks for Worker 2

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULT
WORKER 2	B	SEPARATION OPERATION (FOREIGN CARGO PACKAGES)	BACK	1. Straight	Level 1
				2. Bent	Level 3
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the separation operation (foreign cargo packages), it is observed from Table 8.3 that worker 2 is experiencing bent and standing on two straight legs in most of the work and this position poses risk for the back and legs. The station where foreign cargo packages are separated is different and independent from other cargoes and there are no interconnected conveyor bents. For this reason, the foreign cargoes coming from the conveyor belt via pallet jack are placed at the workstation by bending from below. There is no automation system in the workplace to transport the cargo to this station. In this case, transporting heavy cargo in this way poses a risk for workers. In addition, the height of the station is extremely low compared to workers and it requires constant reaching distance. This position may cause back pain in the worker. Therefore, it is recommended to increase the height of the workstation to reduce the observed risk factor. In addition, seating can be provided for workers at this station.

Table 8.4 OWAS Observed Level of Risks for Worker 3

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULT
WORKER 3	B	SEPARATION OPERATION (LARGE/SHAPELESS CARGO PACKAGES)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 1
				4. Bent and twisted	Level 4
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the separation process (large/shapeless cargo packages), it is observed from Table 8.4 that worker 3 is bent and twisted in order to separate the large/shapeless cargo packages from the conveyor belt and take them to the DWS station. In this section of the conveyor belt, it is necessary to add an extra belt to this part of the conveyor belt to direct heavy cargo packages to ground level. Thus, employees do not do this job manually. Another important point that manual pallet jacks can be changed with the motorized ones to reduce the pressure on the worker. Therefore, this recommendation can reduce the back pain of the workers.

Table 8.5 OWAS Observed Level of Risks for Worker 4

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULT
WORKER 4	B	SEPARATION OPERATION (SMALL PACKAGES)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 2
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the separation process (small packages), it is observed from Table 8.5 that worker 4 raises both arms at or above shoulder level which may cause pain in the arms for a long-term period. Also, worker 4 is standing on two straight legs for hours until the work is finished. Therefore, these workers need to rest their legs occasionally and work with rotation. Besides, workers in the separation of small packages are exposed to much more repetitive movements than normal and large packages. Even if the workers in the small sorting operations which involving repetitive movements make the necessary ergonomic positions correctly, this repetitive movement causes stress in the muscles and this stress can lead to injury and disorders. In this context, it is recommended to rotate workers to reduce repetitive movement caused by the nature of the work.

Table 8.6 OWAS Observed Level of Risks for Worker 5

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 5	C	DWS MEASUREMENT (CARGO PACKAGES)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the DWS measurement operation, it is observed from Table 8.6 that worker 5 standing on two straight legs extended period of time which may cause pain in the legs for a long-term period. For that reason, job rotation is recommended. If job rotation is not an option, workers can try neutral positions periodically that are different from work-related movements to reduce the stress of tissues caused by doing the same job for a long time. Moreover, the assignment of the tasks to the worker can be determined by considering the physical features (weight, health condition, etc.) of the worker. Depending on these features, working time breaks, and job rotations of the workers can be determined.

Table 8.7 OWAS Observed Level of Risks for Worker 6

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 6	C	DWS MEASUREMENT (FOREIGN CARGO PACKAGES)	BACK	1. Straight	Level 1
				2. Bent	Level 3
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the DWS measurement operation (foreign cargo packages), it is observed from Table 8.7 that worker 6 is making a forward- reaching movement while measuring the cargo packages. This is not the first problem with this workstation. Forward-reaching movement of the worker can be prevented with the elevation of the workstation and a more ergonomic design. Moreover, this operation also requires remaining standing position for a long-time like the other workstations. Therefore, the recommendations stated in previous operations can be used in this workstation.

Table 8.8 OWAS Observed Level of Risks for Worker 7

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 7	C	DWS MEASUREMENT (LARGE/SHAPELESS CARGO PACKAGES)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 1
				4. Bent and twisted	Level 3
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the DWS measurement operation (large/shapeless cargo packages), it is observed from Table 8.8 that worker 7 bending movement to measuring the cargo packages and twisting movement for directing the cargo packages into large/shapeless conveyor belt. Also, this operation's worker is dealing with much larger and heavier cargo packages in the DWS measurement than the other packages. Also, there is no automated line design for carrying the large cargo packages from the ground to the DWS machine. For that reason, positioning an automated line design in front of the DWS machine can solve the problem. However, two workers are required for lifting the large/shapeless cargo packages and transporting them to the DWS machine. Then, after the measurement of the cargo, it needs to be directed to the conveyor belt which requires force and twisting back movement. For this job, the different workers can be assigned to direct the cargo to the belt.

Table 8.9 OWAS Observed Level of Risks for Worker 8

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 8	D	SORTING OPERATION (FIRST SORTING)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 2
				4. Bent and twisted	Level 3
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the first sorting operation (first sorting), it is observed from Table 8.9 that worker 8 is performing forward-reaching movement to grab Anatolian side cargo packages and twisting movement for sorting and directing the cargo packages into a related compartment. In order to prevent forward reaching movement, one more worker can be located to the other side of the conveyor belt. For twisting movement, workers should be trained in the correct positions.

Table 8.10 OWAS Observed Level of Risks for Worker 9

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 9	D	SORTING OPERATION (SECOND SORTING)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 2
				4. Bent and twisted	Level 3
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the second sorting operation (second sorting), it is observed from Table 8.10 that worker 9 is performing a forward-reaching movement and twisting movement for the same reason as worker 8 and directing the cargo packages into the related compartment. For that reason, the only recommendation for this operation can be training in order to correct the workers twisting movement. In addition, these sorting operations (first, second sorting, and retain) are located on the 2nd floor which enables limited space for the movement. In this context, there is not enough room for neutral movements, which are recommended periodically for continuous repetitive work.

Table 8.11 OWAS Observed Level of Risks for Worker 10

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 10	D	SORTING OPERATION (RETAIN/İZMIR CARGOES)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 2
				4. Bent and twisted	Level 3
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the third sorting operation (retain), it is observed from Table 8.11 that worker 10 is performing the same exact risky movements as other sorting operations due to the related equipment and equipment design. In sorting operations, there are compartments that are positioned next to the workers and divided into relevant provinces. Therefore, the twisting movement is required however, it should not be done from the waist. With the help of necessary training, the risky movements can be corrected.

Table 8.12 OWAS Observed Level of Risks for Worker 11

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 11	D	SMALL SORTING OPERATION	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 2
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 1
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 2
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the fourth sorting operation (small sorting), it is observed from Table 8.12 that worker 11 is having trouble with arms which both arms at or above shoulder level. This stretching movement poses a second-level risk and requires necessary corrective actions in the near future. In this case, it may be suggested that the worker use a ladder in order to reach higher parts of the compartments.

Table 8.13 OWAS Observed Level of Risks for Worker 12

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 12	E	BARCODE SCANNING AND LOADING OPERATION (ANKARA CARGOES)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 2
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 1
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 2
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the first barcode scanning and loading operation (Ankara cargoes), it is observed from Table 8.13 that worker 12 is having trouble with arms which both arms at or above shoulder level. In order to propose a solution to this problem, ladders need to be used regularly when filling the tops of the truck. Due to automated line design which can be placed in the truck and can be adjusted to the worker, the moving space is limited inside of the truck. For that reason, the necessary positions for work-related activities might be challenging. In this part, the worker needs to adjust the automated line in a way that does not restrict his or her movements and can be moved comfortably and easily.

Table 8.14 OWAS Observed Level of Risks for Worker 13

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 13	E	BARCODE SCANNING AND LOADING OPERATION (OTHER ANATOLIAN REGIONS)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 2
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the second barcode scanning and loading operation (other Anatolian region cargoes), it is observed from Table 8.14 that the same risky movement poses a threat for the worker that can cause pain in the arms and legs. Therefore, the same recommendations presented in the first barcode scanning and loading operation can be used to solve this problem.

Table 8.15 OWAS Observed Level of Risks for Worker 14

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 14	E	BARCODE SCANNING AND LOADING OPERATION (İSTABUL ANATOLIAN SIDE)	BACK	1. Straight	Level 1
				2. Bent	Level 2
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 2
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the third barcode scanning and loading operation (İstanbul Anatolian side), it is observed from Table 8.15 that worker 14 is bending while performing the job. In this context, personal protective equipment (upright posture corset, wearable equipment, etc.) can be used to prevent back posture disorders. Also, arm positions of the worker, which both are above shoulder level, poses risk for the arms. By using a ladder to reach higher parts of the truck, this problem can be eliminated, and risk factors can be reduced. In addition to that, this workstation is one of the busiest workstations among loading operations. Due to the nature of the work, it is necessary to take breaks and rest at regular intervals in order to prevent tissue and muscle damage caused by movements that require constant repetition.

Table 8.16 OWAS Observed Level of Risks for Worker 15

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 15	E	BARCODE SCANNING AND LOADING OPERATION (İSTABUL EUROPEAN SIDE)	BACK	1. Straight	Level 1
				2. Bent	Level 2
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 2
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the fourth barcode scanning and loading operation (İstanbul European side), it is observed from Table 8.16 that worker 15 is bending, standing a long time, and stretching to reach higher areas while performing work. Since similar ergonomic risks were seen in the previous operation, the same recommendations can be used in this workstation. In addition to what is written above, the selection of shoes depending on work conditions and characteristics is also important for workers who stand for a long time. Choosing comfortable and non-slip (compatible with the floor) shoes can play an effective role in reducing ergonomic risk factors.

Table 8.17 OWAS Observed Level of Risks for Worker 16

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 16	E	BARCODE SCANNING AND LOADING OPERATION (BURSA)	BACK	1. Straight	Level 1
				2. Bent	Level 2
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 2
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 1
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

In the fifth barcode scanning and loading operation (Bursa), it is observed from Table 8.17 that worker 16 is experiencing bent and standing on two straight legs in most of the work and this position poses risk for the back and legs. The forward bending movement, which is required to place the cargo on the ground of the truck, should be by bending both legs and keeping the waist straight. Otherwise, if the forward bending movement is done by keeping the legs straight and forcing the waist, it can cause serious damage and injuries to the waist. Therefore, workers are required to receive relevant training at certain times, and it needs to be constantly monitored by ergonomics specialists. If the worker continues to make the wrong positions, training, observation, and warnings about the wrong postures should continue until it gets better.

Table 8.18 OWAS Observed Level of Risks for Worker 17

NAME OF THE WORKER	SUB-PROCESS CODE	OPERATION NAME	ASSESSED BODY REGIONS		RESULTS
WORKER 17	E	BARCODE SCANNING AND LOADING OPERATION (İZMIR/RETAIN)	BACK	1. Straight	Level 1
				2. Bent	Level 1
				3. Twisted	Level 1
				4. Bent and twisted	Level 1
			ARMS	1. Both arms below shoulder level	Level 1
				2. One arm at or above shoulder level	Level 1
				3. Both arms at or above shoulder level	Level 1
			LEGS	1. Sitting	Level 1
				2. Standing on two straight leg	Level 2
				3. Standing on one straight leg	Level 1
				4. Standing or squatting on two bent legs	Level 1
				5. Standing or squatting on one bent leg	Level 1
				6. Kneeling	Level 1
				7. Walking	Level 1

For the last barcode scanning and loading operation (İzmir), it is observed from Table 8.18 that worker 17 is standing on two straight legs in most of the work to like the other workers. Required remediation actions are presented for this posture above. Presented recommendations can facilitate workers to perform their work-related postures more easily.

8.2 PROACTIVE APPROACH

Under this headline of the study, possible risk factors, and potential problems, that may pose disorders or injuries in the future, are proposed by the observer, and solutions to these problems are presented. Firstly, a temperature problem was observed along with the worker's guidance as an environmental risk factor. Workers indicated that the temperature was extremely hot in the summer and extremely cold in the winter. Especially for the worker who is working on the second floor are working way harder circumstances that are compared to the first floor. For this purpose, it is recommended to place a heater in the second-floor workstations in order to protect the workers from the cold. Another potential risk that can poses injuries to workers is the second floor's surface. Due to there is no protective substance on the floor, the floor transmits cold and this problem affects the health and work performance. Therefore, a floor covering that will both provide isolation on the floor and prevent workers from slipping on the moist floor should be provided for the workstations on the second floor.

Apart from this, pallet jacks are generally used for moving heavy cargo from one place to another. Usage of manual pallet jack (non-automatic) is risking the safety and comfort of the worker and hinder workflow by slowing down. Thus, it is recommended to replace manual pallet trucks with automatic ones in order to provide a solution to this problem.

Lastly, during the Covid-19 outbreak, while companies are trying to implement mask, distance, and hygiene rules, some protective equipment is produced that warns the workers in case of social distance violation. For example, a factory in Bursa has started to use this special helmet that has an alarm tag and sends an alarm to workers' supervisors if workers are closer to each other for more than 2 minutes and less than 1.5 meters (Anadolu Ajansı, 2020).

CHAPTER 9
DISCUSSION AND CONCLUSION

Even though the ergonomics term has been generated to use in simpler interaction amidst human and environment in its early stages, the usage area of ergonomics has expanded much more with the mechanization of businesses in order to adapt to the developing technology and increasing production. In this intense mechanization process, ergonomics has faced with wider systems that consist of various risk factors. However, the human factor has been forgotten while businesses focused on these recent advancements to adjust to this ever-changing world and conditions. In this rapid mechanization process, the increase in production activities also caused a dynamism in distribution activities. Especially, with the effect of the COVID-19 outbreak, all dynamics have shifted once again, and the whole production, distribution, consumption activities have come up with new challenges. Production and consumption habits have changed due to reasons such as countries closing their borders, stopping production and distribution activities and people closing homes due to quarantine. Hence, during this period of people staying at home, online shopping rates increased, and hence there was a huge increase in distribution activities. As production speed and distribution activities gain momentum, it has been observed that the environment where the workers are located, human physiology, and many ergonomic risk factors are neglected by the managers. The logistics sector is one of these neglected areas in terms of ergonomics. In this context, the main purpose of this thesis is the detailed examination of the operations of Company A in order to detect possible risk factors that can cause WMSDs. In other words, the main aim is detecting the root causes underneath of the WMSDs, and injuries for minimizing and eliminating the risk factors in the working environment by using hybrid ergonomic risk assessment methods. However, before the risk factors are identified, related WMSDs are explained one by one in order to understand the concept more clearly. In the next section of the thesis, ergonomic risk factors are investigated under two main groups as work-related risk factors and personal risk factors, and each risk factor has been studied in detail.

Following in the literature review section, the methodologies applied in the current literature studies and ergonomic risk assessment techniques are presented in the table. Each of the studies has been examined and summarized to understand why that methodology has been used in this study. This literature review has been facilitated the observer’s decision to select the right and proper methodology for this study. In the other section of the thesis, the problems found as a result of the company's general observation are stated and explained. Moreover, the purpose of the study, research questions, hypotheses, limitations, and assumptions of the study are presented. In addition, in this section, the five stages of the proposed methodology are presented after the general assessment of the company. Depending on that, the first stage is general system assessment which involves the detailed examination of the company such as characteristics, main and sub-operations, workflows, workstations, layout, departments, working hours, shift numbers, and so on. This information has facilitated the observer’s job and give insights about the company. The next stage is a preliminary ergonomic assessment which identified the risks within the company via using checklists. Thus, the Ergonomic Assessment Checklist of OSHA has been used to determine the work-related activities of the workers and related risk factors. Furthermore, NIOSH workstation and material handling checklists have been conducted for the detection of the likelihood of hazardous occurrences because of equipment and tool handling and workstation-related reasons. Hybrid ergonomic risk assessment is the third stage of the proposed methodology. In this hybrid assessment, the NORDIC questionnaire has been applied to the workers and collected data from workers. Moreover, the OWAS method had been conducted by observing workers who are working on various operations. OWAS method has provided the risk levels of the workers while they are performing their work-related postures and movements. In order to assess and detect the environmental risk factors, exposure values have been obtained from the company. According to exposure values, the limit values and measurement values of the lightning, noise, temperature, and chemical agents that present in the working environment presented as a table. Another method that has been used in this hybrid ergonomic assessment is the self-assessment questionnaire (Self-Reports). The Nordic Musculoskeletal Questionnaire (NMQ) has been applied to workers from each observed operation to understand the problem underneath. After the hybrid ergonomic assessment, OWAS results and risk levels are presented in order to focus on the ones which require remediation actions. For this purpose, context, priority has been given to the operation that has high-risk levels (2, 3, and 4). These risk levels require immediate actions in the near future. A reactive approach has been used in order to provide required ergonomic interventions (managerial, engineering, and behavioral) for these operations. Apart from this, ergonomic interventions with a proactive perspective are also presented because there are risks observed in the work environment and not seen as risk factors in the assessments. However, these risk factors may occur in the long term, so focusing on these risk factors before they emerge can provide a great advantage to the company. Companies generally preferred to take reactive actions instead of proactive actions to save the day. In this sense, the short-term reactive approach is preferred by the companies.

9.1. Contributions

This hybrid ergonomic risk assessment study has been aiming to provide many contributions to the literature by proposing ergonomic interventions to the related ergonomic risk factors present in the working environment. For this purpose, both reactive and proactive approaches have been provided to the literature. In this context, automatized or motorized version of the pallet jacks must be provided or switched with the old, portable pallet jacks. In addition to that, an automation system or extra conveyor belt is needed for some of the workstations such as the large/shapeless DWS operation. So that, the transition into automated processes and using mechanical lifting aids are a requirement for many operations of Company A. Besides, increasing some of the workstation's height level are also necessary (e.g., foreign cargo packages operation). Therefore, some readjustments of the workstations and tools and ergonomic designs must be provided. Especially for the foreign cargo packages operation, forward-reaching distance is at a risky degree. Thus, modification of this workstation layout is a requirement in order to solve the problem. By conducting those ergonomic interventions, reducing heavy lifting, overexertion, repetitive movements can be prevented from many angles.

For the administrative control approach, job rotation is provided as an answer. So, rotating workers in order to decrease exposure to repetitive movement are recommended as an implication for this study. If it is not an option, workers need to try some neutral positions and warm-up stretching in order to reduce the stress of the tissues caused by performing the same tasks for a long time. In addition to that, wrong working postures and movements in order to fix it with the neutral body positions with comfortable posture. Therefore, by studying these wrong postures, these wrong postures can be corrected in order to complete tasks without stressful angles. So, required training for proper lifting postures should be provided to the worker. Lastly, the working assignments, breaks, break times, working hours, etc. of the workers needs to be arranged depending on physical features such as height, weight, lifting capacity, injuries or disorders, and so on.

Personnel protective equipment needs to be provided as a last step of the ergonomic interventions after engineering and administrative controls. Using personnel equipment while performing a job such as upright posture corset, wearable equipment, etc. is recommended to prevent back posture disorder. Also, shoe selection requires attention for the operations performed in Company A because these workers are working on standing on two legs for hours to get the job done. Therefore, comfortable and non-slip shoes must be provided for each of the workers to increase the performance and prevent risk factors. Lastly, using a higher ladder can be much more useful for loading operations. So that, wrong postures while trying to reach higher parts of the truck or higher compartments can be eliminated.

As a conclusion for this study, it is observed that personal risk factors have an impact on both physical and psychosocial risk scores depending on the questionnaire applied to the workers via the Nordic questionnaire. Also, by looking at the NIOSH workstation checklist we can deduct that environmental risk factors have an impact on both physical and psychosocial risk scores. Workstation conditions are affecting the worker's performance and degree of WMSDs. Therefore, the severity of body parts from physical and psychosocial perspectives are examined in detail to provide ergonomic interventions. However, the managers and policymakers need to be mindful about allocating time and budget to ergonomic issues because significant lacks and policy challenges are resulting from governmental sides such as lack of legal systems on ergonomics, effective execution, lack of required ergonomic standards and governmental support, etc.

Also, a manager’s attitude on ergonomic issues is crucial because poor leadership & management can result in some neglections on ergonomic risk factors which can cause many serious work-related accidents and diseases even deaths.

9.2. Future Research Directions

- In this thesis, sharing the changes after the application part of the proposed ergonomic interventions can be a future research direction.
- This study also can be expanded by adding different methods such as infirmary records and lost working day data assessment and biomechanical assessment to use more methods for validation.
- This study can also be applied to drivers of cargo vehicles and trucks.

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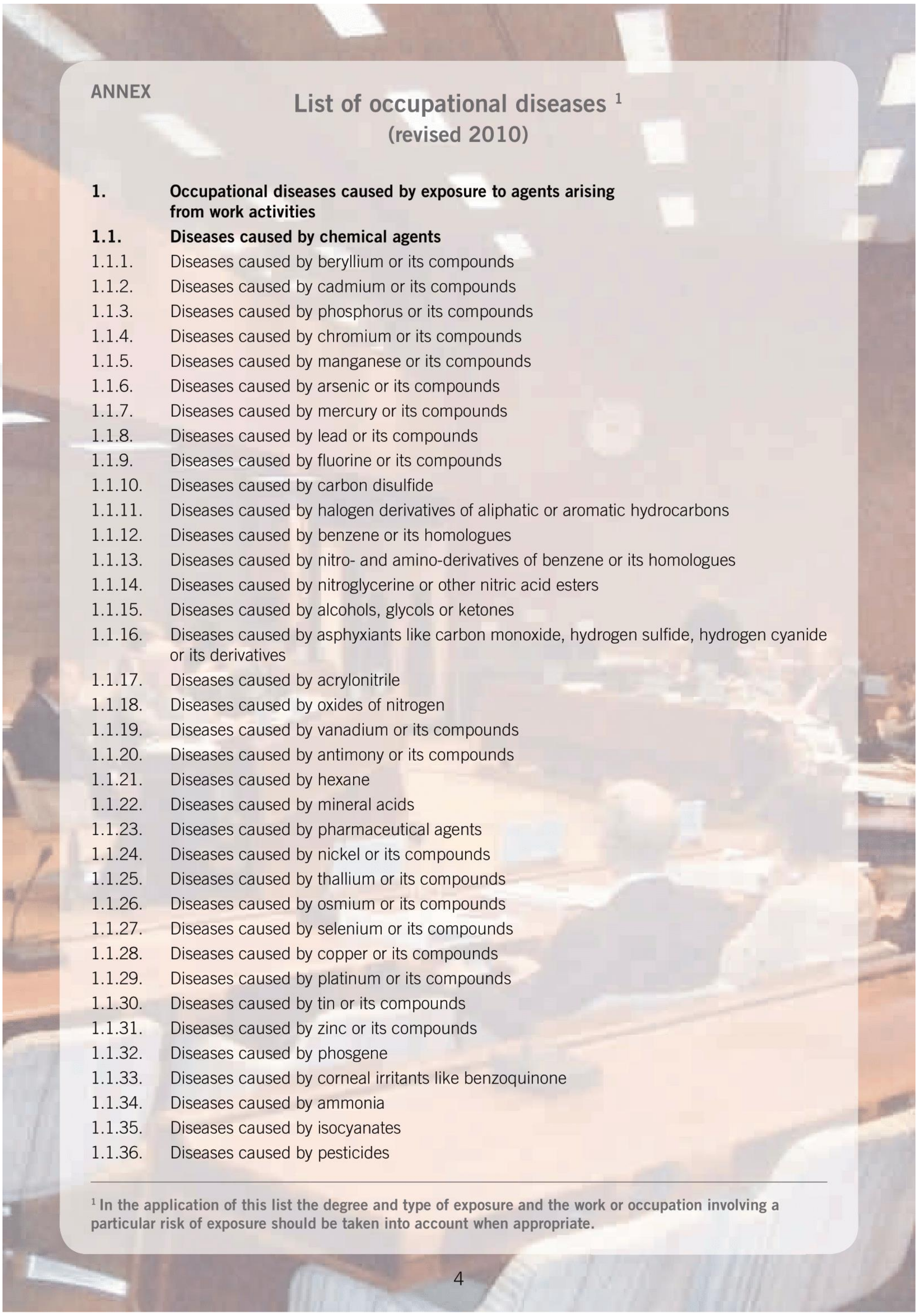
APPENDIX 1 – ILO’S List of Occupational Diseases



ANNEX

List of occupational diseases [1]
(revised 2010)

1. Occupational diseases caused by exposure to agents arising from work activities

1.1. Diseases caused by chemical agents

1.1.1. Diseases caused by beryllium or its compounds
1.1.2. Diseases caused by cadmium or its compounds
1.1.3. Diseases caused by phosphorus or its compounds
1.1.4. Diseases caused by chromium or its compounds
1.1.5. Diseases caused by manganese or its compounds
1.1.6. Diseases caused by arsenic or its compounds
1.1.7. Diseases caused by mercury or its compounds
1.1.8. Diseases caused by lead or its compounds
1.1.9. Diseases caused by fluorine or its compounds
1.1.10. Diseases caused by carbon disulfide
1.1.11. Diseases caused by halogen derivatives of aliphatic or aromatic hydrocarbons
1.1.12. Diseases caused by benzene or its homologues
1.1.13. Diseases caused by nitro- and amino-derivatives of benzene or its homologues
1.1.14. Diseases caused by nitroglycerine or other nitric acid esters
1.1.15. Diseases caused by alcohols, glycols or ketones
1.1.16. Diseases caused by asphyxiants like carbon monoxide, hydrogen sulfide, hydrogen cyanide or its derivatives
1.1.17. Diseases caused by acrylonitrile
1.1.18. Diseases caused by oxides of nitrogen
1.1.19. Diseases caused by vanadium or its compounds
1.1.20. Diseases caused by antimony or its compounds
1.1.21. Diseases caused by hexane
1.1.22. Diseases caused by mineral acids
1.1.23. Diseases caused by pharmaceutical agents
1.1.24. Diseases caused by nickel or its compounds
1.1.25. Diseases caused by thallium or its compounds
1.1.26. Diseases caused by osmium or its compounds
1.1.27. Diseases caused by selenium or its compounds
1.1.28. Diseases caused by copper or its compounds
1.1.29. Diseases caused by platinum or its compounds
1.1.30. Diseases caused by tin or its compounds
1.1.31. Diseases caused by zinc or its compounds
1.1.32. Diseases caused by phosgene
1.1.33. Diseases caused by corneal irritants like benzoquinone
1.1.34. Diseases caused by ammonia
1.1.35. Diseases caused by isocyanates
1.1.36. Diseases caused by pesticides

[1] In the application of this list the degree and type of exposure and the work or occupation involving a particular risk of exposure should be taken into account when appropriate.

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APPENDIX 1 – ILO'S List of Occupational Diseases (Continue)

1.1.37.	Diseases caused by sulphur oxides
1.1.38.	Diseases caused by organic solvents
1.1.39.	Diseases caused by latex or latex-containing products
1.1.40.	Diseases caused by chlorine
1.1.41.	Diseases caused by other chemical agents at work not mentioned in the preceding items where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to these chemical agents arising from work activities and the disease(s) contracted by the worker
1.2.	**Diseases caused by physical agents**
1.2.1.	Hearing impairment caused by noise
1.2.2.	Diseases caused by vibration (disorders of muscles, tendons, bones, joints, peripheral blood vessels or peripheral nerves)
1.2.3.	Diseases caused by compressed or decompressed air
1.2.4.	Diseases caused by ionizing radiations
1.2.5.	Diseases caused by optical (ultraviolet, visible light, infrared) radiations including laser
1.2.6.	Diseases caused by exposure to extreme temperatures
1.2.7.	Diseases caused by other physical agents at work not mentioned in the preceding items where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to these physical agents arising from work activities and the disease(s) contracted by the worker
1.3.	**Biological agents and infectious or parasitic diseases**
1.3.1.	Brucellosis
1.3.2.	Hepatitis viruses
1.3.3.	Human immunodeficiency virus (HIV)
1.3.4.	Tetanus
1.3.5.	Tuberculosis
1.3.6.	Toxic or inflammatory syndromes associated with bacterial or fungal contaminants
1.3.7.	Anthrax
1.3.8.	Leptospirosis
1.3.9.	Diseases caused by other biological agents at work not mentioned in the preceding items where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to these biological agents arising from work activities and the disease(s) contracted by the worker
2.	**Occupational diseases by target organ systems**
2.1.	**Respiratory diseases**
2.1.1.	Pneumoconioses caused by fibrogenic mineral dust (silicosis, anthraco-silicosis, asbestosis)
2.1.2.	Silicotuberculosis
2.1.3.	Pneumoconioses caused by non-fibrogenic mineral dust
2.1.4.	Siderosis
2.1.5.	Bronchopulmonary diseases caused by hard-metal dust
2.1.6.	Bronchopulmonary diseases caused by dust of cotton (byssinosis), flax, hemp, sisal or sugar cane (bagassosis)

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APPENDIX 1 – ILO'S List of Occupational Diseases (Continue)

2.1.7. Asthma caused by recognized sensitizing agents or irritants inherent to the work process

2.1.8. Extrinsic allergic alveolitis caused by the inhalation of organic dusts or microbially contaminated aerosols, arising from work activities

2.1.9. Chronic obstructive pulmonary diseases caused by inhalation of coal dust, dust from stone quarries, wood dust, dust from cereals and agricultural work, dust in animal stables, dust from textiles, and paper dust, arising from work activities

2.1.10. Diseases of the lung caused by aluminium

2.1.11. Upper airways disorders caused by recognized sensitizing agents or irritants inherent to the work process

2.1.12. Other respiratory diseases not mentioned in the preceding items where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to risk factors arising from work activities and the disease(s) contracted by the worker

2.2. Skin diseases

2.2.1. Allergic contact dermatoses and contact urticaria caused by other recognized allergy-provoking agents arising from work activities not included in other items

2.2.2. Irritant contact dermatoses caused by other recognized irritant agents arising from work activities not included in other items

2.2.3. Vitiligo caused by other recognized agents arising from work activities not included in other items

2.2.4. Other skin diseases caused by physical, chemical or biological agents at work not included under other items where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to risk factors arising from work activities and the skin disease(s) contracted by the worker

2.3. Musculoskeletal disorders

2.3.1. Radial styloid tenosynovitis due to repetitive movements, forceful exertions and extreme postures of the wrist

2.3.2. Chronic tenosynovitis of hand and wrist due to repetitive movements, forceful exertions and extreme postures of the wrist

2.3.3. Olecranon bursitis due to prolonged pressure of the elbow region

2.3.4. Prepatellar bursitis due to prolonged stay in kneeling position

2.3.5. Epicondylitis due to repetitive forceful work

2.3.6. Meniscus lesions following extended periods of work in a kneeling or squatting position

2.3.7. Carpal tunnel syndrome due to extended periods of repetitive forceful work, work involving vibration, extreme postures of the wrist, or a combination of the three

2.3.8. Other musculoskeletal disorders not mentioned in the preceding items where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to risk factors arising from work activities and the musculoskeletal disorder(s) contracted by the worker

2.4. Mental and behavioural disorders

2.4.1. Post-traumatic stress disorder

2.4.2. Other mental or behavioural disorders not mentioned in the preceding item where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to risk factors arising from work activities and the mental and behavioural disorder(s) contracted by the worker

APPENDIX 1 – ILO’S List of Occupational Diseases (Continue)

3. Occupational cancer

3.1. Cancer caused by the following agents

3.1.1. Asbestos

3.1.2. Benzidine and its salts

3.1.3. Bis-chloromethyl ether (BCME)

3.1.4. Chromium VI compounds

3.1.5. Coal tars, coal tar pitches or soots

3.1.6. Beta-naphthylamine

3.1.7. Vinyl chloride

3.1.8. Benzene

3.1.9. Toxic nitro- and amino-derivatives of benzene or its homologues

3.1.10. Ionizing radiations

3.1.11. Tar, pitch, bitumen, mineral oil, anthracene, or the compounds, products or residues of these substances

3.1.12. Coke oven emissions

3.1.13. Nickel compounds

3.1.14. Wood dust

3.1.15. Arsenic and its compounds

3.1.16. Beryllium and its compounds

3.1.17. Cadmium and its compounds

3.1.18. Erionite

3.1.19. Ethylene oxide

3.1.20. Hepatitis B virus (HBV) and hepatitis C virus (HCV)

3.1.21. Cancers caused by other agents at work not mentioned in the preceding items where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to these agents arising from work activities and the cancer(s) contracted by the worker

4. Other diseases

4.1. Miners’ nystagmus

4.2. Other specific diseases caused by occupations or processes not mentioned in this list where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure arising from work activities and the disease(s) contracted by the worker

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APPENDIX 2 – OSHA Ergonomic Assessment Checklist

Ergonomic Assessment Checklist	**Date**	**Activity Assessed**	
Risk Ratting (circle one) **High Medium Low** *See Notes on bottom of form to obtain the Rating*	**Organization**		**Point of Contact**
	Personnel Observed		
	BLDG NO/Location		**ROOM/AREA**

Ergonomic Assessment Checklist

Risk Factors	**Yes**	**No**
1. Have any shop workers been previously diagnosed with any of the following CTD's: Carpal tunnel, Tendonitis, Tenosynovitis, De Quervain's disease, Trigger Finger, White finger, Hand Arm Segmental Vibration Syndrome, Muscle strains, or Back ailments?		
2. Have there been any worker complaints concerning ergonomic issues?		
3. Do employees perform high repetition tasks? (100 reps/hour to 2000 per/day)		
4. Do the employee's routine tasks require repeated heavy lifting? (>20 lbs) or occasional heavy lifting (>50 lbs)		
5. Are employees using awkwardly designed tools, which cause the worker to operate the tool outside of a neutral position for an extended period of time? (> 1 hour)		
6. Do employees perform tasks with an awkward head or neck position for an extended period of time? (1 to 3 hours)		
7. Do employees perform tasks that require awkward back angles to be held for extended periods of time (2 to 3 hours)? i.e…hunching, bending, or squatting		
8. Do employees perform tasks with an awkward elbow angle for an extended period of time (1 to 3 hours) or with extreme force application?		
9. Do employees perform tasks with an awkward elbow abduction angle for an extended period of time (1 to 3 hours) or with extreme force application?		
10. Do employees perform tasks with an awkward wrist flexion angle for an extended period of time (1 to 3 hours) or with extreme force application?		
11. Do employees perform tasks with an awkward wrist extension angle for an extended period of time (1 to 3 hours) or with extreme force application?		
12. Do employees perform tasks with an awkward back/hip flexion angle for an extended period of time (1 to 3 hours) or with extreme force application?		
13. Do employees perform tasks with an extreme reaching distance for an extended period of time (1 to 3 hours) or with extreme force application?		
14. Do employees perform tasks with an odd work station height (either standing or sitting) for an extended period of time (1-3 hours) or with extreme force application?		
15. Are high impact tools used routinely? i.e., riveters, bucking bars, or impact wrenches		
16. Are high vibration producing tools used routinely? i.e., die grinders, sanders, weed eaters		
17. Do employees perform tasks at an extreme height (high or low) for an extended period of time (1 to 3 hours) or with extreme force application?		
18. Are there any other areas of concern either from your observations or employee complaints?		

*Note if there is a **Yes** checked in any block please use page two to give a brief explanation of what the activity is or what the worker complaint was.

High Risk: If you answered Yes to #1 (and the shop has done nothing to fix it), if Yes to #2 or 3 and two other Yes's in #'s 4 through 15, or if Yes to six or more in #'s 4 through 15.
Medium Risk: If you answered Yes to #1 (and the shop has made changes), if Yes to #2 or 3 and one other Yes in #'s 4 through 15, or if Yes to three to five in #'s 4 through 15.
Low Risk: If no Yes's in #'s 1, 2, or 3 and less than 3 Yes's in #'s 4 through 15.

APPENDIX 2 – OSHA Ergonomic Assessment Checklist (Continue)

Ergonomic Survey Evaluation	**Date**	**Activity Assessed**

Ergonomic Survey Checklist Evaluation Explanation

Question number & Activity Name	**Brief Explanation – use this section if you answered yes to any questions on page 1 (please list corresponding question number) and briefly outline any risks associated with an activity**	**Risk Factors**

Name of Assessor	**Name of Reviewer**

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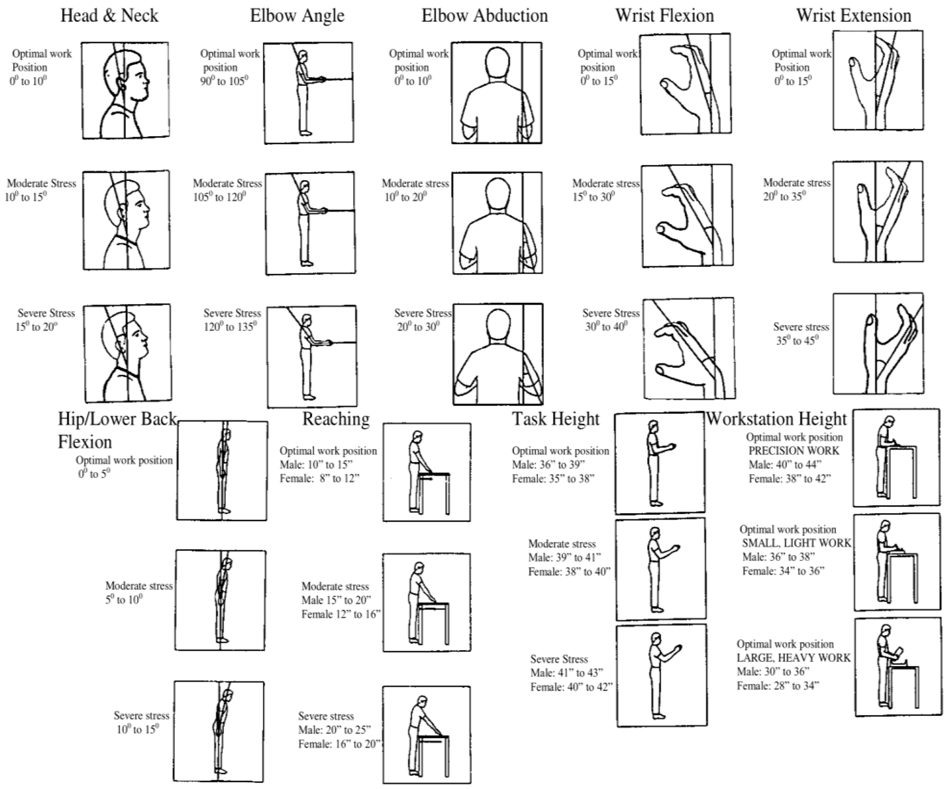
APPENDIX 2 – OSHA Ergonomic Assessment Checklist (Continue)

Risk Factor Guide



APPENDIX 3 – NIOSH Workstation Checklist

Workstation Checklist

Date ____/____/________ Company/Plant __________________________________

Dept __________________________ Job Name _______________________________________

Workstation Name/# _______________________________ Evaluator _____________________

"No" responses indicate potential problem areas that should receive further investigation.

1. Does the work space allow for full range of movement?	☐ Yes ☐ No
2. Are mechanical aids and equipment available?	☐ Yes ☐ No
3. Is the height of the work surface adjustable?	☐ Yes ☐ No
4. Can the work surface be tilted or angled?	☐ Yes ☐ No
5. Is the workstation designed to reduce or eliminate the following:	
- bending or twisting at the wrist?	☐ Yes ☐ No
- reaching above the shoulder?	☐ Yes ☐ No
- static muscle loading?	☐ Yes ☐ No
- full extension of the arms?	☐ Yes ☐ No
- raised elbows?	☐ Yes ☐ No
6. Are workers able to vary posture?	☐ Yes ☐ No
7. Are workers' hands and arms free from sharp edges on work surfaces?	☐ Yes ☐ No
8. Is an armrest provided where needed?	☐ Yes ☐ No ☐ N/A
9. Is a footrest provided where needed?	☐ Yes ☐ No ☐ N/A
10. Is the floor surface flat?	☐ Yes ☐ No
11. Is the floor surface free of obstacles?	☐ Yes ☐ No
12. Are cushioned floor mats provided for employees required to stand for long periods?	☐ Yes ☐ No ☐ N/A
13. Are chairs or stools easily adjustable?	☐ Yes ☐ No ☐ N/A
14. Are chair or stools appropriate for the worker performing the task?	☐ Yes ☐ No ☐ N/A
15. Are all task elements visible from comfortable work postures?	☐ Yes ☐ No

APPENDIX 4 – NIOSH Materials Handling Checklist

Materials Handling Checklist

Date ____/____/________ Company/Plant ____________________________________

Dept _____________________________ Job Name ____

Task Name ____________________________________ Evaluator _____________________________

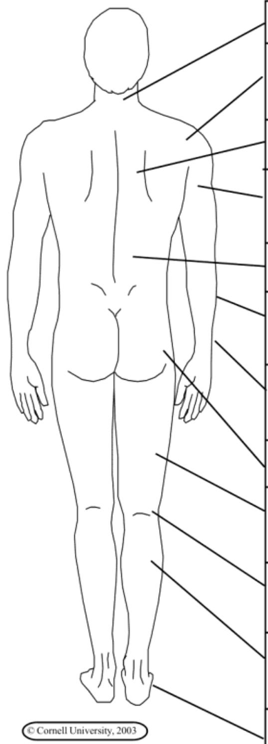
"No" responses indicate potential problem areas that should receive further investigation.

1. Do workers perceive/judge the weights of materials to be lifted acceptable?	☐ Yes	☐ No	
2. Are materials moved over minimum distances?	☐ Yes	☐ No	
3. Is the distance between the lifted item and the body minimized?	☐ Yes	☐ No	
4. Are walking surfaces…			
- … level?	☐ Yes	☐ No	
- … wide enough?	☐ Yes	☐ No	
- … clean and dry?	☐ Yes	☐ No	
5. Are items/materials…			
- easy to grasp?	☐ Yes	☐ No	
- stable?	☐ Yes	☐ No	
- held without slipping?	☐ Yes	☐ No	
6. Are there handholds on these items/materials?	☐ Yes	☐ No	
7. When worn, do gloves fit properly?	☐ Yes	☐ No	☐ N/A
8. If required, is the proper footwear worn?	☐ Yes	☐ No	☐ N/A
9. Is there enough room for the worker handling the materials to maneuver?	☐ Yes	☐ No	
10. Are mechanical aids used whenever possible?	☐ Yes	☐ No	☐ N/A
11. Are working surfaces adjustable to the best handling heights?	☐ Yes	☐ No	
12. When handling materials, do workers avoid the following:			
- movements below hip height?	☐ Yes	☐ No	
- movements above shoulder height?	☐ Yes	☐ No	
- static muscle loading?	☐ Yes	☐ No	
- sudden movements?	☐ Yes	☐ No	
- twisting at the waist?	☐ Yes	☐ No	
- extended reaching?	☐ Yes	☐ No	
13. Are mechanical aids available for heavy or awkward lifts?	☐ Yes	☐ No	☐ N/A
14. Are repetitive motions avoided by the following:			
- job rotation?	☐ Yes	☐ No	
- self-pacing?	☐ Yes	☐ No	
- sufficient pauses/breaks?	☐ Yes	☐ No	
15. Are pushing or pulling forces minimized?	☐ Yes	☐ No	
16. When handling materials, do workers have an unobstructed view?	☐ Yes	☐ No	☐ N/A
18. Are workers trained in correct handling and lifting procedures?	☐ Yes	☐ No	

APPENDIX 5 – CORNELL Musculoskeletal Discomfort Questionnaire

(English Version)

The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.		During the last work week how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
		Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Shoulder	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Back		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Arm	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Back		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forearm	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wrist	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hip/Buttocks		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Thigh	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Knee	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Leg	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Foot	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐



APPENDIX 6 – CORNELL Musculoskeletal Discomfort Questionnaire (Turkish Version)

KAS İSKELET SİSTEMİ RAHATSIZLIK FORMU

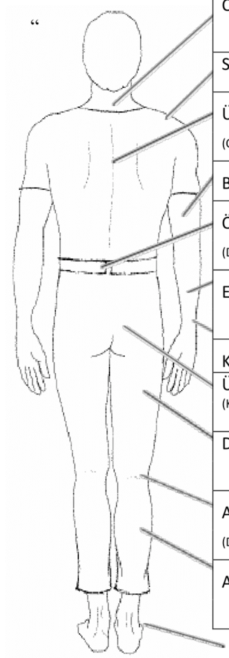
Tarih: …/…/…..

ADI SOYADI: …………………………………..

Ne kadar süredir bu işi yapıyorsunuz? ...... yıl …….ay

Yaşınız: ……….. Boyunuz: ………. cm Kilonuz: ……….. kg

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	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Kaynak: Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)