



THE ROLE OF OFFICE FURNITURE DESIGN IN OCCUPATIONAL HEALTH AND ERGONOMICALLY FEASIBLE OFFICE CHAIR SOLUTIONS

MELİS ÇOBANYILDIZI

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ABSTRACT

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Çobanyıldızı, Melis

Master's Program in Design Studies

Advisor: Prof. Dr. Murat Bengisu

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Office workers spend most of their day at office and they usually work in a sitting position. Sitting for a long time causes work-related musculoskeletal diseases. The work-related musculoskeletal diseases influence the lives of office workers. Ergonomic office furniture designs have been developed in order to make the quality

of life more comfortable in the office. However, despite these developments, many office workers still experience work-related musculoskeletal disorders. In this study, the reasons of this situation were investigated. Survey and interview techniques were used as research methods. Participants from Turkey and the United Arab Emirates were selected to get a broader perspective. Interviews were conducted with professional designers working in the furniture industry. Also, the study focuses on the office chair because people working in offices are mostly interacting with their office chair during the day. According to the survey and interview results, the effect of the demographic characteristics of the user on the health status was observed. In addition, the importance of adjustable pieces on office chairs was emphasized by the participants and professionals. Survey results indicate that office workers who have adjustable lumbar support in their office chairs, adjustable seat height, and suitable seating elements for their body size have better neck health than those who do not. Based on the results of all these data, a design proposal is presented to make the user feel more comfortable. It is aimed to develop a solution for minimizing work-related musculoskeletal disorders with the design proposal.

Keywords: Office Furniture Design, Office Chair, Work-related Musculoskeletal Disorders, Ergonomic Design, Office Workers

ÖZET

İŞ SAĞLIĞINDA OFİS MOBİLYA TASARIMININ ROLÜ VE ERGONOMİK OLARAK UYGULANABİLİR OFİS KOLTUĞU ÇÖZÜMLERİ

Çobanyıldızı, Melis

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Ofis çalışanları günün büyük bir kısmını ofiste geçirirler ve genellikle oturur pozisyonda çalışırlar. Uzun süre oturmak işe bağlı kas-iskelet sistemi hastalıklarına neden olur. İşe bağlı kas-iskelet sistemi hastalıkları, ofis çalışanlarının yaşamlarını birçok yönden etkiler ve bu durum onların yaşam kalitelerinde çeşitli sorunlara neden olabilir. Ofisteki yaşam kalitesini daha konforlu hale getirmek için ergonomik ofis mobilya tasarımları geliştirilmiştir; ancak bu gelişmelere rağmen pek çok ofis çalışanı

halen işe bağlı kas-iskelet hastalıkları yaşamaktadır. Bu çalışmada, bu durumun nedenleri araştırılmıştır. Araştırma yöntemi olarak anket ve mülakat tekniklerine başvurulmuştur. Uluslararası bir sonuca varmak için Türkiye ve Birleşik Arap Emirlikleri'nden katılımcılar seçilmiştir. Mülakatlar, mobilya sektöründe çalışan profesyonel tasarımcılar ile gerçekleştirilmiştir. Ofiste en çok ofis koltuğu ile etkileşim içerisinde bulunulduğundan, bu çalışmada ofis koltuğu üzerine odaklanılmıştır. Anket ve görüşme sonuçlarına göre, kullanıcının demografik özelliklerinin sağlık durumuna etkisi gözlemlenmiştir. Ayrıca ofis koltuklarında eklenebilir parçaların önemi katılımcılar ve profesyoneller tarafından vurgulanmıştır. Anket sonuçları, ofis koltuklarında ayarlanabilir bel desteği, koltuk yüksekliği ayarlanabilen ve vücut ölçülerine uygun oturma elemanları olan ofis çalışanlarının, boyun sağlıklarının daha iyi olduğunu göstermektedir. Bütün bu verilerin sonucuna dayanarak, kullanıcıyı daha rahat hissettirecek bir tasarım önerisi sunulmuştur. Bu tasarım önerisiyle, işe bağlı kas-iskelet sistemi rahatsızlıklarının en aza indirilmesine yönelik bir çözümün geliştirilmesi amaçlanmıştır.

Anahtar Kelimeler: Ofis Mobilyaları Tasarımı, Ofis Koltuğu, İşle İlgili Kas-İskelet Sistemi Hastalıkları, Ergonomik Tasarım, Ofis Çalışanları

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TABLE OF CONTENTS

ABSTRACT.....	iii
ÖZET.....	v
ACKNOWLEDGEMENTS.....	vii
TABLE OF CONTENTS.....	viii
LIST OF TABLES.....	xi
LIST OF FIGURES.....	xii
CHAPTER 1: INTRODUCTION.....	1
1.1 Problem Definition.....	1
1.2 The Purpose of Study.....	2
1.3. Research of Questions.....	2
1.4. Methodology	2
1.5. Structure of Thesis.....	3
CHAPTER 2: LITERATURE REVIEW.....	4
2.1. Ergonomics and Musculoskeletal Disorders	4
2.1.1. Development of Ergonomics.....	5
2.1.2. Critical Success Factors for Ergonomics.....	7
2.1.3. Ergonomics Contributions to Strategic Objectives.....	8
2.2. Biomechanics - Posture.....	9
2.3. Musculoskeletal Disorders Related with Occupational Issues.....	10
2.4. Occupational Behaviour in Offices.....	12
2.5. Sedentary Work Style.....	14
2.6. Ergonomics of Office Furniture.....	16
2.7. Software for the Measurement of Ergonomic Problems (Siemens Jack).....	17
2.8. Occupational Disorders Related with Office Furniture	19
2.9. Office Furniture.....	21
2.9.1. Office Table.....	21
2.9.2. Office Chair.....	21
2.10. User Oriented Office Furniture Design.....	22
2.11. Wearable Technologies About Ergonomic Office furniture.....	24

2.11.1. Wearable Lumbar Support Systems.....	24
2.11.2. Wearable Arm and Shoulder Support System.....	24
2.11.3. Wearable Knee Support System.....	25
2.11.4. Ergonomic Benefits of Wearable Technologies.....	25
2.12. Workstations.....	25
CHAPTER 3: METHODOLOGY.....	28
3.1. Research Methods.....	28
3.2. Hypothesis.....	29
3.3. Survey.....	29
3.3.1. Population and Sample Group.....	29
3.4. Interview.....	30
3.5. Data.....	30
3.5.1. Quantitative Data.....	30
3.5.2. Qualitative Data	31
3.6. Statistical Analysis of Data.....	32
3.6.1. Analysis of Data Regarding Quantitative Aspect.....	32
3.6.2. Analysis of Data Regarding Qualitative Aspect	33
CHAPTER 4: RESULTS & DISCUSSION, DESIGN PROPOSAL.....	34
4.1. Survey Findings.....	34
4.1.1. Distribution of Demographic and Work Life Characteristics of the Participants.....	34
4.1.2. Distribution of Participants' Opinions About Seating Elements in the Workplace.....	36
4.1.3. Distribution of Participants' Opinions on Body Posture in the Work Environment.....	37
4.1.4. Distribution of the Preferences of the Individuals in the Study of the Seating Elements in the Working Environment.....	38
4.1.5. Examination of Participants with respect to the Descriptive Features of Health.....	39
4.1.6. Examination of the Relationship between the Anthropometric and Sitting Time at Work and Health of Individuals.....	43

4.1.7. Examination of the Health of the Participants According to the Characteristics of the Seating Elements at the Workplace.....	43
4.2. Findings of Qualitative Data Analysis.....	50
4.2.1. Opinions of the Respondents Participating in the Study on the Most Important Elements in Office Chair Design.....	50
4.2.2. The Opinions of Respondents Participating in the Research on the Processes Followed in Designing an Office Chair.....	51
4.2.3. Evaluations of the Respondents Participating in the Study on How They Establish the User-Office Chair Relationship.....	53
4.2.4. Evaluations of the Respondents Participating in the Research Regarding the Suitability of the Office Chair for the User.....	54
4.2.5. The Views of the Respondents Participating in the Study on the Continuation of Work-Related Musculoskeletal System Diseases.....	55
4.2.6. The Evaluations of the Respondents Participating in the Study on the Suitability of the Office Chair to the User and its Ergonomic Design.....	56
4.3. Discussion.....	57
4.4. Design Proposal.....	60
CHAPTER 5: CONCLUSION.....	65
REFERENCES.....	67
APPENDICES.....	73
Appendix A – Survey Questions.....	73
Appendix B – Interview Questions.....	76
Appendix C – Ethics Committee Report.....	77

LIST OF TABLES

Table 1. Distribution of the Demographic Characteristics of Office Workers.....	29
Table 2. Descriptive Characteristics of the Individuals that were interviewed.....	30
Table 3. Distribution of Participants' Work Life Characteristics.....	34
Table 4. Distribution of Anthropometric Properties of the Participants.....	35
Table 5. Distribution of Participants' Evaluations on Health.....	35
Table 6. Distribution of the Qualifications of the Participants' Seats in the Workplace.....	36
Table 7. Distribution of the Preferences of the Individuals in the Research of the Seating Elements in the Working Environment.....	39
Table 8. Participants' Neck Health Status According to their Demographic and Working Life Characteristics.....	39
Table 9. Participants' Lumbar/Spine Health Status in Accordance with their Demographic and Working Life Characteristics.....	40
Table 10. Participants' Arm Health Status According to their Demographic and Working Life Characteristics.....	41
Table 11. Participants' General State of Health According to their Demographic and Working Life Characteristics.....	42
Table 12. Investigation of the Relationship between the Anthropometric and Working Time and Health of Individuals.....	43
Table 13. Participants' Neck Health Status According to the Characteristics of the Seating Elements in the Workplace.....	44
Table 14. Participants' Lumbar/Spine Health Status According to the Characteristics of the Seating Elements in the Workplace.....	45
Table 15. Participants' Arm Health Status According to the Characteristics of the Seating Elements in the Workplace.....	47
Table 16. Participants' General State of Health According to the Characteristics of the Seating Elements in the Workplace.....	49
Table 17. The Percentage and Frequency Distribution of the Codes of the Respondents' Opinions on the Most Important Elements in Office Chair Design.....	50

Table 18. The Opinions of the Respondents Regarding the Processes Followed in Designing an Office Chair.....	52
Table 19. The Percentage and Frequency of Participants' Approaches Used to Establish User-Office Chair Relationship.....	53
Table 20. The Percentage and Frequency of the Codes of the Respondents' Evaluations on the Office Chair for the User.....	54
Table 21. The Percentage and Frequency of the Codes of the Respondents' Evaluations on the Continuation of Work-Related Musculoskeletal Diseases.....	55
Table 22. Percentage and Frequency of the Codes of the Respondents' Evaluations Regarding the Ergonomic Suitability of the Office Chair to the User.....	56
Table 23. The Percentage and Frequency Distribution of The Codes of The Respondents' Evaluations on the Ergonomic Design Suitable For the User.....	57

LIST OF FIGURES

Figure 1. Some positions to test ergonomic standards for office furniture.....	18
Figure 2. Sensor(left) and Sensor Silhouette.....	61
Figure 3. The sensor placed on an office chair.....	61
Figure 4. User Scenario.....	62
Figure 5. Chair and Personal Data Information Pages.....	63
Figure 6. Awkward Posture and Analysis.....	64



CHAPTER 1: INTRODUCTION

1.1. Problem Definition

Each product is designed in accordance with ergonomic principles. Ergonomics is making work and workplace arrangements, also it is a branch of science whose main purpose is to realize work arrangements in accordance with human characteristics. Ergonomics is determined according to the anthropometric measurements of the person. Every people have different sizes and structures, and it depends on factors such as environmental factors, anatomical structure, psychological state. Therefore, ergonomics and anthropometry work together.

In recent years, time spent at the computer has increased rapidly and the use of office furniture has increased over the years. Therefore, the ergonomics and design of office furniture play a very important role. A well-designed office furniture increases anatomical performance and reduces body tension. In addition, the axis of the hip, knee and ankle and the body axis will move together, so muscle strain can be prevented with well-designed office furniture. For this reason, when choosing office furniture, ergonomic features should be preferred rather than colour, appearance and price.

Working hours of sitting in areas such as offices gradually increase and people who work in jobs that require passive sitting for such long hours have to sit in a certain position. Passive sitting causes the problem of occupational musculoskeletal diseases due to reasons such as insufficient work equipment and workplace arrangements, i.e. inadequate ergonomic conditions. Work-related musculoskeletal disorders are the most common diseases that office workers face. The biggest factor that causes this disease is the permanent sitting position. These disorders occur in areas such as hands, elbows, shoulders, neck, spine, waist and coccyx. Studies show that if insidious pains are not treated, they will limit hand, arm and body functions, prevent activities and can be lead to disabilities if no precautions are taken. If the pain continues for a long time, psychological problems such as depression can be encountered.

In this study, diseases of the musculoskeletal system are discussed from different

perspectives, and the positive and negative effects of office furniture's compliance with ergonomic conditions on people and businesses were examined. As a result of these examinations and research; office chair, table, computer keyboard and mouse have been examined in terms of ergonomics and design, and special designs have been made. However, they could not prevent the musculoskeletal disorders completely; they still continue as a risky disease group still. Therefore, in this study, the causes are investigated and a design proposal was developed.

1.2. The Purpose of Study

The main purpose of this thesis is to investigate the role of office furniture design in improving quality of life of office workers in office. In order to achieve this, a participatory design research was conducted with office workers and office furniture designers. The outcome is expected to be beneficial for the office workers health. Besides, this study focuses on work-related musculoskeletal disorders and the effect of office furniture, particularly the office chair, on these disorders.

1.3. Research Questions

The main research questions of this study are as follows:

- How can the office furniture design contribute to improving the quality of life of office workers in office?
- What are the reasons of not preventing musculoskeletal disorders related to work even though there are many ergonomically feasible solutions for office furniture?

1.4. Methodology

In this study, quantitative research methods were used to determine work- related musculoskeletal disorders of individuals working in the office environment caused by office furniture and qualitative research methods were used to gain information about the design processes of office chairs in office furniture. A descriptive survey model was used in the quantitative aspect of the study to obtain information about the health status of the individuals by taking into account the characteristics of office furniture, the anthropometric and sitting times of the office workers. In the qualitative part of the study, learning the opinions of the individuals involved in the design of office furniture

about the key points and the design processes in office chair design was aimed. For this purpose, qualitative research has been executed in a case study pattern. The participants of the study consist of individuals over the age of 18 and working in an office environment. Accordingly, 300 office workers working in Turkey and United Arab Emirates constituted the sample group of the study. A questionnaire was used to collect data from the quantitative part of the study. The questionnaire form was delivered to the participants through the online survey platform. For the qualitative aspect of the research, the working group consisted of 5 office furniture design experts. The data constituted by statements of the experts was obtained by applying in depth interview techniques.

1.5. Structure of Thesis

This thesis contains five chapters. The chapters explain the aim of the study, research questions, hypotheses as well as the method.

The first chapter defines work-related musculoskeletal disorders for office workers and the importance of ergonomics in office furniture design. Also, it presents the aims, scope of the thesis, research questions, and hypotheses of the thesis.

The second chapter dwells upon the literature of ergonomic office furniture and provides a background on the definitions and classifications of office furniture designs. It also gives an idea about the general features of ergonomics and office furniture and the studies on this subject are presented.

The third and fourth parts provide a theoretical framework for the study and describe a work with specific office workers and professional designers, especially on office furniture. It bases this on certain results and provides evidence for the design proposal to be made. The fourth chapter also introduces the design proposal. The aims of the proposal are also presented and discussed in this chapter.

The fifth chapter provides an overview of the study and revisits the research questions. The limitations and strengths of the study are discussed and recommendations for further studies are presented.

CHAPTER 2: LITERATURE REVIEW

2.1. Ergonomics and Musculoskeletal Disorders

People need to perform various physical tasks during their daily life. These tasks may be suitable with the human capabilities and attributes or they may require different characteristics that a person may not be capable of doing them. The term of “Ergonomics” is mainly about this important connection between task requirements and human capabilities. International Ergonomics Association (2016) defines ergonomics as: “Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people”. MacLeod (2006) stated that ergonomics can be described under four basic rules: fitting tasks to person, making things user-friendly, working smarter but not harder and knowing the rules for how to optimize your work. So, ergonomics is the science of fitting the work people do and the environment people work according to the human characteristics.

Ergonomics principles are one of the most important aspects in a work environment if working conditions are wanted to be optimized. Darcor (2015) explained that ergonomics had a direct effect on productivity, quality, and injury conditions. It was stated that ergonomic interventions improved the conditions and comfortability of work and workers tended to feel more suitable with the work they have done, efficiency and productivity increases eventually. This tells us about the importance of ergonomics on industry. It affects economic, efficiency and health issues. However, the main aim of ergonomics is the improvement of health and safety of humans during their work.

2.1.1. Development of Ergonomics

As a word ergonomics has been derived from the combination of two Greek words: ‘ergon’ and ‘nomos’. The prior word means work and the latter means natural laws so ergonomics is working with natural laws (Dzissah, 2001). European Productivity Agency is one of the leading organizations in its field. After the foundation, one of the first action was conducting a study with the participation from different countries in an international platform to conceive an operational definition of ergonomics. Experts have been formed a new description of ergonomics in order to make it easier to comprehend as “fitting the job to the worker”. This definition is widely accepted from many authorities from academicians, unions to labors and company owners (Realyvásquez et al., 2014). Another term for ergonomics is *human factors* and both terms are used within the scope of the thesis.

In the early years, ergonomics was mostly performed at a micro level generally for the individuals, teams or subsystem levels. Based on analyses on detailed worker task observations, improper movements of tasks were eliminated by redesigning or arranging workplace according to human capabilities (Hendrick, 1987). Ergonomists were also designing the process due to the human performance capabilities and limitations for matching proper human-task or machine-task processes. Within the technological improvements and increased human-machine interaction ergonomists used their professional knowledge for specific job design, right match of job-worker and then a well-judged person and machine interface (Hendrick, 1987). Although micro level applications still maintaining their importance ergonomics has reached a more comprehensive perspective by successfully harmonizing work system both at macro and micro levels (Realyvásquez et al., 2014).

Ergonomics is the science that takes forward both human well-being and human performance via an optimum balance between human integration to system and system adaptation to human (Dul and Neumann, 2010). Ergonomics seeks to find the conditions for adapting the work to the human by investigating the unique qualities and abilities of human beings. Research studies have been carried out on human characteristics and abilities, and the movements of people during work tasks. Behavioral tendencies were examined in the finest detail, with the objective of

increasing production capabilities of workers without risking their health.

Ergonomics –related precautions should be applied to an organization step-by-step. First, environmental design needs to be fit to human, then the right person selection who fits the environment or educating that person to fit system is only considered when the former is not possible. When the correct matching is achieved, employees are able to contribute more to organizational performance (Dul et al., 2012).

Organization as a human factor engineering (HFE) element refers to organizational design such as tasks or activities, consideration of employee skills, employee needs, and human limits. Additional considerations, the usage of appropriate technology and the interaction with the other two elements to increase human productivity; to keep up with the pace of the machine, more production, more profit. With the introduction of automation in almost every department in current organizational systems, organizational designs and related managerial approaches to decision-making and control become more constrained in comparison to traditional non-automatized systems. Because of this progressively increasing automation, macroeconomic considerations such as management model have gained more importance, even prior to person-machine micro level design modules (Hendrick, 1987). Any system that includes human and environment interaction is a potential topic of ergonomics. Environment and system have referred to multiple implications. According to Dull et al. (2012) “The environment is complex and consists of the physical environment (things), the organizational environment (how activities are organized and controlled), and the social environment (other people, culture). The system can be a work system (where the human is a worker and the environment is the work environment) or a product system (where the human is a product user, the environment is the environment where the product is used). The focus of human factors engineering is to jointly improve performance and well-being by designing the integrative whole better, and by integrating the human into the system better. This is done by fitting the environment to the human.”

The system designed by human factor engineers can interpret more efficient systems, fewer quality deficiencies, healthy and satisfied employees. However, the potential of HFE remains under-exploited (Dul et al., 2012). Managerial authorities within the

organizations generally associate ergonomics with only health-related topics, most managers are not aware of the ergonomics contributions to organizational performance. This wrong perception caused by an insufficient number of human factors focused articles in the management magazines. Furthermore, in many countries ergonomics is perceived as a legal obligation which is forced by governments and authorities to ensure a safe and healthy workplace (Dul and Neumann, 2010). In fact, ergonomics not only focuses on human well being but also the level of output achieved through the system in which people work.

2.1.2. Critical Success Factors for Ergonomics

There have been different studies which aim to find the important factors for successful ergonomics implementation. Hendrick (2003) compiled the factors that result in cost advantage via human factors engineering interventions. Real management commitment, true professional ergonomics leadership and expertise, participatory ergonomics, and ergonomic improvements reduce work-related musculoskeletal disorders are important issues that enhance the productivity.

Carayon et al. (2006) studied ergonomic work systems that affect working life quality, performance outputs and health and safety. Work system model includes the person in the middle of the system structure, organization, tasks, environment and technology, and tools in the field of health care. Factors have five categories and these are education, skills and knowledge, motivation and needs, physical characteristics, psychological characteristics, teamwork for the first element. Organizational elements include coordination, collaboration and communication, organizational culture and safety culture, work schedules, social relationships supervisory and management style, performance evaluation, rewards, and incentives. Technology and tools include factors such as ergonomics characteristic, technological devices, and tools. Factors under the task element are task variety, demanded job, job content and skill utilization for a task and control of task and participation. The environment includes factors such as workstation and layout design, lighting, humidity, noise, and temperature. Even though an employee is highly talented and well educated that does not guarantee the output quality of work. Carayon highlighted these factors as supplementary for a work structure (Carayon, 2006).

Karim (2018) aimed to decide performance indicators with the macro ergonomics approach that has a principle of balancing between social and technical sides in a running system. The main attributes determined from this study were organization, human resources, tasks and activities, technology, physical environment, information systems.

Erensal and Albayrak (2004) examined the factors for an excellent macro ergonomics adaptation and to determine the most advantageous management style. Physical conditions, organizational conditions, leadership, participation, culture, employee, and employee attitudes are indicated as critical factors for macro ergonomics adoption.

Fitzgerald et al. (2010) emphasized that a safe and healthy environment can be obtained via ergonomic applications. They indicated ten key factors as follows; training and competence, staffing, organizational change, safety critical communications, ergonomic design, fatigue and shift work, organizational culture, managing human failures and maintenance, inspection and testing, human failures management and procedures.

Vargas et al. (2017), specified macro ergonomics factors for manufacturing systems as follows; education knowledge and skills, physical characteristics, psychological characteristics, motivation and needs, teamwork, coordination, collaboration and communication, organizational culture and safety culture, work schedules, social relationships, supervision and management styles, performance evaluation, rewards, and incentives task variety, job content, challenges, and use of skills, autonomy, job control, and participation, work demands, information technology, advanced manufacturing technology, human resources characteristics in technology and tool usage.

2.1.3. Ergonomics Contributions to Strategic Objectives

Dul and Neumann (2010) claimed that human factors can be more adopted by managers when ergonomics has a straight effect on strategy. If managers are not aware of the ergonomic improvements that contribute directly to strategy, health and safety improvement actions takes longer time to apply. When ergonomics is implemented to

the organizational strategy there would be definitely development in ergonomics application since it is a part of strategy especially managers will prioritize and that will lead to better system performance.

Ergonomics is not a strategy by itself, it is a contributor and a significant feature while setting up the strategy and execution (Dul and Neumann, 2010). Two ergonomics factors; organizational culture and communication have straight positive impact on customers and indirectly impact on the manufacturing operations and the development of the organization itself. Those analyses might bring new know-how and target oriented information to the company in order to increase companies' competitiveness (Realyvásquez et al., 2014). Communicating the care about ergonomics might be appreciated especially by customers.

Ergonomics contributes not only to company targets but also the employees in terms of their safety, health, gladness, and performance. That leads the organization to find better solutions against faced troubles and decrease the number of discontinuity of employees in order to raise customer satisfaction and devotion by increasing efficiency and rivalry of the system (Vargas et al., 2017). This provides a company to attract and maintain talented employees.

Although longer time periods are needed, engagement of communities and people in the organization is recommended by ergonomics. Nevertheless, the integration of ergonomics to company strategies and targets is an encouraging method to have a stable expansion for companies with low social costs coming from the work-related sickness (Dul and Neumann, 2010). In the long run that significantly contributes to the rate of profit.

2.2. Biomechanics - Posture

Biomechanics refers to the study of how skeletal and muscular systems work under different conditions. The human movement system consists of planes and axes. The human body can be analyzed in three different planes and axes. First of all, the Sagittal plane divides the body into two equal parts, right and left. Secondly, frontal plane divides the body into two equal parts, front and back. Finally, the horizontal

(transversal) plane divides the body into two equal parts, the upper and lower. The human body's natural shape is defined as "S" shape. The "S" shape of the spine of a person standing erect gives the entire structure. Humans should protect the S shape because its loss causes back pain, loosening of posterior spinal ligaments, and deformation in the spine. Posture is the position in which we hold our body while standing or sitting. Good posture is the correct alignment of body parts supported by the right amount of muscle tension against gravity. Posture is often imposed by the task or workplace. Prolonged posture can cause muscle and joint pains. Stress occurs due to prolonged sitting and standing. Humans cannot stay in the same posture for a long time, but they should protect the basic posture. In daily life, people have different types of postures while working, sitting, standing, lifting, pushing, or pulling. In offices, people mostly use standing and sitting postures. According to earlier studies the lowest disc pressure during sitting occurred at an angle of 110 degrees. However, more recent studies (2006-2007) using MRI showed that an angle of 135 degrees is even better to reduce disc pressure (Pandy, 1998), but there is a tendency to slide off the seat and it is not convenient for office work.

2.3. Musculoskeletal Disorders Related with Occupational Issues

Work related musculoskeletal disorders (WRMSD) are defined as "impairments of body structures such as muscles, joints, tendons, ligaments, nerves, bones, or a localized blood circulation system caused primarily by the performance of work and by the effects of the immediate environment where the work is carried out". They are one of the most common work-related problems in Europe. Upper limb disorders are a type of WRMSD, and they most likely affect hands, arms, shoulders, and neck (Van der Beek et al., 2000). The risk factors of upper limb disorders are repetition, postures while working, forces applied to these areas, and exposure duration.

According to Darcor (2015), Musculoskeletal Disorders (MSDs) are disorders and injuries in body parts like muscles, bones, nerves, tendons, joints, ligaments, cartilage and spinal disc. MacLeod (2006) reported that MSDs represent about one third of all work related injuries. Thus, MSDs are main health and safety issues among work related risks for workers and one of the main concern areas of ergonomics.

According to Van Tulder et al. (1995) MSDs cause massive harm to both humans and society. Furthermore, these disorders were also very frequent in working population as well as general population (Van der Beek et al., 2000).

Most of the office workers in today's world face repetitive movements and/or static postures in their work lives. Since we live in a digital age, most of the tasks are accomplished by computers. Computer use mostly affects upper parts of the body. Williams and Westmorland (1994) stated that most common diseases related to computer use are carpal tunnel syndrome, tension neck syndrome, and thoracic outlet syndrome. Repetitive movements (such as using keyboard and mouse) result in muscle fatigue since muscles are not able to rest sufficient time, thus inflammation, degeneration and changes in tissues may occur. The patients with Repetitive Strain Injury (RSI) reported that their computer use is more than four hours a day (Palmer, 2001). Static postures while using computers result in muscle fatigue because of irregular blood flow in the body. Such WRMSDs result in unhealthy employees, reduction of efficiency and effectiveness, and economic costs for organizations.

Prevention from WRMSDs has been discussed widely in previous works. The organizations make prevention plans, interventions as well as Health and Safety Agencies throughout Europe. Health and Safety Laboratory in the United Kingdom published a report which explains the type of exercises that should be performed for preventing WRMSDs (Leah, 2011). Additionally, the European Agency for Safety and Health at Work published a prevention report, which is a combination of workplace interventions, including behavioral modifications (Podniece et al., 2008). The most common characteristics of reports and research in this domain are that they recommend simple micro-breaks from repetitive works. Henning et al. (1997) suggested 30-60 seconds micro breaks from computer use at every 15 minutes in order to prevent musculoskeletal discomfort and increase the employees' productivity.

Similarly, McLean et al. (2001) found that breaks at 20 minutes interval have a positive effect on reducing discomfort for computer terminal workers. Galinsky et al. (2007) also showed the significance of breaks and their effects on eye strain and musculoskeletal discomfort. They also suggested stretching exercises for data entry workers during breaks. Friedrich et al. (1998) also made suggestions for performing

simple exercises at workstations so that the compliance could be improved.

WHO statistics (2005) reported that every year about 268 million nonfatal workplace injuries were occurring which cause at least 3 days absenteeism from work (Kumar, 2007).

Kumar (2007) also added that about 43% of injuries in US were related to sprain and strains in body which indicates that a large amount of work-related accidents are musculoskeletal injuries. Moreover, in economic terms, MacLeod (2006) also added that workers' MSD related compensation costs were about \$50 billion; lost productivity and absenteeism costs were about \$60 billion in US for one year. These facts tell us about MSDs in industry, they disable people from working efficiently, cause injuries and accidents, moreover they also effect economic situation of companies in terms of loss efficiency, absenteeism, and injury compensations.

MSDs are related to various risk factors associated with work, environment, and person. MacLeod (2006) listed these risk factors as awkward postures, static load, pressure points, repetition, excessive force, environmental factors like vibration, noise, temperature etc., organizational problems and personal issues like physical condition and diseases. Elimination or reduction of these risk factors is one of the main objectives of ergonomic evaluations. As a result, workers get the chance of working at much safer and less risky environments.

2.4. Occupational Behaviour in Offices

Computer use in the workplace has increased considerably in recent years. The introduction of computers to the workplace has increased productivity but it also created an important health problem such as work-related musculoskeletal system disorders. Musculoskeletal disorders are among the diseases commonly seen by office workers worldwide. These disorders have detrimental effects on the health and productivity of employees. These can be divided into individual, ergonomic and psychosocial effects. Musculoskeletal impairment is triggered by high workload, prolonged mouse and keyboard use, high muscle tension in the neck and shoulder. This is possible by applying the correct body mechanics principles and providing an

ergonomic working environment. Awareness and knowledge of the relationship between computer use and employees is necessary to prevent this disease from becoming more severe. Therefore, in the working environment, ergonomics education / training, computer users should be trained on office ergonomics. The effect of office ergonomics training indicates a reduction in musculoskeletal disorders.

The most common musculoskeletal disorders originating from the office environment are carpal tunnel syndrome, tendonitis, cervical radiculopathy, and fibromyalgia. These diseases' main symptoms include pain, swelling, stiffness, numbness, tingling, weakness, incoordination, loss of function, skin color and temperature changes. It is accepted that the development and chronicity of these diseases are affected by physical activities or working postures at the workplace and working conditions. It is possible to avoid this situation by applying the correct body mechanics principles in the workplace and by providing a comfortable and ergonomic working environment. It has been observed that well-planned ergonomics interventions reduce the disease. Training-based intervention programs create awareness of ergonomics in employees, leading to behavioral changes in individuals, using the body in correct positions, and a reduction in work-related musculoskeletal disorders (Züger et al., 2018).

Non-ergonomic sitting positions, sitting behavior, working conditions or low comfort levels cause musculoskeletal complaints. The optimal occupational sitting position and sitting behavior has been studied extensively. The constant change of sitting positions suggests that there is no ideal sitting posture. Changing the sitting position can change spine geometry and lumbar disc pressure. Therefore, a dynamic sitting behavior can change the conditions of the spinal segments. Frequent movements are also an indicator of discomfort and imbalance, but an appropriate range of motion has yet to be determined. Recent systematic reviews argue that sitting dynamically alone has a positive effect; however, more scientific studies are needed to fully understand the possible effects of dynamic sitting on the human body. Hence, studying a subject's behavior can offer a practical solution (Matic et al., 2012).

2.5. Sedentary Work Style

Regardless of WRMSDs, sedentary working style of office employees causes many health-related problems. Warren et al. (2010) declared that individuals with sedentary lifestyle have a higher risk of having cardiovascular disease. Similar to WRMSDs, taking breaks from sitting for prolonged periods can decrease the risk of metabolic diseases. For example; Healy et al. (2008) showed the association between taking frequent breaks from sitting and a healthier metabolism.

In recent years, with the help of digitalized environments, there have been several studies for reminding office employees to take a break or make stretching exercises. One of the prior studies that was conducted in this area is the study of Monsey et al. (2003). They used a reminder software named "Stretch Break", and conducted study with treatment and control groups. All participants were informed about taking stretch breaks at 45 minutes interval reduces musculoskeletal discomfort and the risk of RSI. The treatment group used reminder software, whereas the control group did not. The results showed that the treatment group made stretching exercises more than the control group. Their results show that although the participants of their study were instructed to take breaks, most of the time they did not comply to take breaks. They concluded that there may be different factors that affect the decision of individuals for taking breaks. For example, an interesting point to be investigated is the relationship between musculoskeletal discomfort and compliance to the break-reminder programs/applications.

Trujillo and Zeng (2006) conducted a study in which they investigated the perception and satisfaction of data entry workers toward a stretching program named "Stop and Stretch". They have found that 63.3% of the workers stated that the program had a positive effect on their productivity. Another study (Morris et al., 2008) offered an interactive break reminder package named "Super Break", which encourages office workers to take more breaks. As a difference from previous work, Super Break detects keyboard and mouse activity between breaks and based on the activity it reminds taking a break or not. Additionally, it provides interactive games to users so that breaks can be more enjoyable and users are encouraged to take more breaks. According to the results of the study, 85% of the workers stated that they prefer Super Break compared

to traditional break reminder programs. Similarly, Berque et al. (2011) designed a software system, which persuades users to avoid immoderate typing speeds, to use typing shortcuts, and to take breaks from typing in order to prevent RSI. The system reminded participants when they exceeded a typing speed and gave feedback. The results showed that the feedback provided by the system had a positive effect on typing behavior, and shortcuts for words were used more effectively.

A more recent study (Van Dantzig et al., 2013) showed the importance of taking breaks and that it can be improved with persuasive strategies. Dantzig developed a mobile application named “Sit Coach”, which monitors the physical activity and reminds users to take breaks from sitting. The main aim of the mobile application is to decrease sedentary behavior of office workers. Users can configure the number of inactive minutes (default was 30 minutes), and at the end of this period “Sit Coach” sends a reminder. The experiment was conducted with treatment and control groups: The treatment group received persuasive messages about taking breaks whereas the control group did not receive any messages. The results showed that users who got intervention (got persuasive messages) reduced their computer use, and their physical activity increased compared to the control group.

Cooley and Pedersen (2013) conducted a study with 46 participants for increasing non-purposeful movement breaks at work in order to reduce prolonged sitting times. They designed a persuasive software that reminds employees to take a break from their sitting times. They concluded that reminders should be unobtrusive for the system to be successful in the long term.

As an opposite view, Wang et al. (2014) stated that obtrusive reminders are necessary for non-difficult and easy-to-perform behaviors (e.g. brushing teeth, or taking breaks). In addition, doing simple exercises can be performed during coffee/tea breaks so that employees do not get overwhelmed.

2.6. Ergonomics of Office Furniture

The basis of a human working environment is an environment designed in a human size. The table, seat and footrest must match. The conditions brought about by an incorrectly designed working environment and their negative consequences can only be eliminated with correctly resolved designs and the results conditioned by them. Anthropometric data should be used in office furniture design. The dimensions of the human body, the lengths of its organs, the distance they can reach, the movement areas of the hands and feet should be known. Body sizes and proportions differ from individual to individual. However, the average values are used in the arrangement of the workplace unless a special situation is required. Essentially, the points to be considered are that the person may be in a sitting position during the day when necessary, and may have to perform some tasks by leaning or standing. Therefore, it is the ability to design furniture that enables people to do their work all day long without feeling tired and uncomfortable, without any decrease in performance and motivation (Çelik and Özmen, 2017). There are two important topics about it. Work surface (Çelik and Özmen, 2017; Olabode and Adesanya, 2017) is one of the significant topics. The writing area and the plane on which the computer keyboard is located must be in the same field of view. The field of view should be neither too big nor too small. Optimum viewing distance (40-45 cm) should be maintained between the writing surface and the eye. Thus, excessive stress on the neck and back muscles is prevented. The height of the work surface should correspond to body dimensions. So the shoulders can work freely. The upper arm hangs down in a relaxed state. The upper arm and lower parcel form a right angle. Thus, the tension of the shoulder arm system is prevented. Work surface height and seating (font) height should be "compatible" with each other. The height of the desk should be 75 cm and the height of the seat should be adjustable. Thus, it is not loaded in a way that damages the spine, spinal cord and ribs. Seating Surface (Çelik and Özmen, 2017; Carlson et al., 2018; McKeown, 2018; Chandwani et al., 2019) is another significant topic. The seat surface height of the item should be adjustable according to body size This adjustment may vary between 42-50 cm. Thus, the tension of the abdomen and legs and blood circulation disorders are prevented. There should be a suitable space for the upper legs and feet between the seating surface and the writing surface. Thus, the forced positions of the legs are prevented. The backrest of the seat must be strongly supported on the

back. In order to do this, the object carrying the backrest (eg spring or hydraulic system) must be sufficiently rigid and therefore resilient (reclining). Thus, by providing effective support, the muscle contractions required to move and balance the upper body are prevented. The seating surface (font) should be about 40 cm wide and deep, smooth, non-slippery, and comfortable, made of a material that provides ventilation. The leading edge should be clearly rounded. Thus, "comfortable" sitting can be provided for a long time. There should be no possibility of "tipping over" the seating item. In order to achieve this, the support points of the element must be at a sufficient distance from each other at the base. If the item is movable, 5 wheels should be used. It should not be forgotten that the best balance in movable structures is achieved at 5 points. Thus, the act of sitting in "confidence" can be realized. Feet should rest on the ground for a correct sitting position. For this reason, foot supports are generally used in many sitting items. The height of this support from the ground and its angle relative to the ground should be adjustable. Foot support depth 30-40 cm. and it should be a non-slippery material. Thus, the necessary "comfort" is provided to the legs. If the environment is ergonomically designed correctly, the table seat element, foot support, and the human action and needs are resolved, the person using it is no longer sitting in the pincer. He's not about to fall, he's not in trouble or pain, and he feels safe. An environment on a human scale has been established.

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2.7. Software for the Measurement of Ergonomic Problems (Siemens Jack)

Ergonomics aims to provide an easy, effective, and safe working environment for people. This also includes the design of furniture, equipment, goods, and other necessary devices to improve the overall performance of people. One way to ensure productivity is to check whether the environment is suitable for anthropometric measurements. At the same time, musculoskeletal disorders should be prevented. In this case, simulation studies have also been done in order to reach a standard. The Jack Siemens Software simulation program was developed based on ergonomics research.

It is one of the leading human simulation tools for ergonomic analysis of designs. One of the capabilities of this software is that it has anthropometrically and biomechanically accurate and scalable human figures. In order to properly simulate the sitting posture of workers in the workplace, objects to interact with should be added such as office desk, office chair and keyboard. With this software, desired movement and positioning of the human figure can be made. Especially the upper body points such as head, arms, elbows, wrists and torso were focused. As a result of the movements, the comfort or discomfort of the human figure is measured. As a result of the study, it was revealed that three points are important, but it has been shown that body measurements also affect the recognition of proper and incorrect sitting posture. According to the measurements made, the software was able to recognize 232 suitable and 137 inappropriate sitting positions. It has been concluded that each person requires different degrees in recognizing the proper and incorrect sitting posture, because each person has different body sizes and different movement habits, so no common conclusion can be drawn. According to this study; it is recommended to research the appropriate table height for each body size in more depth. Determining the appropriate and acceptable workplace design for each body standard may reduce the risks of musculoskeletal disorders, but a generally valid standard has not been established (Siemens, 2012).

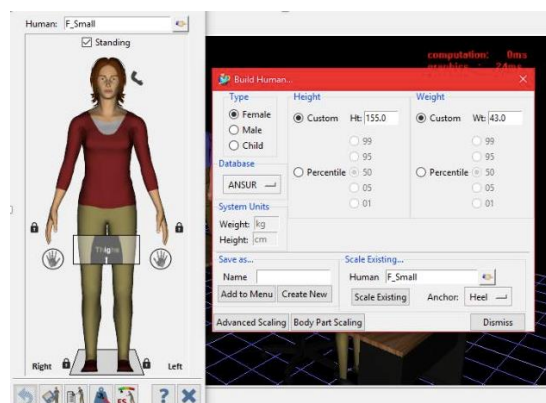


Figure 1. Some positions to test ergonomic standards for office furniture (Source : Siemens, 2012)

2.8. Occupational Disorders Related with Office Furniture

Almost all office workers spend more than half of their working time in front of the computer. Therefore, it is of great importance to have a working chair that fully supports the body in preventing discomfort caused by prolonged and improper sitting, such as pain, chronic fatigue, waist and neck hernia. When choosing the most suitable office furniture, many factors should be considered, from the way of working to habits and special needs. The most important office furniture is the office chair. Also, other furniture items such as office table and computer should support proper posture (Chim, 2018; Ailneni et al., 2019). That's why table, computer and mouse should be designed ergonomically.

A healthy working chair should have some basic features. One of the most essential features is that the seat height can be adjusted slightly lower and higher than ideal height. Thus, the seat height should be adjusted in accordance with the body size, the height of the table and the working position. While adjusting the height of the working chair, care should be taken that the feet are flat on the ground and the upper leg is parallel to the ground. (Çelik and Özmen, 2017). The working chair must have sufficient seating space in accordance with the body size. When you sit, the upper leg should be supported; however, it should not be so large that it touches the back of your knees and makes it difficult for you to rest your arms on the armrests. A lumbar support can be adjusted to suit the body is one of the most important features that a healthy work chair should have. Lumbar support supports the lumbar space and lower spine, reducing the pressure and load that prolonged sitting will cause on the waist. A work chair can be adjusted the height of the back according to the body size reduces the stress and pressure on the spine by supporting the back and the lower back in different sitting positions. A correct back height helps you maintain your posture by improving the position of your legs and arms. An adjustable backrest should support the natural curvature of the spine, and it should protect the upper body and back. Thus, leaning back reduces the pressure on nerves by sitting in the same position for a long time and helps regulate blood flow. A healthy work chair should be able to rotate to accommodate your movements, often without having to move with your whole body. The materials used in the production of an office chair that touches your body throughout the day should not contain chemicals harmful to health. The materials used

when choosing the working chair must comply with the safety and health standards. The seat of your work chair should not slide or be stiff enough to prevent movement. The back upholstery should be made of material that is breathable and adapts to the movements during work. The legs of the working chair should be wide enough to prevent falling even if the center of gravity changes. Wheels, on the other hand, should be preferred according to the floor of the space used, in accordance with the hard ground or soft ground. In addition, it should have lockable features when you sit or stand up according to the way you work. The armrests, which can be adjusted in height and width independently from each other and have the ability to move back and forth, adapt to your body size and working position. Thus, the risk of health problems that may occur in your shoulders, arms, elbows and wrists is minimized. The back stiffness allows you to adjust the amount of force of the work chair to suit your weight. It should help support the back and maintain the posture also in an upright position. They should be able to exercise active sitting and the muscles even while sitting, by applying a certain level of pressure. A neck support that can be adjusted in angle and height according to the structure of your neck and your working position should support and protect the risk of neck discomfort by supporting the neck, especially during long periods of sitting. The mechanism of the work chair should control how the seat front and back will move, as well as adjust your seat in the most suitable way for you with various controls (button, joystick etc.). (Çelik and Özmen, 2017)

Every person has a different working behavior. Some people select to stand while working, some like to change position. The table should be available to change position (Ailneni et al., 2019). The table height should be adjustable according to your position. The table angle should be adjustable according to your position. The table width is min 1 meter to work easily. The computer ergonomics is another issue for your health in offices. The computer should have wide range of motion. Thus, you can position your screen at a comfortable spot based on where you're sitting or standing, bringing the monitor to you. The computer up to 80 degrees rearward and 10 degrees forward, prevents your neck from craning and your shoulders from hunching-creating a healthier posture that can lead to increased productivity. (Ailneni et al., 2019)

2.9. Office Furniture

Office furniture consists of the following elements (Çelik and Özmen, 2017); cabinets (glass and shelves, cabinets, drawers, other special purpose items), tables (desk, meeting table, etc.), chairs (fixed or adjustable seats, etc.) and other furniture elements (stools, shelves, cabinets, etc.) that increase employee productivity.

2.9.1. Office Table

Office tables should be compatible with the way employees work. For this reason, desks should be designed to increase the performance of the employee and to ensure the proper use of the equipment used in the office environment. Accordingly, the size of the desks designed to be used in offices must meet the goals of the employees. Desks in offices should generally include the following features in terms of ergonomics (Pentikis et al., 2002; Ghosh, 1997). Height adjustment (ground clearance) should be at least 70 cm. Table's surface must be matte (non-reflective). Surface width should be 120-150 cm and width 70 cm. It should have rounded edges and corners. Reliability must be ensured (not fragile and slippery). It must be fixed to the floor (No wheels).

2.9.2. Office Chair

Office chairs are the most important elements of office furniture to have a good posture and comfortable work. Well-adjusted office chair improves blood circulation and body position and reduces back pressure of the employee. Therefore, the office chair should have the following features (Aksoydan, 2013). Height adjustment option should be inclined forward with an angle of 20 degrees. Lumbar support should be adjustable between 38-46 cm in height. The fabric of the seat cushion must be breathable. It should be able to rotate 360 degrees around itself. Movement must be capable of supporting five wheels. The back of the chair and the structure of the upper part of the foot must have appropriate dimensions.

The products used to provide functionality in an office generally fall into three categories (Çelik and Özmen, 2017) such as office furniture, technology and office supplies.

Inside the furniture, office equipment used around is smaller and generally cheaper, while the furniture itself, which makes up the whole office, is the main product. However, there are some common pieces of common office furniture. One is desks. For many people, desks are the main work area where they write, answer the phone, and hold many meetings. Along with the desks, the most natural piece of office furniture is the office chair (Çelik and Özmen, 2017).

Office furniture for storage are bookcases, filing cabinets and shelves. They can be made of a variety of materials such as wood, resin, laminate, and metal, and in many sizes and styles. Meeting tables and hangers are other pieces of furniture that help complement office furniture. There are also guest chairs, comfortable seating without wheels for people and visitors coming outside the office or for a meeting.

Many office furniture companies have worked on ergonomic office chairs, and some of them have begun to create office chairs that perform positively in terms of health and environmentally. They have achieved this with adjustable features and material selection. For example, these are 8 zone points, special pellicle fabric and adjustable posture features that support both the sacrum and lumbar to better nurture the natural S shape of the spine. Pellicle fabric is breathable or permeable membrane. It is made of a synthetic material called woven in a straight and consistent pattern. It looks similar to net or wicker materials, but it is much stronger. The chair also features a tilt mechanism, adjustable tilt and seat angle, and movable armrests. The tilt mechanism has been specially created for the natural S curve of the human body. It is easily adjusted and comes with a leaf spring. Seat angle adjustment provides the right angle to adjust the seat without straining the back.

2.10. User Oriented Office Furniture Design

Each definition of the user in furniture design through the product-user relationship is considered as a different input in the design process and plays an active role in this process. Different definitions are used in different disciplines to define the target audience of the product. These differences are based on differences in the attitudes of manufacturers, owners and designers, or differences in disciplines (Tosi, 2020).

When design is considered in terms of office tools and equipment, it can be defined as a sequential decision-making process for the development of a product or system. All decisions, observations and estimates in this process are taken into account according to the evaluation criteria and it is aimed to be considered within the scope of the best possible decisions throughout the process (Chim, 2018).

Workers' needs, performance requirements, and factors that determine boundary conditions should be clarified early in the design process. In order to get the desired result in design processes, design processes should be based on theoretical background, strategic methods and techniques. However, two different strategies need to be taken design for human oriented design (HCD). User-oriented design (UOD) is also called human-oriented design. Design strategy refers to the design parameters (cost, production, assembly, quality, usability, etc.) focused during the design process. The area of application of these strategies may change in order of priority in organizations. In this case, the user-oriented design (UOD) strategy has been developed during the design process and this strategy needs to be used effectively. This is only possible with a good design strategy that integrates ergonomics (Babalık, 2007). The success of the user-oriented design approach for office furniture design depends on the following qualities (Tengilimoğlu et al., 2008): A clear explanation should be made about the work and duties. In the design process, it should focus on the natural elements that determine the operation of the system. The purpose should be clearly stated and there should be a common understanding and harmony among the group members. Continuous feedback should be provided across all processes. The evaluation should be made according to the goals and criteria determined at macro and micro level.

Ergonomics is important issue in the design process. Ergonomics are handled with technology-oriented approaches. In this direction, Özok (1995) conducted a study examining the ergonomic situation in 452 workplaces. According to this research, it has been observed that approximately 54% of the workplaces have not been designed ergonomically. In the same study, the rate of workplaces that are well designed in terms of ergonomics was 8%. However, it has been demonstrated that businesses focus on cost rather than ergonomics when buying office furniture. Accordingly, user-oriented ergonomic data / information and methods have been ignored during the

design process. The main purpose of the user-oriented approach is to produce products suitable to users.

The importance of being user-oriented depends on the feature and technical functionality of the system (Alabay, 2010). In office furniture, the features, requirements and expectations of potential users are often ignored. This situation causes long-term cost increases in companies producing office furniture (loss of market, decrease in competition, correction of errors caused by negligence of ergonomic factors, etc. is very expensive and time consuming.). For this reason, companies have started to adopt a user-oriented design approach.

2.11. Wearable Technologies About Ergonomic Office furniture

Wearable technologies are used to support the skeletal system of office workers and to reduce the power spent on the job. In this way, the strains in the skeletal system are minimized and musculoskeletal disorders are prevented.

2.11.1. Wearable Lumbar Support Systems

These support systems reduce the pressure on the lower back area (L5 / S1 disc) by 60% in the user's standing, lifting, bending or stretching movements. Thus, they increase the strength of the user and reduce the risk of back injury. Lumbar support systems are suitable for use all day long and are designed not to hinder natural movements. In this way, the user can comfortably climb and descend stairs, drive cars, ride a bicycle and move without any restrictions (Ailneni et al., 2019).

2.11.2. Wearable Arm and Shoulder Support System

This support system reduces the forces due to gravity within the shoulder complex. This helps the user to make shoulder and arm movements with less effort for a long time. With this system, users can move and position their shoulders and arms as they wish while working in the office (Nath et al., 2017).

2.11.3. Wearable Knee Support System

With this support system, the pressure on the users' joint and quadricep muscle strength is reduced. Users can squat over and over again or for a long time. The amount of support can be adjusted according to the user's needs and weight. The knee support system provides a special working performance to maximize user comfort. The knee support system provides support to the employee by separating movements such as walking, climbing stairs and squatting. However, this support system provides users with unimpeded movement. It also has a locking mode where the exoskeleton can be used like a chair. With an anthropomorphic profile and adjustable sizing, it allows natural movements and intuitive awareness of the person's position in tight spaces (Lo Presti et al., 2020).

2.11.4. Ergonomic Benefits of Wearable Technologies

In recent years, wearable technology is developed in terms of design. It started to be used most of designs and wearable technologies provide some ergonomic benefits. These benefits are special design for load distribution, passive body harmony, easy and convenient use, reliable structure, adjustable usage level, adjustable structure according to body, intelligent design. Also, it does not restrict user movement, so it is preferred as a design element. (Ailneni et al., 2019). Thanks to these features, some of designs have been developed to prevent on musculoskeletal disorders as wearable technology.

2.12. Workstations

With the rapidly developing technology and rapid changes in the field of science used today, the need and level of use of computers are gradually increasing. Computers, which have almost become a part of life and living standards, are used extensively, especially in office and work environments. These computers, which are used extensively in many industrial areas and enterprises, cause people to experience health problems and physical problems (Shikdar and Al-Kindi, 2007).

Technological developments experienced every day have also affected education and training, and computers have become indispensable for schools. Many academic studies are carried out through computer systems. Students and users working in these environments are faced with many different physical problems. In order to eliminate these problems, products and systems must be designed in accordance with ergonomics principles (Akkoyunlu, 1998).

Problems such as eye ailments, hand and wrist pains, back and neck ailments, headaches are encountered in front-of-screen work for a long time. These inconveniences arise from the fact that working environments are not designed in accordance with ergonomic criteria. According to the statistics of a study conducted in the USA, it has been concluded that work-related health problems are mostly related to computer and desk jobs. It is stated that the rate of these health problems that users who are in direct contact with computer systems are exposed to is 64% and the annual expenditure on this issue is 20 billion dollars (Aksoydan, 2003). In a study conducted on a company with 200 employees between 2002 and 2003 in India, certain groups were formed, and when the health problems experienced by employees were examined in the findings of the studies made on those who use computer systems and work on a desk, the rate of health problems was 93%. When we look at the studies conducted in the light of different criteria, it has been determined that 77.5% of them suffer from muscle stress and 76% of them eye stress (Maciel and Marziale, 1998).

Computer systems and the equipment used in office environments are used extensively should have ergonomic features. It is a necessity for the office materials used to have high performance and productivity of the employees and to benefit the institution and the work done, to have ergonomic and physical features. This obligation is no longer a luxury but an obligation.

Ergonomics tries to reveal the basic laws of system efficiency and human, machine and environment adaptation in the face of organic and psychological stresses. Such "pressures" that may occur with the effect of all factors in line with the working principles in industrial and work offices. It works with a very high discipline and principle in terms of ergonomics working principle (Akkoyunlu, 1998).

It is possible to understand from the studies how important ergonomic suitability is in design. Ergonomic and anthropometric features are not a luxury for employees, but a legal obligation. The harmony between the workstations and human movements should be integrated with the right design.



CHAPTER 3: METHODOLOGY

3.1. Research Methods

The research was designed with respect to the mixed method in which quantitative and qualitative research are used together in order to serve the purpose of the research better and to examine the relationships between variables in depth by providing methodological abundance. Mixed method research is a study in which qualitative and quantitative methods are used together in line with the principles of pragmatist philosophy in order to examine the research problem comprehensively and multidimensionally (Yıldırım and Şimşek, 2013). In other words, the mixed method is that the researcher uses quantitative research in one part of the research and qualitative research in the other part (Balcı, 2009).

In this study, quantitative research methods were used to determine the health problems of individuals working in the office environment caused by office furniture and qualitative research methods were used to gain information about the design processes of office chairs in office furniture.

In the quantitative part of the study, descriptive survey model was used to obtain information about the health status of the individuals by taking into account the characteristics of office furniture and the anthropometric and sitting times of the office workers. The descriptive survey model aims to define a situation or a phenomenon without interference in order to investigate the past or present of that situation or phenomenon (Karasar, 2006).

In the qualitative part of the study, it aimed at learning the opinions of the individuals involved in the design of office furniture about the key points and the design processes in office chair design. In accordance with the purpose of the research, the phenomenological pattern among the qualitative research methods was chosen as the design of the research. Phenomenological design is a scientific method that is followed in order to determine how people in research perceive and evaluate a certain phenomenon, based on their own observations and experiences (Gay et al., 2012). In the research, semi-structured interview technique was used to obtain systematic and comparable qualitative data (Yıldırım and Şimşek, 2013). The data obtained through

the interviews were analysed by creating appropriate coding.

3.2. Hypothesis

The hypothesis that were prepared in line with the purpose of the research and belong to the quantitative part of it were determined as follows:

H1: The severity of neck-related musculoskeletal disorders increases with the length of sitting time in the workplace.

H2: The severity of lumbar/spine related musculoskeletal disorders increases with the length of sitting time in the workplace.

H3: The severity of the negative impact on the general health status increases with the length of sitting time in the workplace.

3.3. Survey

3.3.1. Population and Sample Group

While determining the population and sample of the research, the research processes belonging to the quantitative and qualitative part of the research were examined under different headings.

The population of the study consist of individuals over the age of 18 and working in an office environment. Accordingly, 300 office workers in Turkey and United Arab Emirates constitute the sample group of the study. Hence, the distribution of the demographic characteristics of the individuals a is shown in Table 1.

Table 1. Distribution of the Demographic Characteristics of Office Workers

Variables	Groups	N	%
Gender	Female	151	50,3
	Male	149	49,7
		Avg.	S.D.
Age		40	11,03

As for that Table 1, 50.3% of the participants are women and 49.7% are men. the

average age of the participants was determined as 40 ± 11.03 .

3.4. Interview

The descriptive characteristics and qualifications of these individuals who were interviewed are indicated in Table 2.

Table 2. Descriptive Characteristics of the Individuals that were interviewed

Respondents	Gender	Age	Expertise / Assignment
A1	Female	55	Freelance Industrial Designer
A2	Male	45	Lecturer on furniture techniques and design in the field of interior architecture and industrial design
A3	Male	47	Freelance Interior Architect
A4	Female	32	Industrial designer at a private office furniture company
A5	Male	28	Industrial designer at a private office furniture company

As can be seen from the table, two respondents were female and three were male. The ages of the respondents range between 28 and 55. Among the respondents, there was one freelance industrial designer, one lecturer experienced in furniture design, one freelance interior architect and two industrial designers working in a private office furniture company.

3.5. Data

There is information about data collection and its tools used in the quantitative and qualitative parts of the research.

3.5.1. Quantitative Data

A questionnaire was used to collect data belonging to the quantitative part of the study. The questionnaire form was delivered to the participants through the online survey platform. The questionnaire form consisted of five parts.

Introductory Features Section: There are seven questions in total in order to have information about the participants' demographic characteristics, working life characteristics, anthropometric characteristics, and length of staying time in the

workplace.

Health Status Section: There are four questions to get information about the neck, lumbar/spine, arm, and general health conditions of the participants.

Questions About Seating Elements: It contains a total of nine questions about the qualifications of office components in the workplace.

Body Posture Status: There are eleven statements to get information about the posture positions of office workers in the working environment. The expressions here are in 5-point Likert type.

Office Furniture Priorities: There are two questions to obtain information about office furniture that individuals find uncomfortable and the qualities which are priority for them in office furniture.

3.5.2. Qualitative Data

The data constituted by statements of the experts was obtained by applying depth interview techniques. In the depth interview technique, the person conducting the research aims to obtain information from respondents by preparing open-ended questions that cover all the details of the concept, phenomenon, or subject. By using this technique, those conducting the research provide direct and face-to-face interviews with the participants and realize knowledge acquisition. Furthermore, the interviewer conducting the research has the opportunity to get in-depth information by stretching the questions and the interview duration a little more during the interview process (Tekin, 2006).

In this study, the interview processes with the experts in the interview group were carried out with video conferences through online interview platforms due to the pandemic situation, and the interviews were completed with impressions that are not different from the face-to-face interview techniques. Some principles must be followed in order to obtain efficient and effective results in the interview processes (Yıldırım and Şimşek, 2013).

In the research, five individuals who are experts in the subject were interviewed in order to have information about the design stages of office furniture. Accordingly, the

data was collected by a semi-structured interview method. The semi-structured interview form (Appendices) was prepared with the assistance of two research experts. The interview form consists of two parts.

Introductory Features Section: There are three questions to obtain information about the respondents' gender, age, and workplace position.

Open-Ended Interview Questions: There are 6 open-ended questions to obtain information. The respondents will be asked about determining the most important elements in office chair design, the processes followed in designing an office chair, how they establish the user-office chair relationship, ensuring the suitability of the office chair for the user, the causes of musculoskeletal system diseases and the ergonomic design of the office chair.

3.6. Statistical Analysis of Data

Under this heading, the analysis of quantitative data and the analysis of qualitative data are examined separately.

3.6.1. Analysis of Data Regarding Quantitative Aspect

The quantitative data of the study was analysed using the SPSS20 programme. The demographic and working life characteristics of the office workers in the study were expressed with frequency and percentage. The distribution of the anthropometric characteristics of the participants and the length of stay in the workplace are displayed with mean and standard deviation values. Percentage and frequency were used and graphed in the evaluations of office workers on their working positions. Chi-square analysis was used to test the hypothesis in the study. In addition, in the research, Pearson correlation analysis was used to examine the relationship between the anthropometric characteristics of the participants and their length of stay at work and their health status. The data in the research was analysed at a 95% confidence level.

3.6.2. Analysis of Data Regarding Qualitative Aspect

Before proceeding to the data analysis section in qualitative research methods, it is necessary to pay attention to the questions of "how" and "why", and the evaluation of all the answers to the questions causes various complex processes. Instead of perusing all the answers as a whole, the answers are evaluated with classification and coding techniques and various relationship networks can be developed (Yıldırım and Şimşek, 2013).

After the data obtained from the participants was compiled and edited, the process of coding the data was started in order to perform content analysis. In this part of the study, the person conducting the research divided the data into various sections after reviewing them, and attempts were made to identify common concepts within these sections. These concepts are defined as "codes" and they can comprise of a single word or series of words. After the coding process is completed, a code list is created and the inferences are made from this list (Yıldırım and Şimşek, 2013). In this study, as a result of the content analysis method used to analyse the answers obtained from the participants, common concepts among the answers were acquired and these concepts were named and connected to a theme.

CHAPTER 4: RESULTS & DISCUSSION, DESIGN PROPOSAL

Analyses were performed in this part of the study to obtain inferences about the ergonomic equipment of office workers, using quantitative and qualitative research methods.

4.1. Survey Findings

In this part of the research, there are statistical processes related to the data obtained with the data collection tools used within the scope of quantitative research methods.

4.1.1. Distribution of Demographic and Work Life Characteristics of the Participants

The distribution of the characteristics of the individuals participated in the research about working life is presented in Table 1.

Table 3. Distribution of Participants' Work Life Characteristics

Variables	Groups	N	%
Total Working Time	Less than 1 year	5	1,7
	1-5 years	61	20,3
	6-15 years	101	33,7
	16 years or more	133	44,3
Working Time in Current Company	Less than 1 year	36	12,0
	1-5 years	117	39,0
	6-15 years	99	33,0
	16 years or more	48	16,0

Table 3 shows that 44.3% of office workers have been in the workforce for 16 years or more, while 39.0% have been with their current employers for 1-5 years.

The distribution of anthropometric and health characteristics of the individuals participated in the search is displayed in Table 4.

Table 4. Distribution of Anthropometric Properties of the Participants

Variables		Avg.	S.D.
Height (mm)		169,91	13,58
Weight (kg)		73,87	15,14
Sitting Time (hours)		6,35	2,42

Considering Table 4, the average height of office workers was 169.91 ± 13.58 cm, the average weight was 73.87 ± 15.14 kg, and the average duration of time sitting at the workplace was 6.35 ± 2.42 hours.

The distribution of the evaluations of the individuals in the study on health is presented in Table 5.

Table 5. Distribution of Participants' Evaluations on Health Status

Variables	Groups	n	%
Neck Health Status	Very bad	10	3,3
	Bad	44	14,7
	Mediocre	127	42,3
	Good	93	31,0
	Very good	26	8,7
Lumbar/Spine Health Status	Very bad	12	4,0
	Bad	60	20,0
	Mediocre	135	45,0
	Good	79	26,3
	Very good	14	4,7
Arm Health Status	Very bad	8	2,7
	Bad	24	8,0
	Mediocre	116	38,7
	Good	119	39,7
	Very good	33	11,0
General State of Health	Very bad	5	1,7
	Bad	22	7,3
	Mediocre	101	33,7
	Good	152	50,7
	Very good	20	6,7

As regards Table 5, 42.3% of the office workers in the study had moderate neck health, 45.0% had moderate lumbar/spine health, 39.7% had good arm health and 50.7% had good general state of health.

4.1.2. Distribution of Participants' Opinions About Seating Elements in the Workplace

The distribution of the characteristics of the seating elements in the workplace of the individuals included in the study is indicated in Table 6.

Table 6. Distribution of the Qualifications of the Participants' Seats in the Workplace

Variables	Groups	n	%
Adjustable Back Support	Yes	89	29,7
	No	211	70,3
Adjustable Lumbar Support	Yes	73	24,3
	No	227	75,7
Adjustable Neck Support	Yes	31	10,3
	No	269	89,7
Adjustable Arm Support	Yes	91	30,3
	No	209	69,7
Can the seat's height be adjusted from the ground?	Yes	203	67,7
	No	97	32,3
Does your office chair take the shape of your body?	Yes	82	27,3
	No	218	72,7
Do you think that it is suitable for your own body measurements?	Yes	147	49,0
	No	153	51,0
Hardness/Softness of the Seat Element	Very Soft	3	1,0
	Soft	16	5,3
	Neither Soft nor Hard	227	75,7
	Hard	27	9,0
	Very Hard	27	9,0
Armrest Hardness/Softness of the Seat Element	Very Soft	2	0,7
	Soft	22	7,3
	Neither Soft nor Hard	132	44,0
	Hard	69	23,0
	Very Hard	75	25,0

As far as Table 6, 70.3% of office workers in the study do not have adjustable back support, 75.7% do not have adjustable lumbar support, 89.7% do not have adjustable neck support, and 69.7% do not have Adjustable Arm Support in their office chairs.

67.7% of the office workers who took part in the research have a height-adjustable office chair. In addition, office chairs of 72.7% of the participants are not ergonomic and take the shape of the body and 51.0% of office workers think that the office chair is not suitable for their body size. Again, 75.7% of the participants explained that the office chair they are using is neither hard nor soft, and 44.0% stated that the arms of the office chair are neither hard nor soft.

4.1.3. Distribution of Participants' Opinions on Body Posture in the Work Environment

The evaluations of individuals regarding the statement "During my work I keep a good work posture." 50.3% of the office workers at work in the study are sometimes, 20.0% seldom, 19.7% often, 7.0% never and 3.0% identified that they always keep a good work posture during work.

The evaluations of participants regarding the statement "At work I sit for long hours in one position." 33.3% of the office workers in the study sit often, 32.3% sometimes, 19.3% seldom, 9.0% never and 6.0% always in the same position for a long time at the workplace.

The evaluations of participants regarding the statement "For more than two hours per day I sit with lifted shoulders." 35.7% of the office workers in the research sometimes, 25.7% seldom, 18.0% often, 17.3% never and 3.3% always sit with lifted shoulders for more than two hours a day.

The evaluations of participants regarding the statement "During my work I sit in awkward postures." 39.0% of office workers in the study sometimes, 25.3% often, 21.0% seldom, 10.7% never and 4.0% always have an awkward body posture during work.

The evaluations of participants regarding the statement "In work I perform repetitive tasks." 37.3% of office workers in the study often, 32.0% sometimes, 12.3% always, 12.3% seldom and 6.0% never perform repetitive tasks in the workplace.

The evaluations of participants regarding the statement "I find my job physically exhausting." 34.7% of office workers in the study sometimes, 24.0% often, 23.3% seldom, 12.0% never and 6.0% always find their job physically exhausting.

The evaluations of participants regarding the statement "When I work my hand is placed in a straight line with my lower arm." 39.0% of office workers in the study sometimes, 25.0% often, 20.3% seldom, 8.7% never and 7.0% always work while their hands are placed in a straight line with their lower arms.

The evaluations of participants regarding the statement "When I work my head is bent." 36.0% of office workers in the research often, 32.7% sometimes, 16.0% seldom, 9.3% always and 6.0% never have their heads bent while work.

The evaluations of participants regarding the statement "During my work, my head is twisted towards the left or right." 37.7% of office workers in the study sometimes, 26.3% seldom, 16.7% never, 16.3% often and 3.0% always twist their heads to the right or left during work.

The evaluations of participants regarding the statement "During my work, my trunk is twisted towards the left or right." 39.3% of office workers in the study sometimes, 25.0% seldom, 19.3% never, 15.0% often and 1.3% always twist their trunks towards the right or left while working.

The evaluations of participants regarding the statement "During my work, my trunk is in asymmetrical position." 40.3% of office workers in the study sometimes, 25.0% seldom, 16.3% often, 16.0% never and 2.3% always position their trunks in an asymmetrical position during work.

4.1.4. Distribution of the Preferences of the Individuals in the Study of the Seating Elements in the Working Environment

Table 7 shows the distribution of the preferences of the individuals in the study of the seating elements in the working environment.

Table 7. Distribution of the Preferences of the Individuals in the Research of the Seating Elements in the Working Environment

Variable	Groups	N	%
Uncomfortable Furniture*	Chair	172	36,2
	Table	85	17,9
	Computer	86	18,1
	Mouse	61	12,8
	Other	71	14,9
Significant Feature for Office Furniture (1st)	Material	33	11,0
	Comfort	251	83,7
	Budget	16	5,3
Significant Feature for Office Furniture (2nd)	Material	182	60,7
	Comfort	49	16,3
	Budget	69	23,0
Significant Feature for Office Furniture (3rd)	Material	85	28,3
	Comfort	0	0,0
	Budget	215	71,7

*more than one answer is marked.

As far as Table 7, 36.2% of the responses of office workers in the study about the most uncomfortable seating elements in the working environment are chairs, 18.1% computers, 17.9% tables, 14.9% others, and 12.8% mouse. Moreover, it was observed that office workers state that they pay attention to the comfort the most in office furniture (83.7%), secondly to the materials of office furniture (60.7%) and lastly, the price of the furniture.

4.1.5. Examination of Participants with respect to the Descriptive Features of Health

The results of the Chi-square analysis performed to examine the differentiation of the neck health status of the individuals included in the study in conformity with the demographic and working life characteristics are presented in Table 8.

Table 8. Participants' Neck Health Status According to their Demographic and Working Life Characteristics

“Table is continued in the following page.”

Demographic and Working Life Characteristics		Neck Health Status					χ^2	P
		Very Bad (%)	Bad (%)	Middle (%)	Good (%)	Very Good (%)		
Gender	Female	9** 6.0	31 20.5	63 41.7	38 25.2	10 6.6	18,251	0,001
	Male	1 0.7	13 8.7	64 43.0	55 36.9	16 10.7		

Total Working Time	Less than 1 year	*	*	*	*	*	7,082	0,313
	1-5 years	*	5 8.5	27 45.8	23 39.0	4 6.8		
	6-15 years	*	21 21.2	40 40.4	27 27.3	11 11.1		
	More than 16 years	*	18 14.2	57 44.9	42 33.1	10 7.9		
Working Time in Current Company	Less than 1 year	*	2 5.6	19 52.8	12 33.3	3 8.3	9,711	0,374
	1-5 years	*	21 19.1	50 45.5	28 25.5	11 10.0		
	6-15 years	*	16 16.5	38 39.2	37 38.1	6 6.2		
	More than 16 years	*	5 10.6	20 42.6	16 34.0	6 12.8		

* Marked cells are less than 5. Thus, they were not included in the analysis.

Considering Table 8, it was determined that the neck health status of office workers in the study differed at 95% confidence level in conformity with gender ($\chi^2 = 18,251$, $p = 0.001$). Therefore, it can be said that the neck health status of men is better than the neck health status of women. Moreover, it was determined that the neck health status of the office workers included in the research did not differ accordant with the total working time and the working time in the current company ($p > 0.05$).

The results of the Chi-square analysis performed to examine the differentiation of the lumbar/spine health status of the individuals included in the study in conformity with the demographic and working life characteristics are shown in Table 9.

Table 9. Participants' Lumbar/Spine Health Status in Accordance with their Demographic and Working Life Characteristics

“Table is continued in the following page.”

Demographic and Working Life Characteristics		Lumbar/Spine Health Status					χ^2	P
		Very Bad (%)	Bad (%)	Middle (%)	Good (%)	Very Good (%)		
Gender	Female	8** 5.3	38 25.2	70 46.4	28 18.5	7 4.6	12,469	0,014
	Male	4 2.7	22 14.8	65 43.6	51 34.2	7 4.7		
Total Working Time	Less than 1 year	*	*	*	*	*	2,661	0,616
	1-5 years	*	16 28.1	23 40.4	18 31.6	*		
	6-15 years	*	19 20.4	47 50.5	27 29.0	*		
	More than 16 years	*	25 20.8	63 52.5	32 26.7	*		

Working Time in Current Company	Less than 1 year	*	8 22,9	14 40,0	13 37,1	*	15,612	0,016
	1-5 years	*	35 32,7	48 44,9	24 22,4	*		
	6-15 years	*	12 13,5	48 53,9	29 32,6	*		
	More than 16 years	*	5 11,6	25 58,1	13 30,2	*		

* Marked cells are less than 5. Thus, they were not included in the analysis.

**Marked number etc. means that people number.

As far as Table 9, it was determined that the lumbar/spine health status of office workers in the study diverged at 95% confidence level with respect to gender ($\chi^2=12.469$, $p = 0.014$). By the data, it can be explained that the lumbar/spine health of men is better than women. In addition, it was determined that the lumbar/spine health status of the office workers included in the research did not differ in relation to the total working time and the working time in the current company ($p > 0.05$).

The results of the Chi-square analysis performed to examine the differentiation of the arm health status of the individuals included in the study in respect of the demographic and working life characteristics are shown in Table 10.

Table 10. Participants' Arm Health Status According to their Demographic and Working Life Characteristics

Demographic and Working Life Characteristics		Arm Health Status					χ^2	P
		Very Bad (%)	Bad (%)	Middle (%)	Good (%)	Very Good (%)		
Gender	Female	*	18** 12,5	71 49,3	42 29,2	13 9,0	23,556	0,000
	Male	*	6 4,1	45 30,4	77 52,0	20 13,5		
Total Working Time	Less than 1 year	*	*	*	*	*	17,159	0,009
	1-5 years	*	4 6,6	14 23,0	35 57,4	8 13,1		
	6-15 years	*	8 8,0	38 38,0	39 39,0	15 15,0		
	More than 16 years	*	12 9,5	62 49,2	44 34,9	8 6,3		
Working Time in Current Company	Less than 1 year	*	*	*	*	*	11,285	0,080
	1-5 years	*	9 8,1	45 40,5	36 32,4	21 18,9		
	6-15 years	*	8 8,2	40 41,2	44 45,4	5 5,2		
	More than 16 years	*	5 10,4	22 45,8	16 33,3	5 10,4		

* Marked cells are less than 5. Thus, they were not included in the analysis.

As far as Table 10, the arm health status of office workers in the study differed at the 95% confidence level based on gender ($\chi^2 = 23.556$, $p = 0.000$). Accordingly, it can be specified that men's arm health is better than women. Furthermore, the arm health status of office workers included in the study diverged at a 95% confidence level based on total working time ($\chi^2 = 17.159$, $p = 0.009$). As a result, office workers with 1-5 years of experience have better arm health than those with 6-15 years of experience and 16 or more years of experience. However, the arm health status of office workers who participated in the study did not differ based on the length of time they work for the current company ($p > 0.05$).

The results of the Chi-square analysis performed to examine the differentiation of the general state of health of the individuals included in the research according to the demographic and working life characteristics are presented in Table 11.

Table 11. Participants' General State of Health According to their Demographic and Working Life Characteristics

Demographic and Working Life Characteristics		General State of Health					χ^2	P
		Very Bad (%)	Bad (%)	Middle (%)	Good (%)	Very Good (%)		
Gender	Female	*	14*** 9.6	65 44.5	58 39.7	9 6.2	18,661	0,000
	Male	*	8 5.4	36 24.2	94 63.1	11 7.4		
Total Working Time	Less than 1 year	*	*	*	*	*	8,099	0,231
	1-5 years	*	4 6.6	15 24.6	36 59.0	6 9.8		
	6-15 years	*	7 7.1	30 30.3	55 55.6	7 7.1		
	More than 16 years	*	11 8.5	54 41.5	59 45.4	6 4.6		
Working Time in Current Company	Less than 1 year	*	*	*	*	*	7,777	0,255
	1-5 years	*	12 10.4	38 33.0	55 47.8	10 8.7		
	6-15 years	*	4 4.1	36 37.1	54 55.7	3 3.1		
	More than 16 years	*	5 10.4	17 35.4	21 43.8	5 10.4		

* Marked cells are less than 5. Thus, they were not included in the analysis.

***Marked number etc. means that people number.

Considering Table 11, it was determined that the general health status of office workers in the study varied at 95% confidence level according to gender ($\chi^2 = 18,661$, $p = 0,000$). By the data, it can be remarked that the general health conditions of men are better than women. In addition, it was determined that the general health status of the office workers included in the study did not differ in relation to the total working time and the working time in the current company ($p > 0.05$).

4.1.6. Examination of the Relationship between the Anthropometric and Sitting Time at Work and Health of Individuals

Table 12 displays the results of Pearson Correlation analysis performed to investigate the relationship between anthropometric and sitting time at work and health of individuals included in the research.

Table 12. Investigation of the Relationship between the Anthropometric and Working Time and Health of Individuals

Variables		Neck Health Status	Lumbar/Spine Health Status	Arm Health Status	General State of Health
Height	r	0,037	0,012	0,128*	0,172**
	p	0,521	0,831	0,027	0,003
Weight	r	0,058	0,022	0,077	0,028
	p	0,317	0,706	0,181	0,057
Sitting Time	r	-0,168**	-0,137*	-0,082	-0,089
	p	0,004	0,018	0,155	0,123

* $p < 0,05$ ** $p < 0,01$

As regards Table 12, a positive and statistically significant relationship was found between the height and arm health ($r = 0.128$) and general health status ($r = 0.172$) of the office workers included in the study.

A negative and statistically significant relationship was found between the time spent sitting at the workplace of office workers in the study and their neck health status ($r = -0.168$) and lumbar/spine health ($r = -0.137$) ($p < 0.05$).

4.1.7. Examination of the Health of the Participants According to the Characteristics of the Seating Elements at the Workplace

The results of the Chi-square analysis performed to examine the differentiation of the neck health status of the individuals involved in the study according to the characteristics of the seating elements in the workplace are displayed in Table 13.

Table 13. Participants' Neck Health Status According to the Characteristics of the Seating Elements in the Workplace

The Qualifications of the Seating Elements in the Workplace		Neck Health Status					χ^2	P
		Very Bad (%)	Bad (%)	Middle (%)	Good (%)	Very Good (%)		
Adjustable Back Support	Yes	1** 1.1	12 13.5	39 43.8	30 33.7	7 7.9	2,434	0,657
	No	9 4.3	32 15.2	88 41.7	63 29.9	19 9.0		
Adjustable Lumbar Support	Yes	0 0.0	5 6.8	32 43.8	28 38.4	8 11.0	9,559	0,049
	No	10 4.4	39 17.2	95 41.9	65 28.6	18 7.9		
Adjustable Neck Support	Yes	0 0.0	5 16.1	17 54.8	9 29.0	0 0.0	5,519	0,238
	No	10 3.7	39 14.5	110 40.9	84 31.2	26 9.7		
Adjustable Arm Support	Yes	1 1.1	15 16.5	41 45.1	29 31.9	5 5.5	4,027	0,402
	No	9 4.3	29 13.9	86 41.1	64 30.6	21 10.0		
Adjustable Seat Height	Yes	5 2.5	34 16.7	88 43.3	65 32.0	11 5.4	11,288	0,024
	No	5 5.2	10 10.3	39 40.2	28 28.9	15 15.5		
Taking the shape of your body	Yes	0 0.0	11 13.4	35 42.7	31 37.8	5 6.1	6,430	0,169
	No	10 4.6	33 15.1	92 42.2	62 28.4	21 9.6		
suitable for your own body measurements	Yes	1 0.7	15 10.2	54 36.7	62 42.2	15 10.2	24,536	0,000
	No	9 5.9	29 19.0	73 47.7	31 20.3	11 7.2		
Hardness/Softness of the Seat Element	Very Soft	*	*	*	*	*	5,202	0,267
	Soft	*	*	*	*	*		
	Mid	*	33 16.0	101 49.0	72 35.0	*		
	Hard	*	7 33.3	10 47.6	4 19.0	*		
	Very Hard	*	3 13.0	11 47.8	9 39.1	*		
Armrest Hardness/Softness of the Seat Element	Very Soft	*	*	*	*	*	10,556	0,307
	Soft	*	2 9.1	11 50.0	7 31.8	2 9.1		
	Mid	*	18 13.8	52 40.0	45 34.6	15 11.5		
	Hard	*	16 23.9	28 41.8	21 31.3	2 3.0		
	Very Hard	*	8 11.4	36 51.4	20 28.6	6 8.6		

* Marked cells are less than 5. Thus, they were not included in the analysis.

**Marked number etc. means that people number.

As for that Table 13, it was determined that the neck health status of office workers included in the research differed at a 95% confidence level according to their status with Adjustable Lumbar Support ($\chi^2 = 9,559$, $p = 0.049$). As a result, it can be said that office workers who have Adjustable Lumbar Support have better neck health than those who do not.

It was determined that the neck health status of office workers in the study diverged at 95% confidence level in relation to the status of having Adjustable Seat's Height ($\chi^2 = 11,288$, $p = 0.024$). Consequently, office workers who have Adjustable Seat Height have better neck health than those who do not.

It was determined that the neck health status of office workers involved in the study varied at a 95% confidence level according to the status of having a seating element suitable for their body size ($\chi^2 = 24,536$, $p = 0,000$). Accordingly, it can be stated that the neck health status of office workers who have seating elements suitable for their body size is better than those who do not.

Furthermore, it was also determined that the neck health status of the office workers involved in the research did not differ with respect to the adjustable back support of the seating elements, the adjustable arm support of the seating elements, the functionality of taking the shape of user's body, the Hardness/Softness of the seating element, or the armrest Hardness/Softness of the Seating Element ($p. > 0.05$).

The results of the Chi-square analysis performed to examine the differentiation of the lumbar/spine health status of the individuals involved in the study according to the characteristics of the seating elements in the workplace are shown in Table 14.

Table 14. Participants' Lumbar/Spine Health Status According to the Characteristics of the Seating Elements in the Workplace

**Table is continued the following page.

The Qualifications of the Seating Elements in the Workplace	Lumbar/Spine Health Status					χ^2	p
	Very Bad (%)	Bad (%)	Middle (%)	Good (%)	Very Good (%)		

Adjustable Back Support	Yes	1** 1,1	17 19,1	38 42,7	29 32,6	4 4,5	4,703	0,319
	No	11 5,2	43 20,4	97 46,0	50 23,7	10 4,7		
Adjustable Lumbar Support	Yes	0 0,0	12 16,4	36 49,3	22 30,1	3 4,1	5,464	0,243
	No	12 5,3	48 21,1	99 43,6	57 25,1	11 4,8		
Adjustable Neck Support	Yes	0 0,0	8 25,8	12 38,7	10 32,3	1 3,2	2,884	0,577
	No	12 4,5	52 19,3	123 45,7	69 25,7	13 4,8		
Adjustable Arm Support	Yes	1 1,1	25 27,5	38 41,8	23 25,3	4 4,4	6,776	0,148
	No	11 5,3	35 16,7	97 46,4	56 26,8	10 4,8		
Adjustable Seat Height	Yes	6 3,0	41 20,2	93 45,8	58 28,6	5 2,5	8,922	0,063
	No	6 6,2	19 19,6	42 43,3	21 21,6	9 9,3		
Taking the shape of your body	Yes	0 0,0	8 9,8	38 46,3	31 37,8	5 6,1	16,614	0,002
	No	12 5,5	52 23,9	97 44,5	48 22,0	9 4,1		
suitable for your own body measurements	Yes	1 0,7	18 12,2	66 44,9	52 35,4	10 6,8	28,374	0,000
	No	11 7,2	42 27,5	69 45,1	27 17,6	4 2,6		
Hardness/Softness of the Seat Element	Very Soft	*	*	*	*	*	3,544	0,315
	Soft	*	*	5 45,5	6 54,5	*		
	Mid	*	*	107 63,7	61 36,3	*		
	Hard	*	*	13 76,5	4 23,5	*		
	Very Hard	*	*	9 52,9	8 47,1	*		
Armrest Hardness/Softness of the Seat Element	Very Soft	*	*	*	*	*	16,697	0,010
	Soft	*	*	*	*	*		
	Mid	*	22 17,1	63 48,8	37 28,7	7 5,4		
	Hard	*	26 39,4	25 37,9	14 21,2	1 1,5		
	Very Hard	*	10 14,5	36 52,2	19 27,5	4 3,1		

* Marked cells are less than 5. Thus, they were not included in the analysis.

**Marked number etc. means that people number.

As described in Table 14, it was determined that the lumbar/spine health status of office workers included in the study varied. In Table 16, respondent A1 gave priority to checking at a 95% confidence level according to the chair's functionality of taking the shape of the user's body ($\chi^2 = 16.614$, $p = 0.002$). As a result, it can be identified that the lumbar/spine health of office workers who have chairs that can conform to the shape of user's body is better than those who do not.

It was determined that the lumbar/spine health status of office workers involved in the research diverged at a 95% confidence level according to the suitability of the office chair to the size of the body ($\chi^2 = 28,374$, $p = 0,000$). By the data, it can be stated that the lumbar/spine health of the office workers who have suitable chairs for their own body measurements is better than the office workers who do not.

It was determined that the lumbar/spine health status of office workers involved in the study differed at a 95% confidence level in relation to the armrest hardness/softness of the seating element ($\chi^2 = 16.697$, $p = 0.010$). By the data, it can be specified that office workers who have seating elements with hard armrests have better lumbar/spine health than those having seating elements with medium or very stiff armrests.

In addition, the lumbar/spine health conditions of the office workers in the study are not affected by whether the seating elements have the adjustable back support, the adjustable body support, the adjustable neck support, the adjustable arm support, the adjustable height support, and the hardness/softness of the seating elements. ($p > 0.05$).

The results of the Chi-square analysis performed to examine the differentiation of the arm health status of the individuals involved in the study according to the characteristics of the seating elements in the workplace are shown in Table 15.

Table 15. Participants' Arm Health Status According to the Characteristics of the Seating Elements in the Workplace

“Table is continued in the following page.”

The Qualifications of the Seating Elements in the Workplace		Arm Health Status					χ^2	p
		Very Bad (%)	Bad (%)	Middle (%)	Good (%)	Very Good (%)		
Adjustable Back Support	Yes	2** 2.2	7 7.9	30 33.7	37 41.6	13 14.6	2,503	0,644
	No	6 2.8	17 8.1	86 40.8	82 38.9	20 9.5		
Adjustable Lumbar Support	Yes	1 1.4	4 5.5	25 34.2	29 39.7	14 19.2	7,728	0,102
	No	7 3.1	20 8.8	91 40.1	90 39.6	19 8.4		
Adjustable Neck Support	Yes	1 3.2	5 16.1	9 29.0	14 45.2	2 6.5	4,640	0,326
	No	7 2.6	19 7.1	107 39.8	105 39.0	31 11.5		
Adjustable Arm Support	Yes	1 1.1	3 3.3	33 36.3	42 46.2	12 13.2	6,965	0,138
	No	7 3.3	21 10.0	83 39.7	77 36.8	21 10.0		

Adjustable Seat Height	Yes	2 1,0	15 7,4	76 37,4	91 44,8	19 9,4	12,946	0,012
	No	6 6,2	9 9,3	40 41,2	28 28,9	14 14,4		
Taking the shape of your body	Yes	1 1,2	4 4,9	28 34,1	40 48,8	9 11,0	5,220	0,265
	No	7 3,2	20 9,2	88 40,4	79 36,2	24 11,0		
suitable for your own body measurements	Yes	*	9 6,2	43 29,5	76 52,1	18 12,3	18,683	0,000
	No	*	15 10,3	73 50,0	43 29,5	15 10,3		
Hardness/Softness of the Seat Element	Very Soft	*	*	*	*	*	2,717	0,437
	Soft	*	*	5 45,5	6 54,5	*		
	Mid	*	*	90 47,9	98 52,1	*		
	Hard	*	*	10 52,6	9 47,4	*		
	Very Hard	*	*	11 68,8	5 31,2	*		
Armrest Hardness/Softness of the Seat Element	Very Soft	*	*	*	*	*	1,264	0,738
	Soft	*	*	8 47,1	9 52,9	*		
	Mid	*	*	52 51,0	50 49,0	*		
	Hard	*	*	23 43,4	30 56,6	*		
	Very Hard	*	*	33 53,2	29 46,8	*		

* Marked cells are less than 5. Thus, they were not included in the analysis.

**Marked number etc. means that people number.

As described in Table 15, it was determined that the arm health status of office workers included in the study differed at a 95% confidence level by whether they have adjustable office chairs or not ($\chi^2 = 12.946$, $p = 0.012$). Consequently, it can be observed that office workers who have adjustable office chairs have better arm health than those who do not.

It was determined that the arm health status of office workers in the research diverged at a 95% confidence level in relation to the suitability of the office chair to the size of the body ($\chi^2 = 18.683$, $p = 0.000$). As a result, it can be stated that office workers who have chairs that fit the size of their bodies have better arm health than those who do not.

In addition, the arm health conditions of the office workers in the study are not affected by the hardness/softness of the seating elements, the armrest hardness/softness of the seating elements, or whether the seating elements have adjustable back support,

adjustable body support, adjustable neck support, adjustable arm support, adjustable height support. ($p > 0.05$).

The results of the Chi-square analysis performed to examine the differentiation of the general state of health of the individuals involved in the research according to the characteristics of the seating elements in the workplace are indicated in Table 16.

Table 16. Participants' General State of Health According to the Characteristics of the Seating Elements in the Workplace

“Table is continued in the following page.”

The Qualifications of the Seating Elements in the Workplace		General State of Health					χ^2	P
		Very Bad (%)	Bad (%)	Middle (%)	Good (%)	Very Good (%)		
Adjustable Back Support	Yes	*	6** 6.8	27 30.7	47 53.4	8 9.1	1,606	0,658
	No	*	16 7.7	74 35.7	105 50.7	12 5.8		
Adjustable Lumbar Support	Yes	*	2 2.8	19 26.4	45 62.5	6 8.3	7,076	0,070
	No	*	20 9.0	82 36.8	107 48.0	14 6.3		
Adjustable Neck Support	Yes	*	2 6.5	11 35.5	16 51.6	2 6.5	0,068	0,995
	No	*	20 7.6	90 34.1	136 51.5	18 6.8		
Adjustable Arm Support	Yes	*	6 6.7	33 36.7	45 50.0	6 6.7	0,393	0,942
	No	*	16 7.8	68 33.2	107 52.2	14 6.8		
Adjustable Seat Height	Yes	*	14 7.0	64 32.0	111 55.5	11 5.5	4,487	0,213
	No	*	8 8.4	37 38.9	41 43.2	9 9.5		
Taking the shape of your body	Yes	*	5 6.2	23 28.4	49 60.5	4 4.9	3,662	0,300
	No	*	17 7.9	78 36.4	103 48.1	16 7.5		
suitable for your own body measurements	Yes	*	9 6.2	40 27.4	86 58.9	11 7.5	6,895	0,058
	No	*	13 8.7	61 40.9	66 44.3	9 6.0		
Hardness/Softness of the Seat Element	Very Soft	*	*	*	*	*	7,792	0,051
	Soft	*	*	6 46.2	7 53.8	*		
	Mid	*	*	69 35.9	123 64.1	*		
	Hard	*	*	10 45.5	12 54.5	*		
	Very Hard	*	*	16 64.0	9 36.0	*		
Armrest	Very Soft	*	*	*	*	*	1,203	0,752

Hardness/Softness of the Seat Element	Soft	*	*	7 33,3	14 66,7	*		
	Mid	*	*	46 40,0	69 60,0	*		
	Hard	*	*	25 45,5	30 54,5	*		
	Very Hard	*	*	23 37,7	38 62,3	*		

* Marked cells are less than 5. Thus, they were not included in the analysis.

**Marked number etc. means that people number.

Based on Table 16, it was found that the general health conditions of the office workers in the study are not determined by whether the seating elements have adjustable back support, adjustable body support, adjustable neck support, adjustable arm support, height adjustment, suitability for different body sizes, the hardness/softness of the seating elements and the hardness/softness of the armrests ($p > 0.05$).

4.2. Findings of Qualitative Data Analysis

In this section of the research, there are statistical processes related to the data obtained with data collection tools used within the scope of qualitative research methods.

4.2.1. Opinions of the Respondents Participating in the Study on the Most Important Elements in Office Chair Design

The percentage and frequency distribution of the codes of the opinions of the respondents in the study regarding the most important elements in office chair design are given in Table 17.

Table 17. Distribution of the Codes of the Respondents' Opinions on the Most Important Elements in Office Chair Design

“Table is continued in the following page.”

Codes	Respondents
Ergonomics	A1, A2, A3, A4, A5
Material	A1, A2, A3
Aesthetic	A1, A2
Easiness / Comfort	A4, A5
Posture Preservation	A1
Colour	A1

Production Techniques	A3
Being purposeful	A4

Table 17 displays that "ergonomics (5)" stands out the most among the most important aspects in the design of the office chair by the respondents. Following, the respondents specified "material (3)", "aesthetic (2)" and "easiness/comfort (2)" issues, respectively. In addition, the respondents indicated "preservation of posture (1)", "colour (1)", "production techniques (1)" and "purposefulness (1)" among the important issues in office chair design.

Some of the statements of the respondents regarding the related statements are as follows:

"It is ergonomics and visuality. In terms of ergonomics, it is necessary to reform the static posture we lost while sitting in the work chair. Sitting constantly in the same position is the main problem with the office chair.... Lastly, it is very important that the chair appeals to the eye. Aesthetics, colour and the choice of material is also an important factor..." (Evaluation of the respondent with the A1 code).

"The most important thing we pay attention to in the design of the office chair is to enable the user to work comfortably for a long time without any trouble. That's why ergonomics is the most important element." (Evaluation of the respondent with the A5 code).

4.2.2. The Opinions of Respondents Participating in the Research on the Processes

Followed in Designing an Office Chair

The evaluations of the respondents in the study regarding the processes they followed in designing office chairs are given in Table 18.

Table 18. The Opinions of the Respondents Regarding the Processes Followed in Designing an Office Chair

Respondents	Process
A1	1. Checking suitability for different body sizes 2. Checking adjustability 3. Paying attention to the availability of armrests. 4. Paying attention not to having a hard sitting. 5. Paying attention to the use of mesh fabric.
A2	1. Starting with anthropometric data. 2. The user profile, the environment in which the product will be used, and the expected quality standard of the product are taken into account.
A3	1. Target audience selection, 2. Calculation of the cost, 3. Material selection, 4. Determination of ergonomic standards, 5. Ensurance of suitability for production capability
A4	1. To determine the user profile. 2. To determine the characteristics of the office chair, 3. The commencement of the research process, 4. The commencement of the concept process, 5. Presenting design alternatives, 6. Analysis of technical details 7. Focusing on adjustable details, 8. Cost control.
A5	1. Sketch phase 2. Construction phase of small models using a 3D printer 3. One to one size production

In Table 18, respondent A1 gave priority to checking the suitability of office chair for different body sizes at the office chair design stages. The respondent A2 stated that the process should be started with anthropometric data. Respondent A3 denoted that target audience selection of the office chair should be made. Respondent A4 similarly expressed that the user profile should be determined. Finally, respondent A5 emphasized the importance of sketch scanning primarily.

Some of the statements of the respondents are as follows:

"... started with anthropometric data. I start my process in this way. I would create a design setup, considering the user profile, the environment it will be used in, the standard of the product, and then continue my process." (Evaluation of the respondent with the A2 code).

"First of all, the user profile is determined... After the user profile is decided, the

properties of the office chair are determined. Having said that, the research process commenced. Then the concept process begins. ... So, we can only change certain forms. We tend to solve the technical details of the chair if it is approved for production after the design alternatives are formed. The details are completed by concentrating on adjustable details. Cost is also an important factor in this process." (Evaluation of the respondent with the A4 code).

"After the sketch phase, we move on to the mini model phase. We use a 3D printer. Then we reveal the product by using one-to-one production techniques. Our standard measurements vary from product to product." (Evaluation of the respondent with the A5 code).

4.2.3. Evaluations of the Respondents Participating in the Study on How They Establish the User-Office Chair Relationship

Table 19 summarizes the approaches used by the participants to establish user-office chair relationship.

Table 19. The Participants' Approaches Used to Establish User-Office Chair Relationship

Codes	Respondents
Ensuring adjustability / adjusting according to the user's needs	A1, A2, A3, A5
Suitability to body sizes	A1
No customization (private)	A2
Usage scenario / Intended purpose	A4

In Table 19, the respondents expressed their opinions on how the relationship between the user and the office chair is established. Accordingly, the respondents stated that the relationship between the user and the office chair was provided by "ensuring the adjustability of the office chair in line with the user's needs (4)". In addition, it was specified that "suitability to body sizes (1)" was taken into account in providing this relationship. The A2 coded user approached the establishment of this relationship negatively and denoted that the office chair is not "custom/private (1)".

Some of the opinions of the respondents regarding the related statements are as follows:

"It is the most important factor to be suitable for the user's body size. The relationship between them is established by adjusting the chair in line with their body size. " (Evaluation of the respondent with the A1 code).

"This relationship is provided by the adjustable chair. There are specifications such as height, back support, movement of the armrests in 3-4 directions, the sitting plane working in sync with the back. These adjustment features are added or removed according to the target audience." (Evaluation of the respondent with the A3 code).

4.2.4. Evaluations of the Respondents Participating in the Research Regarding the Suitability of the Office Chair for the User

The distribution of the codes of the respondents' evaluations on ensuring the suitability of the office chair for the user are given in Table 20.

Table 20. The Respondents' Evaluations on the Office Chair for the User

Codes	Respondents
Reference of international standards / norms	A3, A4, A5
Ergonomic standards	A1
Anthropometric Measurements	A1
Adjustable features	A2
Proper material selection	A5

In Table 20, the respondents indicated that "International standards/norms reference (3)" is taken to ensure that the office chair is suitable for the user. In addition, the respondents stated that "ergonomic standards (1)", "anthropometric measurements (1)", adjustable features (1) "are also taken into account in ensuring conformity. Finally, the respondent coded A5 explained that "proper material selection (1)" could provide the convenience of the office chair to the user.

Some of the statements of the respondents are as follows:

"We use international standards as a basis. We generally target 95% of people. If we want to address 5%, we need to make a special design." (Evaluation of the respondent with the A4 code).

"We provide by paying attention to the norms. It is necessary to choose the right shock absorber. The materials that can make the necessary settings for the product are selected. In this way, it fits the general audience. When you make all parts based on this system, a design suitable for the general user is achieved." (Evaluation of the respondent with the A5 code).

4.2.5. The Views of the Respondents Participating in the Study on the Continuation of Work-Related Musculoskeletal System Diseases

The distribution of the codes of the respondents' evaluations regarding the continuation of work-related musculoskeletal diseases are given in Table 21.

Table 21. The Respondents' Evaluations on the Continuation of Work-Related Musculoskeletal Diseases

Codes	Respondents
Insensible use	A2, A4, A5
Sitting constantly	A1, A4
Physiological fact	A3
Desk ergonomics	A4
Design Problems	A5

Table 21 shows that the reasons for the continuation of work-related musculoskeletal diseases are "insensible use of office furniture (3)", "sitting constantly (2)", "physiological fact (1)", "desk ergonomics (1)" and "design problems (1)".

Some of the opinions of the respondents regarding the related statements are as follows:

"Sitting constantly. The chair must have a feature that encourages movement. Human structure is not prone to sitting for long hours. Therefore, we need to make designs that increase the movement..." (Evaluation of the respondent with the A1

code).

"Users are not very aware of this. They may not know how to sit in the right posture..." (Evaluation of the respondent with the A2 code).

4.2.6. The Evaluations of the Respondents Participating in the Study on the Suitability of the Office Chair to the User and its Ergonomic Design

The distribution of the codes of the respondents' evaluations regarding the ergonomic suitability of the office chair to the user are given in Table 22.

Table 22. The Respondents' Evaluations Regarding the Ergonomic Suitability of the Office Chair to the User

Codes	Respondents
Ensuring comfort	A1
Adjustability	A2
Ergonomics	A3
Being functional	A4
Suitability to the User	A5

In Table 22, the respondents were asked to indicate what the ergonomic suitability of the office chair means for them. By the data, each of the respondents made specific evaluations. Among this group of people, the person marked with A1 indicated the significance as "ensuring comfort", the person marked with A2 as "adjustability", the person marked with A3 as "ergonomics", the person marked with A4 as "being functional" and the person marked with A5 as "suitability to the user".

The percentage and frequency distribution of the codes of the respondents' evaluations on the ergonomic design suitable for the user are given in Table 23.

Table 23. The Respondents' Evaluations on the Ergonomic Design Suitable For the User

Codes	Respondents
User Characteristics	A1, A5
Additional Parts	A2
Custom Design	A3
User Satisfaction	A4
Being Ergonomic	A5

Table 23 expresses that the respondents learn "user features (2)", use "additional parts (1)", make "special design (1)", pay attention to "user satisfaction (1)" and attach importance to "being ergonomic (1)" in order to constitute an office chair that is ergonomic and suitable for the user in the design phase.

Some of the statements of the respondents are as follows:

"It is to provide the comfort of the person using it. We provide this in design by considering user characteristics." (Evaluation of the respondent with the A1 code).

"The design discipline is based on ergonomics. It is ensured by designing products that are acceptable to everyone within the limits of furniture and industrial design. In order to be 100% suitable for the person, it is necessary to make a special design." (Evaluation of the respondent with the A1 code).

"The most important feature of the office chair is ergonomics, after all. So, it must be ergonomic and suitable for the person. We provide this with adjustable features in the design." (Evaluation of the respondent with the A1 code).

4.3. Discussion

In this study, quantitative research methods were used to determine the health problems of individuals working in the office environment caused by office furniture and qualitative research methods were used to gain information about the design processes of office chairs in office furniture. The participants of the survey consisted of individuals of age 18 or more and working in an office environment. Accordingly, 300 office workers working in the furniture sector in Turkey and United Arab Emirates

constitute the sample group of the study. For the qualitative aspect of the research, five office furniture design experts were interviewed.

44.3% of office workers that participated in this study have been in the workforce for 16 years or more, while 39.0% have been with their current employers for 1-5 years. 42.3% of the office workers in the study had moderate neck health, 45.0% had moderate back/spine health, 39.7% had good arm health and 50.7% had a good general state of health. 70.3% of office workers in the research do not have adjustable back support, 75.7% did not have adjustable lumbar support, 89.7% did not have adjustable neck support, and 69.7% did not have adjustable arm support in their office chairs. 67.7% of the office workers who took part in the research used a height-adjustable office chair. In addition, office chairs of 72.7% of the participants were not ergonomic and did not take the shape of the body and 51.0% of office workers thought that the office chair was not suitable for their body size. Again, 75.7% of the participants stated that the office chair they were using is neither hard nor soft, and 44.0% remarked that the arms of the office chair were neither hard nor soft.

In the study, 50.3% of office workers specified that sometimes they kept a good work posture while working, 33.3% often sat in one position for a long time, 35.7% sometimes sat with lifted shoulders for more than two hours a day, 39.0% sometimes in an awkward body posture, 37.3% often perform repetitive tasks, 34.7% sometimes find their job physically exhausting, 39.0% place their hands in a straight line with their lower arms sometimes while working, 36.0% often work while their heads is bent to the side, 37.7% sometimes twist their heads towards to left or right, whereas 26.3% seldom twist their heads towards to left or right during work, 39.3% sometimes twist their torso towards the right or left, lastly 40.3% sometimes their torsos are in an asymmetrical position while working. 36.2% of the responses of office workers in the study about the most uncomfortable seating elements in the working environment are chairs, 18.1% computers, 17.9% tables, 14.9% others, and 12.8% mouse.

In the study, it was found that the neck, lumbar/spine, arm health and general health of male office workers were better than women. The time spent sitting at work by office workers in the research was found to have a negative relationship with their health status in the neck and lumbar/spine. In other words, it was determined that by the increase in the sitting time of the employees and the increase in the neck complaints

was observed to be directly proportional.

In the research, it was found out that office workers who have adjustable lumbar support in their office chairs, adjustable seat height, and suitable seating elements for their body size have better neck health than those who do not.

Based on the findings of the study, office workers who have office chairs that can conform to the shape of the user's body have better lumbar/spine health than those who do not. The lumbar/spine health of the office workers who have suitable chairs for their own body measurements is better than the office workers who do not have them, and the lumbar/spine health of the office workers whose seating elements have hard armrests is better than those whose seating elements have either medium or very stiff armrests.

In the study, it was found that the arm health of office workers with adjustable office chairs or chairs that fit the size of their bodies was better than those without such chairs

The most important element in office chair design, in line with the interviews with office furniture design experts, is ergonomics, followed by material. The respondent A1 gave priority to checking the suitability of the office chair for different body sizes in the stages of office chair design. Respondent A2 stated that the process should be started with anthropometric data. Respondent A3 remarked that the target audience selection of the office chair should be made. Respondent A4 similarly denoted that the user profiles should be determined. Lastly, respondent A5 expressed that a sketch scan should be done primarily to make brain storming and see your design ideas visually. The respondents pointed out that the relationship between the user and the office chair can be established by ensuring that the chair can be adjusted for the user. They stated that international standards/norms, ergonomic standards, and anthropometric measurements are taken as reference in order to ensure the convenience of the office chair to the user. They cited the insensible use of office furniture, the need to sit constantly and the physiological facts of the human being as the main reasons for the continuation of work-related musculoskeletal diseases. It was clearly seen in the evaluations of the interviews that the characteristics of the users should be determined well in order to ensure the suitability of the office chair at the design stage.

4.4. Design Proposal

Office furniture design is a product group designed with emphasis on ergonomic conditions. Office furniture includes chair, table, computer and mouse. In this study, the focus was the question why musculoskeletal disorders persist and its relationship with design, so factors causing disorders were investigated. Based on research, analysis, surveys and interviews, the office chair was determined as the major office furniture which affects work related musculoskeletal disorders. Thus, a specific office chair was examined for a design proposal.

According to the survey results, it was observed that not everyone has the same type of office chair. At the same time, it has been determined that everyone has different needs and health problems. This idea is supported with the designer interviews. Furthermore, it is not possible to make a special design for each person, so typically the design considers the average person. Office chair plays a major role in preventing musculoskeletal disorders if it is used correctly, and it has adjustable pieces to provide the user health condition. Therefore, the person needs to know the office chair and at the same time get to know his/her own body. For example, not everyone may need neck support, but for some workers, neck support can be very important. It is necessary for the person to analyse this and use the most suitable office chair for better comfort. For this reason, a design proposal is presented where the user can interact with the office chair in order to evaluate the existing office chair and customize it.

In this design proposal, sensors are designed that can be placed at specific touch points of the office chair. These points were determined according to the research result developed by BMA Ergonomics (Roossien et al.,2017). Pressure sensors should be placed on the seat surface (4 sensors) and on the backrest (2 sensors). The core requirements of sensors are high dynamic range and high precision. Sensors perceive the specific movements and produce a signal with movements of user. Each sensor is connected in series with a resistor and a low voltage is applied between the two series, the change in resistance is converted into a voltage change, thereby motion sense signals are produced (Cheng, 2013). The sensors have the ability of system to recognize a set of predefined postures and simple actions. They detect optimal support, upper back contact, lower back contact, body too far left or right. Also, they perceive

the actions such as nodding, typing on the keyboard, moving, clicking the mouse and not sitting (van der Doelen et al., 2011). Thus, all body movements can be analysed. In this study, the difference of design is that these sensors can be used in every office chair and they are activated with a mobile phone application. Feedbacks are sent to the app based on an algorithm (Roossien et al., 2017) that calculates the variation between sitting positions, sitting time, and movements.



Figure 2. Sensor(left) and Sensor Silhouette



Figure 3. The sensor placed on an office chair

The user scenario of the design proposal is as follows in order to make the product affordable, only sensors will be purchased by the user. The user who purchases the sensors can activate the downloaded application by reading the QR code on the product. The application guides the user for the necessary steps. In the first step, the chair will be identified by taking a photograph of the office chair. Then, the information of the chair will be entered. This information includes whether there is neck, waist and back support, whether the sitting height and arm support height is adjustable, whether the sitting angle is adjustable or not, this information is recorded on application. Based on the information provided, the user will be guided to place the sensors at the required points. After this stage, the user and the office chair must be matched, so the user must enter his/her personal information into the application. This information includes age, gender, weight, height, working hours and current health problems. Accordingly, the application guides the user to adjust the sitting position with the help of anthropometric standards. After all these matching steps are completed, the user's movements during working hours are recorded at 1-second intervals. This data is analyzed in the range of 30-60 minutes. This period was determined based on the result of the experimental BMA research conducted in the Netherlands.(Roossien,2017).

To be able to perform user analysis, data must be recorded for an average of 6.30 hours, for 5 working days. This period was determined based on the average working hours and days of the office workers' answers in survey. After the specified time is completed, the product starts to give feedback about the user's sitting positions. The product provides feedback on standing up, exercise, incorrect sitting posture and progress of user. For example, according to the recorded data, it may be determined that the user needs neck support. In this regard, the application may suggest a neck support or support the user with daily neck exercises. This application does not only give negative feedback, it also gives encouraging feedback on its progress in order to provide a long-lasting experience to the user.

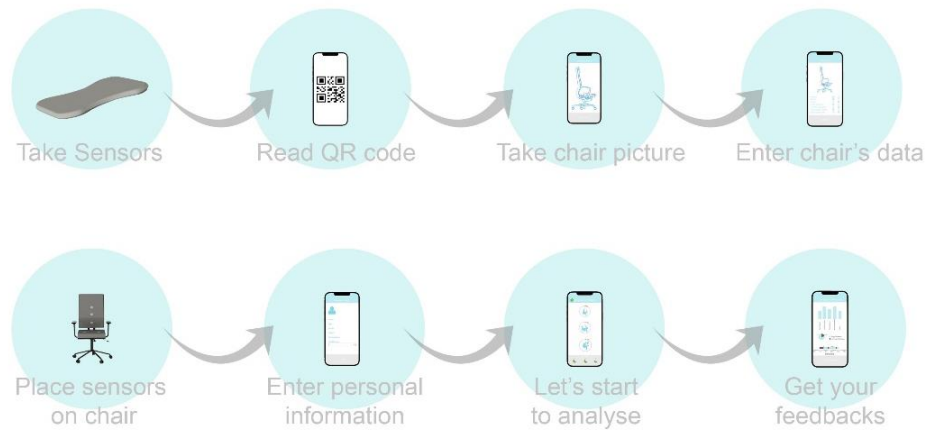


Figure 4. User Scenario

There are office chairs that offer personalized designs, but the interviews with the designers show that the budget is also an important criterion for office chairs. It has been determined that as the number of features increases, the price also increases in direct proportion. This is one of the reasons why the user does not have an office chair that provides all needs. For this reason, with the developed design proposal, it is aimed to minimize the work-related musculoskeletal disorders of office workers and to offer a solution.



Figure 5. Chair and Personal Data Information Pages

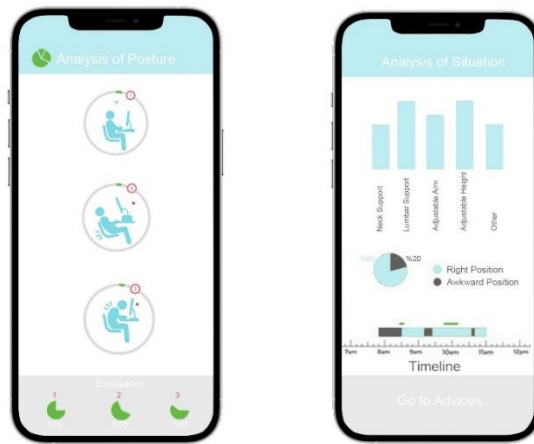


Figure 6. Awkward Posture and Analysis

CHAPTER 5: CONCLUSION

Ergonomics is a branch of science that aims to research and develop the harmony of characteristics. Office furniture designed according to ergonomics principles offers important health benefits for employees. Most of the employees spend many hours in the office, so office furniture is a significant product to make employees' work easier. In this study, the effects of office furniture design on human health were investigated and the office chair was focused on.

Since the human body structure is not suitable for sitting all day, human health is adversely affected by sitting for long periods of time. A lot of research has been done to adapt a product that affects human health so much to human ergonomics. That's why according to literature and interviews, anthropometric measurements are primarily taken into account in office chair design. Designers design by considering these anthropometric measurements. In office chair design, the seat, waist, arms and height should be in harmony with the human body.

Research shows that the evolution of the office chair design has gradually adapted to the human body, so user-oriented studies have been conducted to identify people's needs. The demands and expectations of different people, arising from different needs, also influence the design of office chairs. In order to reach a broad understanding, a survey was conducted with office workers in Turkey and the United Arab Emirates. SPSS program was used to analyze the survey results. It was determined that many office chairs used in office environments are not suitable for employees and they can cause discomfort. In this context, the health status of people was analyzed. As a result of the analysis, it was observed that some demographic characteristics were effective. For example, it was determined that the general health status of women was worse than that of men. In addition, the negative effect of increasing sitting time on health status was analyzed. Survey results indicate that office workers who have adjustable lumbar support in their office chairs, adjustable seat height, and suitable seating elements for their body size have better neck health than those who do not. It was also determined that increased sitting time increased neck complaints. Professional designers were also interviewed in order to focus on these health problems and offer a design-oriented solution proposal. Based on the surveys and interviews, people who

are working in offices generally do not have a choice over the furniture which they use. Furthermore, constraints such as materials, production technologies, and cost prevent user-oriented design.

Since not every employee can choose a suitable chair in the business environment, it is aimed to make an existing office chair suitable for the user. This study proposes a solution to improve the office chair design according to user, so it differs from others in the field in that it focuses on the user rather than the product.

Nowadays, design methods have developed along with technology, and many innovative designs have emerged. Wearable technology is one of the leading innovative design trends. Thanks to wearable technology, the user can be determined as the focal point and designs can be directed in this way. In this study, a design proposal is presented that can be developed by presenting a user scenario and sensor design by utilizing the design inputs of wearable technology. Within the scope of this thesis, it is hoped that it will inspire research and evaluation of the benefits of the design proposal. This study was carried out with questionnaires and interviews due to pandemic conditions. In order to reach more scientific data, one-to-one models can be used. For instance, physiological data can be measured and more experimental data can be added this type of research and features can be added to this design proposal to contribute to its development.

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Appendix A

Survey Form

Dear participant,

The following survey has been prepared to gather valuable information for my Master's Thesis. It is estimated to take only ... minutes. Your personal information will be kept anonymous and will not be used anywhere. Thank you for your support and contribution to this research.

1. Gender:

☐ Female ☐ Male

2. Your age:

-.....

3. Your total experience in your working life:

☐ Less than one year ☐ 1-5 years ☐ 6-15 years ☐ 16 years and over

4. How many years have you been working at your current institution?

☐ Less than one year ☐ 1-5 years ☐ 6-15 years ☐ 16 years and over

5. Height (cm):

6. Weight (kg):

7. Approximately how many hours do you work in a sitting position a day?

-.....

8. How would you evaluate your orthopedic health status related to your neck?

☐ Very Bad ☐ Bad ☐ Middle ☐ Good ☐ Very Good

9. How would you evaluate your orthopedic health status related to the waist / spine area?

☐ Very Bad ☐ Bad ☐ Middle ☐ Good ☐ Very Good

10. How would you evaluate your orthopedic health status related to your arms?

☐ Very Bad ☐ Bad ☐ Middle ☐ Good ☐ Very Good

11. How would you evaluate your general health condition in the last year?

☐ Very Bad ☐ Bad ☐ Middle ☐ Good ☐ Very Good

Questions About Seating Elements

Regarding the office chair or seat that you use at your workplace;

1-Is there an adjustable back support?

☐ Yes ☐ No

2-Is there an adjustable lumbar support?

☐ Yes ☐ No

3-Is there an adjustable neck support?

☐ Yes ☐ No

4- Is there an adjustable arm support?

☐ Yes ☐ No

5-Can the seat's height be adjusted from the ground?

☐ Yes ☐ No

6-Does your office chair take the shape of your body?

☐ Yes ☐ No

7-Do you think that it is suitable for your own body measurements?

☐ Yes ☐ No

8-How do you think the seat is?

☐ Very soft ☐ Soft ☐ neither soft nor hard ☐ hard ☐ Very hard

9-How are the arm sleeves?

☐ Very soft ☐ Soft ☐ neither soft nor hard ☐ hard ☐ Very hard

Body Posture

10- During my work I keep a good work posture.

☐ Never ☐ Seldom ☐ Sometimes
☐ Often ☐ Always



11- At work I sit for long hours in one position.

☐ Never ☐ Seldom ☐ Sometimes
☐ Often ☐ Always

12- For more than two hours per day I sit with lifted shoulders.

☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

13- During my work I sit in awkward postures.

☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

14- In work I perform repetitive tasks

☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

15- I find my job physically exhausting.

☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

16- When my hand is placed in a straight line with my lower arm.
☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

17- When I work my head is bent.
☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

18- During my work, my head is twisted towards the left or right.
☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

19- During my work, my trunk is twisted towards the left or right.
☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

20- During my work, my trunk is in asymmetrical position.
☐ Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Always

21- Which is uncomfortable for you while working? (You can mark more than one option.)
☐ Chair ☐ Table ☐ Computer ☐ Mouse ☐ Other

22- What is the significant feature for office furniture for you?
please write your order of preference for the following choices
☐ Material ☐ Comfort ☐ Budget

Appendix B

Interview Form

1. Gender:

(☐)Female (☐) Male

2. Age:

-.....

3. Profession:

-.....

Open-Ended Interview Questions

1. What is the most important element in office chair design?

2. What kind of process do you follow while designing the office chair?

3. How do you establish relevance between user and office chair?

4. Is every office chair suitable for every user, how do you ensure this?

5. Many award-winning ergonomic designs have been made, but related musculoskeletal disorders still continue, what do you attribute the reason for this situation?

6. What does it mean for you that the office chair is ergonomically suitable for the person and how do you ensure this in your design?

Appendix C

ETHICS COMMITTEE APPROVAL REPORT

SAYI : B.30.2.EÜ.0.05.05-020-126

28.04.2021

KONU : Etik Kurul Kararı hk.

Sayın Melis Çobanyıldızı,

“The Role office Furniture Design in Occupational Health and Ergonomically Feasible Office Chair Solutions” başlıklı projenizin etik uygunluğu konusundaki başvurunuz sonuçlanmıştır.

Etik Kurulumuz 19.04.2021 tarihinde sizin başvurunuzun da içinde bulunduğu bir gündemle toplanmış ve projenin incelenmesi için bir alt komisyon oluşturmuştur. Projenizin detayları alt komisyon üyelerine gönderilerek görüş istenmiştir. Üyelerden gelen raporlar doğrultusunda Etik Kurul 28.04.2021 tarihinde tekrar toplanmış ve raporları gözden geçirmiştir.

Sonuçta 28.04.2021 tarih ve 120 numaralı **“The Role office Furniture Design in Occupational Health and Ergonomically Feasible Office Chair Solutions”** konulu projenizin etik açıdan uygun olduğuna oy birliği ile karar verilmiştir. Bununla birlikte çalışanların seçiminin rastgele olduğu belirtilmiş, bunun nasıl gerçekleşeceği ve bağlantının nasıl paylaşılacağı belirtilmesi, isteğe bağlı bir katılım söz konusu olsa bile, katılımcılardan izin alınmasında faydalı olacağı tavsiye edilmiştir.

Gereği için bilgilerinize

sunarım.Saygılarımla.



Prof. Dr. Elvan Özkavruk Adanır