EVALUATION OF THE ERGONOMICS CHECKLIST FOR OFFICE CHAIR

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ABSTRACT

Sitting at work for a long time in the office can cause musculoskeletal disorders (MSDs). Sustaining any static posture, such as sitting can affect the human body in terms of increasing pressure on the muscles, ligaments and other soft tissues of the musculoskeletal system. This research clarifies the development of a new assessment tool for ergonomic office chair evaluation checklist to investigate the risk factor of office workers at the office. The purpose of this study is to propose and develop an ergonomic assessment tool capable of quantifying subjective occupant sitting discomfort during office work and to evaluate the proposed ergonomic assessment tool in terms of validity test and reliability test. The initial development of the new tool involved the following procedures. Firstly, the new assessment tool was developed based on literature review. This is followed by the identification of office chair parameters, questionnaire design, grand score and action level development and the development of the observational tool office ergonomic chair assessment (OFFECA) prototype. Secondly, the psychometric properties were evaluated by administering the questionnaire to 50 office workers in ten offices around UTHM. The reliability of the observation was assessed through internal consistency. Construct validity was analyzed by content validity, which is by obtaining the opinion of expert judges in the ergonomic field. Concurrent validity was also used in this prototype to find out the relationship between existing tools and the new assessment tool. Reliability was determined based on the internal consistency of the prototype verified using Cronbach's alpha that is 0.832 and the range Cronbach's alpha values was 0.814 to 0.839. The construct validity analysis using Pearson's Correlation shows correlations are significant at ($p< 0.01$) and ($p< 0.05$) between the existing tools and the prototype of the office ergonomic chair assessment. To conclude, results indicated that the new assessment tool had good psychometric properties for use in studies involving office workers.

ABSTRAK

Duduk di tempat kerja untuk masa yang panjang di pejabat boleh menyebabkan gangguan kecederaan muskuloskeletal (MSDS). Mengekalkan sebarang postur statik, seperti duduk yang boleh memberi kesan kepada tubuh manusia dari segi peningkatan tekanan ke atas otot-otot, ligamen dan lain-lain tisu lembut sistem muskuloskeletal. Kajian ini menjelaskan pembangunan alat penilaian yang baru untuk senarai semak penilaian ergonomik kerusi pejabat untuk menyiasat faktor risiko pekerja pejabat di pejabat. Tujuan kajian ini adalah untuk mencadangkan dan membangunkan satu alat penilaian ergonomik yang mampu mengukur subjektif penghuni yang duduk tidak selesa dalam kerja-kerja pejabat dan untuk menilai dan mencadangkan alat penilaian ergonomik dalam kajian kes yang menggunakan ujian kesahan dan ujian kebolehpercayaan. Pertama, pembangunan alat penilaian baru daripada kajian literatur. Diikuti dengan mengenal pasti parameter kerusi pejabat, mereka bentuk bentuk soalan itu, membangunkan penilaian skor dan tahap tindakan, dan prototaip pemerhatian penilaian ergonomik kerusi pejabat (OFFECA) telah dibangunkan. Kedua, ciri-ciri psikometrik dinilai dengan mentadbir soal selidik kepada 50 pekerja pejabat di sepuluh pejabat di seluruh UTHM ini. Kebolehpercayaan pemerhatian ini telah dinilai melalui konsistensi dalaman. Membina kesahihan dianalisis dengan kesahan kandungan, yang meminta pendapat hakim pakar dalam bidang ergonomik dan kesahan serentak juga digunakan dalam prototaip ini untuk mengetahui hubungan antara alat-alat yang sedia ada dan alat penilaian baru. Kebolehpercayaan ditentukan berdasarkan ketekalan dalaman prototaip yang telah disahkan menggunakan *Cronbach's alpha* adalah 0.832 dan nilai julat *Cronbach's alpha* adalah 0.814 hingga 0.839. Analisis kesahan konstruk menggunakan *Pearson Correlation* menunjukkan korelasi yang signifikan di ($p < 0.01$) dan ($p < 0.05$) di antara alat yang sedia ada dan prototaip penilaian ergonomik kerusi pejabat. Oleh itu, keputusan menunjukkan bahawa alat penilaian yang baru mempunyai ciri-ciri psikometrik yang baik untuk digunakan dalam kajian yang melibatkan pekerja pejabat.

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MSDs	Musculoskeletal Disorders
CTDs	Cumulative Trauma Disorders
SPSS	Statistical Package for Social Sciences
UTHM	Universiti Tun Hussein Onn Malaysia
FKMP	Fakulti Kejuruteraan Mekanikal Dan Pembuatan
FKEE	Fkulti kejuruteraan elektikal Dan elektronik
FSKTM	Fakulti Sains Komputer and Teknologi Maklumat
FSTPI	Fakulti Sains Teknologi dan Pembangunan Insan
PPS	Pusat Pengajian Siswazah
PPD	Pusat Pengajian Diploma
FPTV	Fakulti pendidikan Teknik dan Vokasional
PS3	Postgraduate Office 3
UKM	Universiti Kebangsaan Malaysia
UTEM	University Teknikal Malaysia Melaka
ANSI	American National Standards Institute
HFES	Human Factor Ergonomic Society
SD	Standard Deviation

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Professional workers nowadays spend about 70 percent (70%) of their time sitting in the offices, which is usually for 45 minutes at a stretch (Miller, 2001). In the meanwhile, desk bound workers such as telephone operators, telemarketers and data entry workers spend nearly 100 percent (100%) of their working time sitting on the chair (Miller, 2001). Sitting comfort is a subjective perception and sensory experience, which may not necessarily correspond with the objective layout of office chairs (Legg, 2002). This is because of the limited awareness and cognitive processing of sensory stimulation provided by the ergonomic features of the chairs (Looze, 2003). Features of office chairs, such as the shape of the seat and back, the thickness and density of foam cushions, or type of cushion cover, provides varieties of sensory effects, which are mainly tactile and kinesthetic in nature. Input from this sensory system, however, tends to create more diffuse and holistic perceptions than input from the visual or auditory sensory system (Mueller, 2010).

It is common in the offices that the male clerk shall stand while they are working. The concept was then changed and it is customary to sit while working. (Kroemer, 2001). Yet, low back pain and musculoskeletal irritation, often together with eye strain, are usual complaints from persons who operate computers or do other tasks while sitting in the office. The Liberty reported in 2009 that hand, wrist and shoulder disorders were a fast-growing source of disability in the American workplace, stemming in large part from the dramatic increase in office technologies in the latter part of the twentieth century. “As computers have become a staple in the workplace, work related musculoskeletal irritation has increased” (Liberty, 2009).

This is a serious, disappointing and utterly avoidable development that runs counter to all ergonomic knowledge.

Modern offices has little resemblance to the rooms century ago in which the clerks labored. Clerks at that time is a man who stood by the desk and use ink to write letters and hand printing entries in the ledger (Kroemer, 2001). By the middle of the twentieth century, Females employees are mostly handling the clerical roles and working while standing changed to sit. The idea of 'erect sitting is healthy sitting" had prevailed over standing upright, and office furniture was designed for this body position (Kroemer, 2001). About 120 years ago, body posture had become a great concern to physiologists and orthopedists. In their opinion, the upright (straight, erect) standing posture was balanced and healthy while curved and bents backs were unhealthy and therefore had to be avoided, especially to youngsters (Kroemer, 2001). Consequently, "straight back and neck, with the head erect" became the recommended posture for sitting and, logically, seats were designed to bring about such upright body position (Kroemer, 2001).

Working in an office typically involves spending a great deal of time sitting in an office chair. This position will adds stress to the structures in the spine (Lefler, 2004). Therefore, to avoid developing or compounding back problems, it is important to have an office chair that is ergonomic and supports the lower back and promotes good posture (Lefler, 2004). There are many types of ergonomic chairs available to be used in the office. None of the office chair design is necessarily the best, but there are some things that are very important to look for in a good ergonomic office chair. These will allow the individual user to make the chair work well depending on their specific needs (Lefler, 2004).

1.2 Problem Statement

When a person sits, all the body parts interact in a chain of mechanical events with many short-term and long-term stresses (Miller, 2001). The physical causes of back discomfort or cumulative back pain are believed to stem from the same kinds of ergonomic stresses, or risk factors that cause musculoskeletal disorders (MSDs) of the upper limbs (Miller, 2001).

Sitting at work for a long time in the office can cause the musculoskeletal disorders (MSDs) injury. Sustaining any static posture, such as sitting can affect the

human body in terms of increasing the pressure on muscles, ligaments and other soft tissues of the musculoskeletal system. Common symptoms presented as discomfort and pain on the back, neck and shoulders have been reported by workers who sit for most of their workday. If no intervention is made, this could continue for times causing chronic effect that bring life changing injuries. Nevertheless, musculoskeletal disorders (MSDs) such as back pain and other health effects associated with prolonged sitting can be eliminated or minimized through well designated chairs and other aspects of workstations and design work. In general, an ergonomic checklist has been used to assist office workers to select chairs that can reduce injury and back pain. After that, this assessment tool can propose the users to utilize a better chair design that have adjustable armrest, lumbar support, adjusted backrest at 20 degrees and adjustable seat height with the range of 39 cm to 52 cm.

1.3 Objectives of the Study

This research has a several important objectives to achieve, namely:

1. To propose and develop an ergonomic assessment tool capable of quantifying subjective occupant sitting discomfort during office works.
2. To evaluate the proposed ergonomic assessment tool in terms of validity test and reliability test.

1.4 Scope of Study:

The scopes of this research project are includes:

1. The development of this tool only focused on the parameters of the office chair such as chair, seat height, seat pan width and depth, lumbar support, backrest, and armrest.
2. Type of assessment tool has been developed only focused on the observational tool for subjective occupant sitting discomfort.
3. The validity and reliability study only focused on the office workstation while sitting at work.
4. Five Likert scale has been used in development of the scoring system for the prototype office ergonomic chair assessment and three Likert scale for actual version.

5. The sample size are 50 office workers.
6. Internal consistency using Cronbach's alpha has been used in reliability test.
7. Content validity and concurrent validity has been used in validity testing.
8. Conducted the survey around the UTHM which is FKMP, FKEE, FSKTM, FPTV, FSTPI, PPD, PPS, Library UTHM, Postgraduate Room, and Rapid Prototyping Lab.
9. Analyze the data using Statistical Package for Social Sciences (SPSS) software version 17.0.

1.5 Significant of Study

The significance of this research is to quantify subjective occupant discomfort in office seating. The result of observational tool can be used in the evaluation of office seat design. In addition, the results will be the best tool for discomfort observational tool of prolonged sitting on the office chairs in order to fulfill the human ergonomic requirement and avoid problems that could occur with musculoskeletal disorders (MSDs). This research can be used to provide an ergonomic chair design for office workers who sit on the chair for a long period of time eight to 24 hours. Hence, the proposed observational tool of comfort in sitting for office workers during long working time could possibly reduce bad effects on human musculoskeletal system, enhance safety and also comfort for them. This study hopefully helped industry in order to produce a better chair design for office seating which can reduce the injury**.** Furthermore, this observational tool will be useful for future research related to ergonomic evaluation and design of more user-friendly office chair related to prolonged sitting comfortability.

1.6 Gantt Chart

Table 1.1 shows the Gantt chart for project planning for Master Project 1. Allocation of time for planning Chapter 1 is 3 weeks. Chapter 1 covers the background of study, problem statement, objectives of study, scope and significance of this research study. Time allocation used in Chapter 2 is 4 weeks. Chapter 2 describes the literature review covering ergonomic issues and contained case studies related to musculoskeletal disease risk when using the chair while working at the office.

Meanwhile, the time taken for Chapter 3 is about 3 weeks. Chapter 3 describes the methodology that will be used to gather parameters and do the scoring. Meanwhile, planning for meetings with supervisors is done weekly.

Table 1.2 shows the Gantt chart for project planning for Master Project 2. From the third to the ninth week, the validity tests is run, which includes getting the feedback from an expert review in the ergonomic background. The reliability testing is also done, which involves running the survey at the offices around UTHM.. For 3 weeks, which is from the sixth to the ninth, the data is analyzed using SPSS software 17.0 version. Writing and preparing 1st draft to submit to supervisor takes three weeks. 1st draft is submitted at the 11th week to be checked by supervisor. At week 14, the paper is submitted to the panel and is presented at week 15.

Table 1.1: Gantt Chart PS1 1/2014/2015

Activity / Task	Month	September				October				November				December		
	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Meeting with supervisor.	Planned								MID SEMESTER BREAK							
	Actual															
Choose the project title.	Planned															
	Actual															
Research, study and understand the project title.	Planned															
	Actual															
Submission of Proposal PS1 project title.	Planned															
	Actual															
Literature review (find journal, thesis, book and internet that related to studies).	Planned															
	Actual															
Identification of the office chair parameter, design the question and develop the grand score and action level.	Planned															
	Actual															
Done prepare the prototype of questionnaire (ergonomic office chair evaluation checklist)	Planned															
	Actual															
Submit 1st draft PS1 report to supervisor.	Planned															
	Actual															
Submit a final draft PS1 report to supervisor.	Planned															
	Actual															
Submit PS1 report to examiners (seminar panel).	Planned															
	Actual															
Presentation PS1.	Planned															
	Actual															

Table 1.2: Gantt Chart PS2 2/2014/2015

Activity / Task	Month	March				April				May				June		
	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Meeting with supervisor.	Planned								MID SEMESTER BREAK							
	Actual															
Conducted the validity tests (getting feedback from an expert review in the ergonomic background)	Planned															
	Actual															
Conducted the reliability testing (Run the survey at the office around UTHM)	Planned															
	Actual															
Analyze the data using SPSS software 17.0 version.	Planned															
	Actual															
Writing and prepare 1st draft to submit to supervisor	Planned															
	Actual															
Submit 1st draft PS1 report to supervisor	Planned															
	Actual															
Submit a final draft PS1 report to supervisor.	Planned															
	Actual															
Submit PS1 report to examiners (seminar panel).	Planned															
	Actual															
Presentation PS2.	Planned															
	Actual															

1.7 Thesis Organization

This thesis is divided into three chapters as shown in Figure 1.2. Chapter 1 is an introduction to the study that describes the background of study, problem statement, objectives of study, scope of study, significance of study, Gantt charts and thesis organization. Generally, Chapters 1 is about submitting basic idea and giving a preliminary study for the entire project.

Chapter 2, is a summary of how the study was done in connection with the research topic. The ergonomic issues are also briefly described. In overall the information is obtained from various sources such as journals, books, magazines, articles, reports and thesis.

In Chapter 3, in order to achieve the objectives of the study, several methodologies were used. This chapter describes the methodology used in the implementation to develop assessment tools for sitting discomfort. For the assessment tool to be used as an evaluation of the ergonomics checklist for office chairs, there are methods that need to be carried out. As a result, scoring system is derived from the parameters that have been identified and prototyping tool evaluation is also carried out in stages during the writing of this chapter. After that, the reliability and validity of the prototype is checked. From the result of validity and reliability testing, Some improvement as in changes to the question for the prototype has been made. The actual version 1 for ergonomic office chair evaluation checklist were produced when the chair, seat height, lumbar support, backrest and armrest section needed some improvement and is repaired.

Chapter 4 is about a result of the methodology that has been selected in the previous chapter. Then, those results is discussed to better understand the problem discovered within the survey at the offices. The inputs from users and UTHM's office staff such as administrative officers, office secretaries and others were gathered in the survey. The observation is also discussed in this chapter.

This chapter will go through the conclusion for analysis that had been done. The objectives of this evaluation thus is measured whether it has been achieved and solved or not throughout this research. Recommendation for future needed for further research concerning the ergonomic evaluation is emphasized.

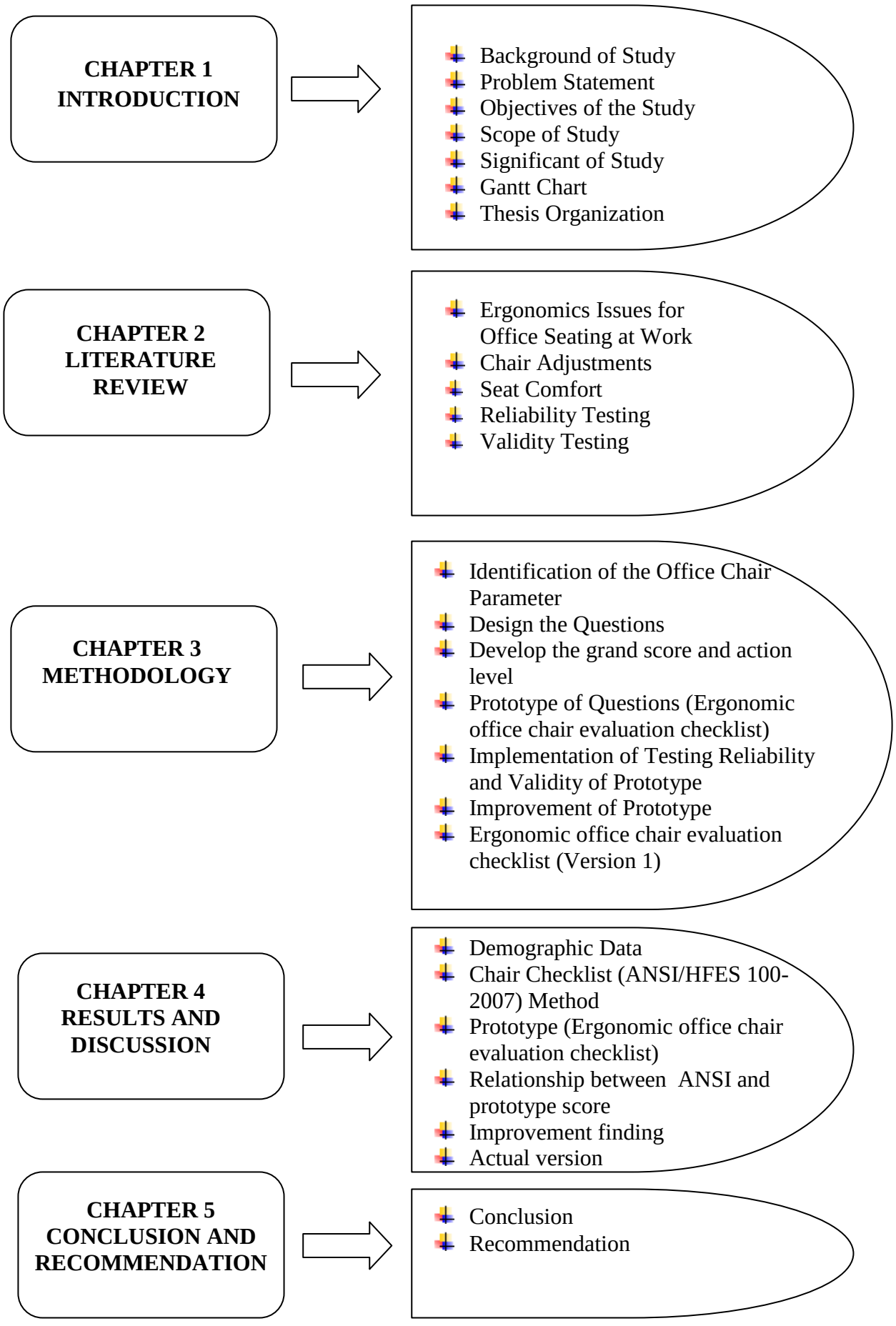


Figure 1.1: Thesis Organization

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review assessed the research development on the effect of the seating for workers at the office. The research will focus on parts of the seats that can provide comfort to employees in the office. Among the topics that has been studied is about the types of questions and how the questions will be provided with. This chapter was review previous journals, books, articles and etc. Firstly, Section 2.2 is about ergonomics issues of the office seating at work with its sub-topics, Section 2.2.1 on musculoskeletal disorders (MSDs) for office seating and Section 2.2.2 on cumulative trauma disorders (CTDs). Next, Section 2.3 is about chair adjustments that have four subtopics consisting of Section 2.3.1 on usability and range of seat pan depth adjustment, Section 2.3.2 on usability and range of backrest adjustment while sitting, Section 2.3.3 on armrests support range of adjustability and Section 2.3.4 on feeling comfortable. On the other hand, Section 2.4 focused on seat comfort which includes Section 2.4.1 on seat pan or cushion comfort, Section 2.4.2 on backrest cushion comfort and Section 2.4.3 on armrest comfort will also explained. Section 2.5 in furtherance is about reliability, which is having three types were test- retest under stability over time, alternative forms under equivalence and split-half, interrater and cronbach alpha under internal consistency. Last is Section 2.6 which explains about validity where having four types, which is statistical conclusion validity, internal validity, construct validity and external validity. Construct validity have two types which are face validity and content validity under translation validity. Predictive validity, convergent validity, discriminant validity and concurrent validity under criterion related validity.

2.2 Ergonomics Issues of the Office Seating at Work

Back pain is one of the most common work-related injuries and is often caused by ordinary work activities such as sitting on office chair or heavy lifting (John, 2000). By applying ergonomic principles to the study of the workplace it may help workers preventing work-related back pain and injury and a healthy back. John stated the goal of an ergonomics program in the industry is to adapt the workplace to a specific worker, depending on the job description, required tasks, and physical makeup of the employee performing those tasks. There are Two types of situations which can typically cause people to begin having back pain or to sustain a back injury while working (John, 2014):

Non-accidental injury, where pain arises as a result of normal activities and requirements of the task. Poor body mechanics (such as slouching in an office chair), prolonged activity, repetitive motions, and fatigue are major contributors to these injuries. This may occur from sitting in an office chair or standing for too long in one position.

Accidental injury occurs when an unexpected event triggers injury during the task. A load that slips or shifts as it is being lifted, and a slip and fall or hitting one's head on a cabinet door are typical examples. These accidents can jolt the neck, back, and other joints which caused muscle strain or tearing of soft tissue in the back. Figure 2.1 below show all components of the workstation which fit each other. East Carolina University, (2007) stated ergonomic keyboards, ergonomic mice, ergo desks, office chairs and ergonomic accessories remain productive and pain free at work. Ergonomic resources, tools and home office design is not just about being attractive. Home office set-up is not just about function. Home office productivity is about comfort, which means ergonomics.

People who sit most of the day, such as those who works with computer while sitting on office chair, are also at high risk for non-accidental back injury. Office ergonomics, or computer ergonomics, can help minimize the risk of repetitive injury, such as carpal tunnel syndrome, and the risks associated with prolonged sitting on office chair, such as neck strain, lower back pain, and leg pain (John, 2014).

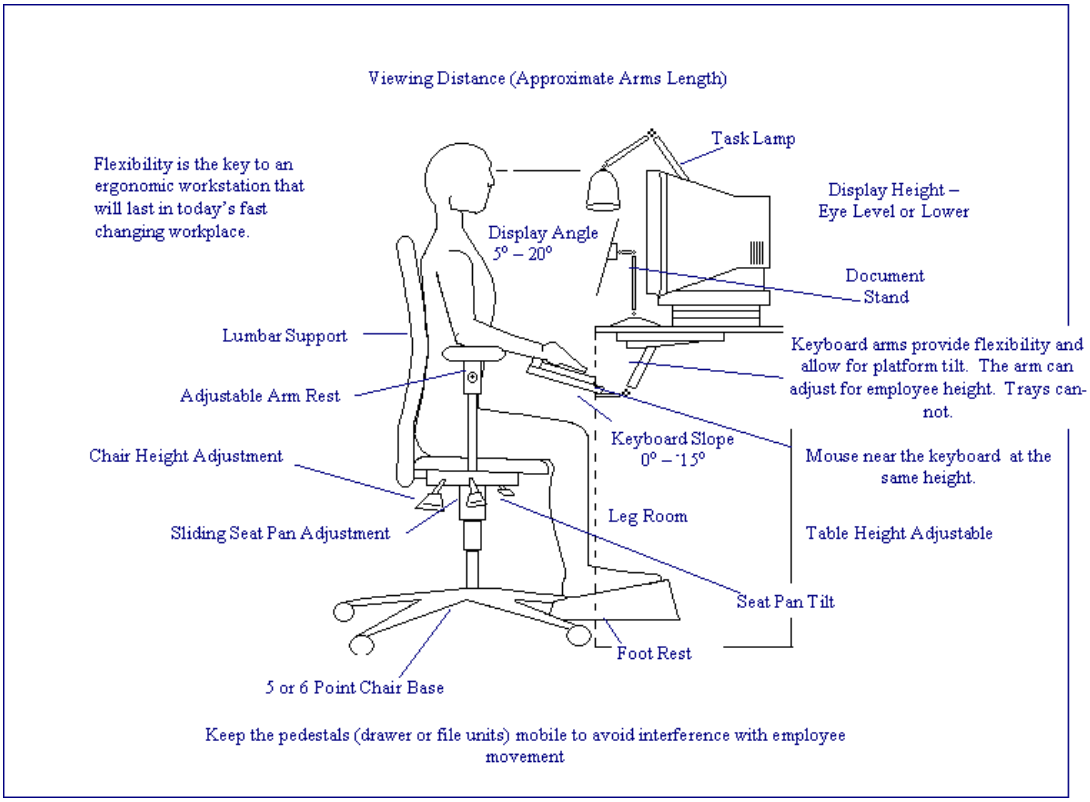


Figure 2.1: The Ergonomic Computer Workstation (East Carolina University, 2013)

2.2.1 Musculoskeletal Disorders (MSDs) for Office Seating

Musculoskeletal disorders (MSDs) denoted health problem of the locomotive apparatus, i.e. muscles, tendons, skeletons, cartilage, ligaments, nerves or peripheral vascular system. Some MSDs are non-specific because only pain or discomfort exists without evidence of a velar specific disorder. Musculoskeletal disorders (MSDs) are a major cause of work-related disabilities and injuries in the developed and industrialized developing countries (Gallagher, 2005). Musculoskeletal disorders primarily focus on the skeletal muscles and their attachments to the bones. Since nerves play a major role in muscle contraction and feeling, they also have an important role in these types of disorders. There are three common forms of musculoskeletal disorders which health and safety professional should be concerned with: Cumulative Trauma Disorders of the extremities, back injuries, and segmental and whole body vibration injuries. The most common of musculoskeletal disorders involved the back (Ergonomics).

Work-related MSDs can affect shoulders, arms, elbows, wrists, hands, back, legs and feet. It is caused by forceful or repetitive movements or a poor working posture. Symptoms include tenderness, aches and pains, tingling, stiffness and swelling. Lower and upper back pain as well as muscle spasm could be due to incorrect seating, which also affects the cervical spine and neck muscles leading to pain (Kuorinka, 1987). (Crawford *et al*., 2005) concluded that physical and psychosocial risk factors are implicated in the etiology of MSDs especially those affecting the neck and shoulder regions. Jensen et al. showed that neck symptoms were the most common (53%) among female call center workers, followed by shoulder (42%) and hand/wrist (30%) symptoms (Jensen *et al*., 2002). The specific nature of dental work is connected with and accompanied by onerous and harmful effects on the musculoskeletal system. Standing or sitting positions which are frequently adopted, twisting of the spine, connected with excessive tightening of some tissues and the straining of others, could be the source of painful disorders and diseases of the musculoskeletal system (Forde, 2002). From previous studies, male dentists had greater prevalence of musculoskeletal symptoms in the low back, n = 199/204 (98%), wrist/hand, n = 104/204 (51%) and neck, n = 102/204 (50%) regions, while the female dentists reported symptoms greater in the neck, n = 304/332 (92%), wrist/hand,n = 288/332 (73.46%), and shoulder, n = 273/332 (82%) regions. The figure 2.2 shown comparison of regions involved with work related musculoskeletal symptoms between male and female dentist.

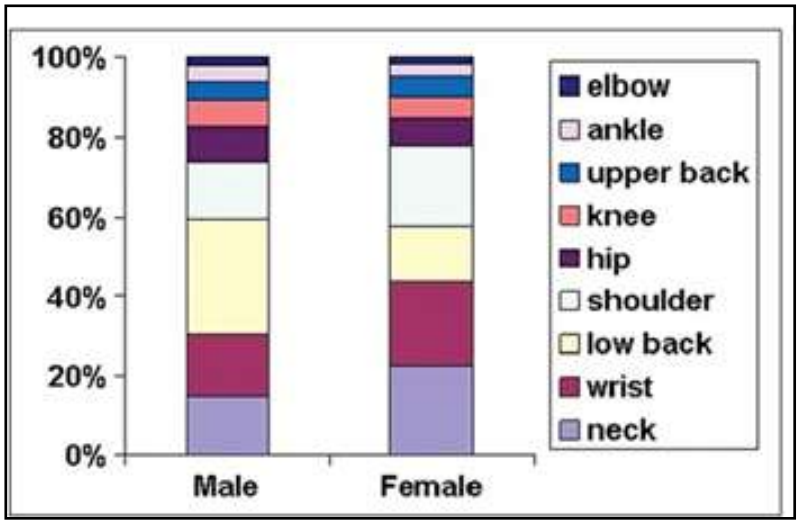


Figure 2.2: Comparison of Regions Involved With Work Related Musculoskeletal Symptoms Between Male and Female Dentist (Vijaya, 2013)

2.2.2 Cumulative Trauma Disorders (CTDs)

Currently, the most practical workplace ergonomics is related to the prevention of CTDs, a broad class of disorders that can approximately be defined as wear and tear from everyday tasks, whether at work, at home or during leisure time activities. This is in coherence with musculoskeletal disorders (MSDs) or repetitive strain injuries (RSIs). CTDs are occasionally referred to in mentioned materials, but are not described in depth because that information is readily available elsewhere. Also, ergonomics provides value far beyond the prevention of CTDs and these rules of work stand by themselves (MacLeod, 2000).

2.3 Chair Adjustments

Chairs have to be selected after a thorough review and testing of what is available on the market. Desks which are currently used in the offices is not adjustable for height, thus that person can only able to adopt a suitable, fully supported working posture by adjusting the chair (McKeown, 2008). Individuals performing a screen based operation at work, or even a simple pen and paper task, should not be used non-adjustable chairs unless their task lasts for only a few minutes at a time and will not be repeated at regular intervals (McKeown, 2008).

The chair should be adjustable for height. The backrest or independent internal lumbar support should be designed so that it can be repositioned relative to the seated user; alternatively, the backrest should be constructed of a material that molds around the individual. It should have five prongs on the base with casters (unless the floor covering makes this unsuitable), and the padding should be sufficient to prevent the user from coming in contact with or being aware of the hard edges of the shell of the seat (McKeown, 2008). For example, a chair could be too high and the arm rests too far apart for a short, slim person. In addition, chairs may not suit every task or arrangement at the workstation. A chair becomes ergonomic only when it specifically suits a worker's size (body dimensions), his or her particular workstation, and the tasks that must be performed there. It is possible to find the right chair, although it is not always easy (Canada, 2014). Figure 2.3 below show the major dimension of the seat.

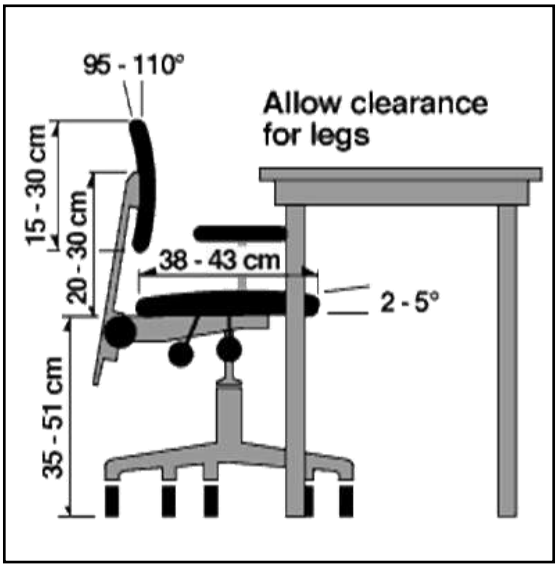


Figure 2.3: Major Dimension of the Seat (Canada, 2014)

2.3.1 Usability and Range of Seat Pan Depth Adjustment

Chairs with a fixed seat pan length limit the numbers that can fit the chair comfortably. Typically a taller person will require more seat pan length and a shorter person will require less (Haworth, 2008). A shorter person sitting on a long seat pan will experience pressure behind the knees, or, if they perch on the edge, they would not have seat back support. A taller person sitting on a short seat pan length will have inadequate support resulting in higher contact pressure under the thighs (Haworth, 2008). Good ergonomic seating incorporates several inches of adjustable seat pan depth. A minimum of 2 inches of adjustability is recommended while 3 inches is preferred (Haworth, 2008).

The range of adjustment offered by office chairs varies from one model to another. Ideally, a seat should be capable of adjusting from around 380 mm to 530 mm above the floor (McKeown, 2008). Typically, office chairs do not offer the full range that might be considered “ideal,” but they are still likely to accommodate many potential users. Only a tall or very small individuals might find that chair does not move enough to accommodate them (McKeown, 2008). This can be dealt with easily by simply approaching suppliers and requesting a chair on a trial that offers a greater range of height adjustment than the “standard” chair (McKeown, 2008). If the chair has seat pan and backrest angle adjustment, adjust the angle of each to support work activities. Adjust the chair height to attain a natural inward curve of the spine and

optimize the comfort of your lower back. If the chair is too low, lower back will flatten or round out. If the chair is too high, feet, and therefore back, are unsupported. Circulation to the lower leg can also be compromised if the chair is too high (Apple, 2014). Figure 2.4 below shows the example of chair height.

Figure 2.4: Example of Chair Height (Apple, 2014)

2.3.2 Usability and Range of Backrest Adjustment While Sitting

The backrests of chairs are varied in style and many are now quite sophisticated in design. Each style of backrest has its merits and a number have drawbacks. It is important to be aware before making any decisions by considering the pros and cons for each design (McKeown, 2008).

The aim of the backrest is to offer support to a significant proportion of the back. Minimumly, this support should be available from around the small of the back to just below shoulder level. As a small of the back is usually concave when an individual adopts a suitable sitting position, the backrest should be shaped so that its lower section, the lumbar support, fits neatly into the small of the back. To execute this efficiently, the lumbar support should be capable of being moved relative to the seated user, or the material of the backrest should be capable of molding around and

supporting the individual. The lumbar support can be moved in a number of ways depending on the design of the chair (McKeown, 2008).

The most usual method of moving the lumbar support into position is to move the whole of the backrest up or down. Alternate methods includes sliding the lumbar roll up and down in the backrest. Some chairs have contoured backrest with distinct lumbar areas, but the whole backrest is fixed to the seat offering no form of adjustment. Users will come in different shapes and sizes, it will be rather hit-and-miss whether, once they sit down, their lumbar region lines up properly with the immovable curve of the seat. If it does not line up the individual will be forced to adopt a posture dictated by the design of the seat. In such evident of mismatch the user should not be expected to sit in the seat (McKeown, 2008).

In offering a feature to change the position of the lumbar support, backrests should be capable of tilting. This will enable users to vary their sitting position within an acceptable range, throughout the day. A number of seats have been designed so that as the backrest is tilted, the seat tilts also. Although there may be merit in offering the user greater choice over how they sit, the design should not dictate a posture to the individual. This can occur if the seat and back move in unison so that the position of one dictates the position of the other. If a chair is intended to provide this combination of adjustability, it should be offered in a way that allows the user to alter the seat and backrest independently of each other (McKeown, 2008). The chair should support an upright position for keyboard activities. If the chair rocks or reclines, consider adjusting the tension to support upright postures for computer and desktop activities (Apple, 2014). Figure 2.5 shows example of backrest angle and seat pan angle.

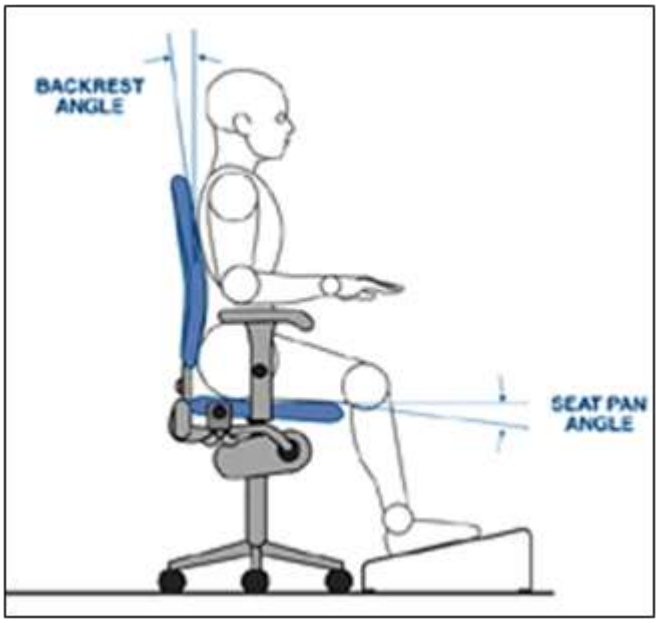


Figure 2.5: Example of Backrest Angle and Seat Pan Angle (Apple, 2014)

2.3.3 Armrests Support Range of Adjustability

Armrest should be considered a serious topic for discussion. Office workers have numbers of misconceptions regarding the presence, or absence, of armrests. Typically, the armrests were considered to reflect the rank of an individual ~~was~~, the more likely they were to have armrests on their chair which itself would typically be bigger, more sophisticated and more expensive than anyone else's chair (McKeown, 2008).

A number of users believe that it is legal requirement to have armrests on the chair. This is not the case. Other users think that they are less likely to develop an upper limb disorder if they have armrests. This is also untrue. Armrests, particularly poorly designed and badly positioned armrests, can create problems for users if they are permanently attached to the chair. The main problem is that some armrests prevent users from sitting closer to the leading edge of the desk as ~~they might wish~~. As a consequence, there are greater reaching distance than they might prefer between them and the keyboard or mouse. To overcome this hurdle, they either extend their arms forward, which increases the workload for the arms, or they sit on the front edge of their seats thereby losing all support from the backrest (McKeown, 2008).

Some users think they can avoid this problem by lowering their seats, which will enable the armrests to move under the desk surface as they pull the seat closest to the desk edge. Unfortunately, this tactic will only create new problems. As the chair lowered, the height of the worksurface, keyboard and mouse rise relative to the user's seating position. They are then forced to raise the shoulders and arms in order to reach the keyboard and mouse. Static muscle work will be required to hold the arms and shoulders in the higher position and this is extremely fatigue and likely to result in discomfort (Pheasant, 2006). The individual is unlikely to change their position until they stand up and leave the workstation, which means that some continue to work in this irregular posture for several hours at a time without interruption (McKeown, 2008).

Some armrests take into account the user's need to be able to sit close to the work surface. Some are adjustable for height, which allow them to be lowered to get them out of the way if required, and some can be adjusted in width, which allows larger users to be accommodated. A number of armrests have been reduced in overall length so that their upper supporting surface does not extend the full length of the

seat, which would normally result in them coming in contact with the desk edge as soon as the chair is moved towards it. Other armrests can be rotated so that they move from extending forward to extending backward and are, in effect, out of the way together (McKeown, 2008).

Chair with armrest is proven causing some problems to those who are using it and thus it should be removed. Most often the armrests are attached to the main frame of the seat as secondary parts and can be removed with the aid of a spanner or Allen wrench.

2.3.4 Feeling Comfortable

The simplistic concept that sitting upright, with thighs horizontal and lower legs vertical, meant healthy sitting lasted, surprisingly, for about 100 years. Now it is obvious that people in modern offices sit any way they like – not only can escape from bad health consequences, but apparently because freely choosing and changing their posture makes they feel comfortable (Kroemer, 2001).

Sitting, as opposed to standing, is suitable when only a small work space is covered by the hands; this is typical for much of today's office work. Sitting keep upper body stable, this is helpful when finely controlled activities has to be performed. Sitting supports the body at its midsection and requires less muscular effort than standing, especially when maintained over long periods of time. But the seat must be supportive to the body, feel comfortable in combination with the other office furniture and equipment and be suitable for the work tasks (Kroemer, 2001).

New work duties, the rethink traditional design recommendations for office furniture. The furniture should accommodate a wide range of body sizes, varying body postures and diverse activities; it should enhance task performance, ~~facility's~~ facilitate vision and allow interaction with co-workers; it should be appealing and help make people feel well in their work environment (Kroemer, 2001).

Ergonomic recommendations for proper design of workstations and furniture, especially of the chair, are at hand to make work easy and efficient (Kroemer, 2001). Feelings of discomfort are mainly associated with pain, tiredness, soreness and numbness. These feelings are assumed to be imposed by physical constraints and mediated by physical factors like joint angles, tissue pressure and circulation blockage. Comfort, on the other hand, is associated with feelings of relaxation and

well-being (Zhang, 1996). In a later study (Helander and Zhang, 1997) involving 20 and 37 subjects, respectively, this factor structure was confirmed. It was also observed that aesthetic design matters with respect to comfort, but not to discomfort.

2.4 Seat Comfort

Feeling of comfort when sitting is associated with such descriptive words as warm, soft, plush, spacious, supported, safe pleased, relaxed and restful. However, comfortability depends very much on the individual habits, on the environment and task at hand, and on the passage of time (Helander, 1997). Esthetics plays a role: if we like the appearance, the color, and the ambience, we are inclined to feel comfortable. Appealing upholstery, for example, can strongly contribute to the feeling of comfort, especially when it is neither too soft nor too stiff, but distributes body pressure along the contact area, and if it breathes by letting heat and humidity escape as it supports the body (Michiel, 2003).

The researchers concluded that it is apparently more difficult to rank chairs, unless truly unsuitable, by the attributes of annoyance (as opposed to comfort) because the body is surprisingly adaptive except when the sitter has a bad back. In contrast, comfort descriptors proved to be sensitive and discriminating for ranking chairs in terms of preference. (Helander *et al*., 1997) It is also of interest to note that preference rankings of chairs could be established early during the sitting trials; they did not change much with sitting duration. Still, it is not clear whether a few minutes of sitting on chairs are sufficient to assess them, or whether it takes longer trial periods (Helander, 1997). The comfort sitting in the office is an important thing because that also can reduce the injury and back pain. The example of comfort sitting at the office workstation on the chair shown on the Figure 2.6 below. There is some tips for ergonomic from researcher Reimer, (2015) which is headed upright and over your shoulders, eye looking slightly downward (30° range from horizontal line of sight) without bending from the neck, back should be supported by the backrest of the chair that promotes the natural curve of the lower back, elbow bent at 90°, forearm horizontal. Shoulders should be relaxed, but not depressed, thighs horizontal with 90° - 110° angle t the hip and feet fully supported and flat on the floor.

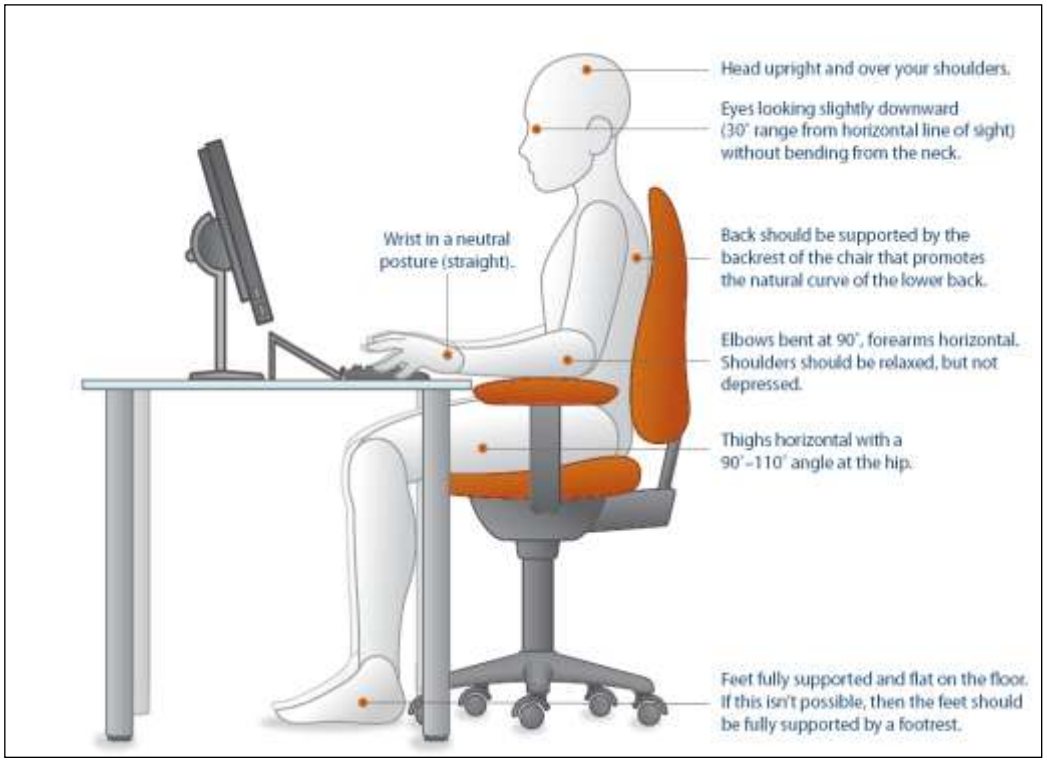


Figure 2.6: The Example Comfort Sitting in the Office Chair (Reimer, 2015)

2.4.1 Seat Pan or Cushion Comfort

The Cambridge Advanced Learner's dictionary (2008) defined comfort as 'a pleasant feeling of being relaxed and free from pain'. Comfortable seat is determined subjectively because the user justifies the seat comfort based on their subjective experience in using the seat (Runkle, 1994). Accordingly, Staffel proposed in 1884a forward – declining seat surface to open up the hip angle and bring about lordosis in the lumbar area. In the 1960s, a seat pan design with an elevated rear edge became popular in Europe. Since then, Mandal (1982) and Congleton *et al.* (1985) again promoted that the whole seat surface slope fore-downward. To prevent the buttocks from sliding down on the forward-declined seat, the seat surface may be shaped to fit the human backside (Congleton, 1985), or one may counteract the downward-forward thrust either by bearing down on the feet or by propping the upper shins on special pads. Dispatchers are usually at their stations for 12 hours at a time. If the chair does not offer the ultimate in seat comfort, those hours can be painful molded, tooled high density foam in concert with multi-density foam layers in the cover supported by a steel pan offer the greatest long term seating comfort. A mushy, soft

seat cushion will become unbearable after an hour or two (Group, 2012). Figure 2.6 shown the example of seat comfort for office workers.

Figure 2.7: Example of Seat Comfort for Office Workers (Group, 2012)

A seat surface that can be tilted throughout the full range (from declined forward, kept flat, to inclined backward) naturally allows the user to assume various curvatures of the lower spinal column, from kyphosis (forward bend) to lordosis (backward bend). The surface of the seat pan must support the weight of the upper body comfortably and securely. Hard surfaces generate pressure points that can be avoided by suitable upholstery, cushion, or other surface materials that elastically or plastically adjust to body contours (Kroemer, 2001).

2.4.2 Backrest Cushion Comfort

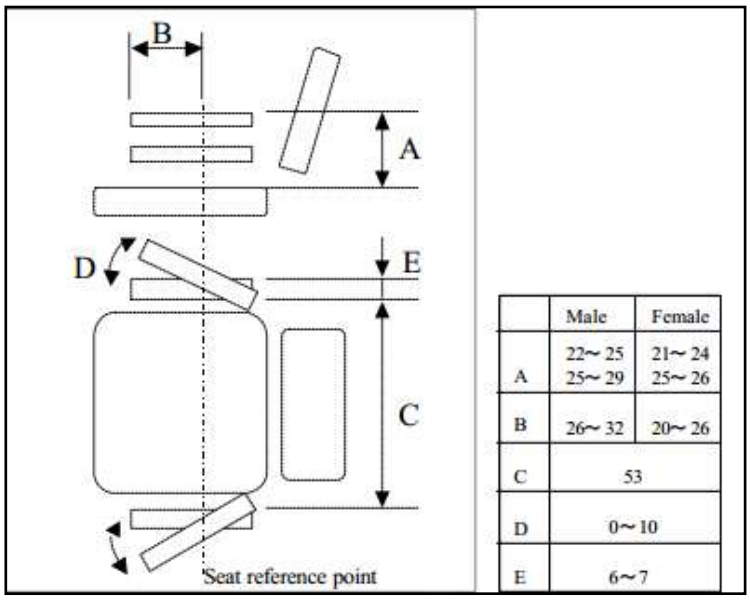
Combined with suitably formed and upholstered seat pan, this shape has been used successfully for seats in automobiles, aircraft, passenger trains, and for easy chairs. In the traditional office, the boss enjoyed these first-class shapes while clerical employees had to use simpler designs (Kroemer, 2001). The so-called secretarial chairs had a small, often back: the most recent task chair is an improved

version. The thermal and moisture test method has shown the importance of the surface material for obtaining a comfortable seating. The hardness of a seat or bed, more commonly expressed as its softness, is an important factor in reducing or preventing the pain or discomfort (Dhigra, 2003).

The backrest should be as large as can be accommodated at the work-place: this means up to 85 cm high above the seat pan, and up 30 cm region, it is usually shaped to follow the back contours, specifically in the lumbar and the neck regions. Many users appreciate an adjustable pad or an inflatable cushion for supporting the lumbar lordosis. The lumbar pad should be adjustable from about 12 to 22 cm, the cervical pad from 50 to 70 cm above the seat surface (Kroemer, 2001).

2.4.3 Armrest Comfort

Armrests can provide support for the weight of the hands, arms, and even portions of the upper trunk. Thus, the armrests can be of help, even if only for short periods of us, when they have a suitable load-bearing surface, best padded. Adjustability in height, width, and possibly direction is desirable. However, armrests can also hinder moving the arm, pulling the seat toward the workstation, or getting in and out of the seat. In these cases, having short armrests, or none, is appropriate (Kroemer, 2001). Japanese people need to change their minds on the importance of the armrest. Because the main work position is changed from forward positions to backward position and upright position by using on a computer for office work and they will use armrests more than now. As they have used a computer for office work more than before, a computer has been very important for office workers (Mitsuaki , 2003). Figure 2.7 below show the armrest dimension.



	Male	Female
A	22~25 25~29	21~24 25~26
B	26~32	20~26
C	53	
D	0~10	
E	6~7	

Figure 2.8: The Armrest Dimensions (Mitsuaki, 2003)

2.5 Reliability

Reliability is a major concern when a psychological test is used to measure some attribute or behavior (Rosenthal and Rosnow, 1991). For instance, to understand the functioning of a test, it is important that the test which is used consistently discriminates individuals at one time or over a course of time. In other words, reliability is the extent to which measurements are repeatable – when different persons perform the measurements, on different occasions, under different conditions, with supposedly alternative instruments which measure the same thing. In sum, reliability is the consistency of measurement (Bollen, 1989), or stability of measurement over a variety of conditions in which basically the same results should be obtained (Nunnally, 1978).

Because reliability is the consistency of measurement over time or stability of measurement over a variety of conditions, the most commonly used technique to estimate reliability is with a measure of association, the correlation coefficient, often termed the reliability coefficient (Rosnow and Rosenthal, 1991). The reliability coefficient is the correlation between two or more variables (here tests, items, or raters) which measure the same thing. Typical methods to estimate test reliability in behavioural research are: test-retest reliability, alternative forms, split-halves, inter-rater reliability, and internal consistency. There are three main concerns in reliability

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