İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

EVALUATION OF COMPUTER USAGE AMONG CHILDREN AT COMPUTER WORKSTATION MEDIUMS

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BİLGİSAYAR ÇALIŞMA ORTAMLARINDA ÇOCUKLARIN BİLGİSAYAR KULLANIMININ DEĞERLENDİRİLMESİ

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PREFACE

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ABBREVIATIONS

CAE	: Computer Aided Education
CAEL	: Computer Aided Education Laboratory
CL	: Computer Laboratory
CTS	: Carpal Tunnel Syndrome
CWS	: Computer Workstation
ET	: Education Technology
IT	: Information Technology
LAN	: Local Area Network
LMD	: Lowered Monitor Desk
RSI	: Repetitive Strain Injury
UCD	: User Centred Design
WAN	: Wide Area Network

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GLOSSARY

Appendicular: Of or relating to an appendage and especially a limb of the appendicular skeleton.

Carpal Tunnel: Channel on the palmar side of the wrist formed by the irregular small bones of the wrist and a tough ligament stretched across it. Through the carpal tunnel pass the flexor tendons of the fingers, the median nerve, and some blood vessels.

Cervical: Of or relating to a neck or cervix.

Clavicle: A bone of the vertebrate pectoral girdle typically serving to link the scapula and sternum – called also collarbone.

Contraction: The shortening and thickening of a functioning muscle or muscle fibre.

Dexterity: Readiness and grace in physical activity; especially: skill and ease in using the hands.

Discomfort: Discomfort: mental or physical uneasiness.

Distal: Situated away from the point of attachment or origin or a central point especially of the body.

Drainage: The act, process, or mode of draining.

Flexor: A muscle serving to bend a body part (as a limb).

Flicker: Flash, twinkle

Forearm: The part of the arm between the elbow and the wrist.

Forelimb: A limb (as an arm, wing, fin, or leg) that is situated anteriorly.

Gluteal: Of or relating to the gluteus muscles.

Gluteus: Any of the large muscles of the buttocks.

Hamstring: Either of two groups of tendons at the back of the human knee.

Hip: The laterally projecting region of each side of the lower or posterior part of the mammalian trunk formed by the lateral parts of the pelvis and upper part of the femur together with the fleshy parts covering them.

Intervertebral Disk: Any of the tough elastic disks that are interposed between the center of adjoining vertebrae and that consist of an outer fibrous ring enclosing an inner pulpy nucleus.

Kyphosis: Pronounced convexity of the spine. Most frequently observed in the thoracic region. Also known as "hunchback".

Ligament: A tough band of tissue connecting the articular extremities of bones or supporting an organ in place.

Limb: A leg or arm of a human being.

Lordosis: Abnormal curvature of the spine forward.

Lumbar: Of, relating to, or constituting the loins or the vertebrae between the thoracic vertebrae and sacrum.

Lumbosacral Joint: Joint between fifth lumbar vertebra and sacrum.

Median Nerve: Large important nerve. Activates muscles that pronate the forearm and flex forearm, wrist, and fingers. The sensory part of the nerve provides feedback information from the thumb and the first two and one-half fingers essential for prompt and effective performance of the "grasp reflex".

Numbness: Devoid of sensation or feeling

Pelvis: A basin-shaped structure in the skeleton of many vertebrates that is formed by the pelvic girdle and adjoining bones of the spine.

Popliteal: Pertaining to the hollow at the back of the knee.

Posterior: Situated behind: as of the human body or its parts.

Pre-pubertal: Of or relating to pre-puberty.

Pre-puberty: The period immediately preceding puberty.

Primate: Any of an order (primates) of mammals comprising humans, apes, monkeys, and related forms. (As lemurs and tarsiers)

Pronate: To rotate the hand and forearm so that the palm faces backwards or downwards.

Proximal: Next to or nearest the point of attachment or origin, a central point, or the point of view; especially: located toward the centre of the body.

Puberty: The onset of sexual maturity.

Rearward: Located at, near, or toward the rear.

Segment: One of the constituent parts into which a body, entity, or quantity is divided or marked off by or as if by natural boundaries.

Skeleton: A usually rigid supportive or protective structure or framework of an organism; especially: the bony or more or less cartilaginous framework supporting the soft tissues and protecting the internal organs of a vertebrate.

Spinal: Of, relating to, or situated near the backbone.

Spurt: A sudden gush.

Stability: The property of a body that causes it when disturbed from a condition of equilibrium or steady motion to develop forces or moments that restore the original condition.

Supinate: To lay backward or on the back.

Supination: Rotation of the forearm and hand so that the palm faces forward or upward and the radius lies parallel to the ulna; also; a corresponding movement of the foot and leg.

Susceptible: Open, subject, or unresistant to some stimulus.

Swelling:	Something that is swollen; specifically; an abnormal bodily protuberance or localised enlargement.
Tendon:	Band of connective tissue that does not contract and connects muscles with bones.
Tendonitis: (Tendinitis)	An inflammation of a tendon. Often associated with repeated tension, motion, bending, being in contact with a hard surface, vibration.
Thigh:	The proximal segment of the vertebrate hind limb extending from the hip to the knee and supported by a single large bone
Thorax:	The part of the mammalian body between the neck and the abdomen; also: its cavity in which the heart and lungs lie
Thought:	An individual act or product of thinking
Traditional: Classroom	A structured classroom arrangement, in which the teacher presents one subject at a time to the entire student body, who sits in rows, facing the teacher.
Venous:	Having passed through the capillaries and given up oxygen for the tissues and become charged with carbon dioxide.
Vertebrae:	One of the bony or cartilaginous segments composing the spinal column.
Waist:	The narrowed part of the body between the thorax and hips.
Wedging:	Forcing or pressing (something) into a narrow space.

EVALUATION OF COMPUTER USAGE AMONG CHILDREN AT COMPUTER WORKSTATION MEDIUMS

SUMMARY

The aim of this study is to find out the needs of a definite group of children using computers at their lessons, the problems they face with in their classrooms and the effect of two different types of computer workstations (CWS) among computer usage.

In today's world, schools are computerized rapidly and students become more computer literate as a result of this technological integration to education. Computer lessons become a need for today's education. Computers in today's Turkey are nearly in everywhere including schools. While using computer as an educational tool and becoming computer literate, the conditions of computer usage in every aspect of life are very important. The computer has become the tool that requires sitting activity at the most of our time. For this reason, the requirements of a person working with a computer are very important. Tiny ergonomic defects, incorrect ways of planning and placing equipment may cause serious health problems. Since, the computer has integrated to school environments. Compared to enormous amount of research on the workplace, problems faced by children at school have been largely ignored. The introduction of computers has, moreover, added a new dimension, which probably means more physically constraining work than in the past for the pupils. Great attention has to be paid to children using computers since children with health problems will lead to unhealthy adults.

In the second section, concepts of development for school children have been given and the interpretations of experts and researchers have been taken into account.

In the third section, educational technology in classroom medium has been examined. Reasons for bringing information technology into school, integrating technology into classroom curriculum are the important points, which have been explained.
In the fourth section, CWS concept, requirements for an ergonomic computer workstation are examined. The ergonomic dimensions of a workstation, the level of comfort, the requirements of people working there have been investigated.

In the fifth section, posture evaluation in CWS medium is made. Problems in sitting, problems in typing and visual problems have been examined. Evaluation for children has been made.

In the sixth section the requirements of CWSs, which are used by children, have been investigated. The help of existing CWS examples tells these requirements. Advantages and disadvantages of these examples are evaluated.

In the seventh section, a special case is told. CWS mediums at Şişli Terakki High School are the case subject. These CWSs establish the basis of the study.

In the eighth section, a detailed method of the research has been told and the findings have been evaluated. During the research activities, students have been

observed directly. A questionnaire has been applied to 72 students working in two different computer laboratories of Şişli Terakki High School.

In the ninth section, the results of the questionnaire application and observations are evaluated. The results of the questionnaire and the observations are demonstrated respectively by visual sources. As the result of findings and state-of-art work, the process and the outcomes of this study are discussed. The problems of observed classroom medium are focused on and probable solutions are suggested.

BİLGİSAYAR ÇALIŞMA ORTAMLARINDA ÇOCUKLARIN BİLGİSAYAR KULLANIMININ DEĞERLENDİRİLMESİ

ÖZET

Günümüzde iletişim teknolojisi yaşamın her alanına girmiş olup, toplumun her kesimini özellikle de çocukları etkilemektedir. Artık, bilgisayar okullarda eğitimin bir parçası olmuştur. Eğitim de çocuklara ve eğitmenlere yardımcı olarak yerini almaktadır. Bilgisayar destekli eğitim, çocukları bugünün dünyasına hazırlayıp onların öğrenme yetilerini geliştirirken, tarafımızdan sorulması gereken soru okullarda mevcut olan bilgisayarla çalışma ortamlarının sağlık koşulları bakımından uygun olup olmayışıdır. Çocuklar, bilgisayar ortamlarında çalışırken farkında olmadan çeşitli yanlış fiziksel duruş özellikleri edinmektedirler. Bu çalışmanın amacı varolan iki bilgisayar çalışma ortamını ergonomik yönlerden karşılaştırıp, bu sistemleri kullanan çocuklarda varolan yanlış fiziksel alışkanlıklar ve karşılaşılan rahatsızlıkları ortaya koyup, çözüm önerileri getirmektir.

İkinci bölümde çocukların fiziksel gelişimlerine değinilmiştir. Çalışmada incelenen oniki , onüç ve ondört yaş grubu çocukları olduğu için daha çok bu yaş gruplarının fiziksel özellikleri üzerinde durulmuştur.

Üçüncü bölümde ise, konuya eğitim teknolojisi bakış açısı ile değinilmiştir. İletişim teknolojilerinin eğitimdeki yerleri, eğitimi ve çocukları nasıl etkiledikleri, bilgisayar-çocuk etkileşimi konuları üzerinde önemle durulmuştur.

Dördüncü bölümde, iş istasyonu, bilgisayar iş istasyonu kavramlarına yer verilip, bilgisayar iş istasyonu kavramı kendisini meydana getiren parçalara ayrılarak irdelenmiştir. Bu tür ortamlarda ergonomik açıdan hangi uygulamaların doğru hangilerinin yanlış olduğuna değinilmiştir.

Beşinci bölümde ise, oturma ve klavyede yazı yazma eylemleri incelenmektedir. Bunun nedeni ise, bilgisayarla çalışmanın, bu iki eylem yapılarak gerçekleşmesidir. Bilgisayar karşısında uzun süre oturan ve çalışan bir insanın karşılaştığı fiziksel rahatsızlıklar ve nedenler ortaya konmuştur.

Altıncı bölümde, daha önceki bölümlerdeki tümdengelim yaklaşımı ile anlatılan bilgisayar çalışma ortamı biraz daha özelleştirilmiş ve de çocukların kullandığı bilgisayar iş istasyonları irdelenmiştir. Bu irdelemeler dünyadaki mevcut örnekler temel alınarak yapılmış, bu örneklerin üzerinde bu tür bir çalışma ortamlarında olması gereken ergonomik kriterler ortaya konmuştur.

Yedinci bölüm, araştırmanın konusunu ve özünü oluşturan Şişli Terakki Lisesindeki bilgisayar laboratuvarları ve de bu ortamlardaki iş istasyonları üzerinde yapılmış bir vaka çalışmasıdır.

Sekizinci bölüm, çalışmanın metodu ve araştırma tekniklerinin irdelendiği ve bulguların yorumlandığı bölümdür. İki ay boyunca okul ortamında, farklı üç yaş grubundan 72 çocuk gözlemlenmiş ve bu çocuklara yapılan anketlerin sonuçları

irdelenerek bulgular elde edilmiştir. Bu bulgular daha önceki bölümlerdeki bilgilerle sentez edilmiş ve mevcut durum için bir değerlendirme yapılmıştır.

Dokuzuncu bölüm, çalışmanın sonuçlarının açıklandığı ve tartışıldığı bölümdür. Anketlerin ve iki ay boyunca okul ortamında gerçekleştirilen gözlemlerin sonuçları bu bölümde görsel bulgularla desteklenerek ayrı ayrı belirtilmiştir. Elde edilen bu bulgular sonucunda, daha önceki kaynak araştırmaları da göz önüne alınarak elde edilen sonuçlar ve çalışmanın işleyişi tartışılmıştır. Söz konusu çalışma ortamında karşılaşılan sorunlara bir kez daha değinilmiş ve çeşitli çözüm önerileri sunulmuştur.

1. INTRODUCTION

1.1. Defining the Research Area and Its Boundaries

Information technology (IT) has dramatically penetrated into every area of society, and every aspect of our social and cultural lives. Computers made it possible for vast amounts of information, from airline reservations to the contents of encyclopedias, to be made instantly available and modified with a keystroke. Writing became a matter of screens and printers, and text became permanently flexible, always ready to be instantly changed. Most significant, however, is the changes wrought in children by the technological revolution. Children have been raised in a world of instant access to knowledge, a world where vivid images embody and supplement information formerly presented solely through text. They are used to an environment where they control information flow and access, whether through a video game controller, remote control, mouse, or touch-tone phone.

Teaching computer skills became a "must" as a result of technological improvements in order to adapt oneself to the new way of life. "By the time children are 4 or 5, school begins to fill an increasingly large portion of their lives, becoming a highly significant factor in both their cognitive development and socialization. The primary purpose of the school is to instruct and thus to influence children's cognitive development. Moreover, as cross-cultural studies have demonstrated, schooling has a major influence on the way children organize their thoughts and cognitions." (Rogoff, 1990).

In today's world, schools are computerized rapidly and students become more computer literate as a result of this technological integration to education. "Technology has effectively revolutionized the society. An unexpected product of this revolution has been the emergence of a generation of children weaned on multidimensional, interactive media sources, a generation who's understanding and expectations of the world differ profoundly from that of the generations preceding them. Although technological advances are not likely to replace teachers, computers, software and access to Internet have become important aids to

children's learning" (Schofield, 1997). Computer lessons become a need for today's education. Computers in today's Turkey are nearly in everywhere including schools. As children are using computers more and more both at school and at home. They are learning concepts with drill and repetition software, designing web pages, designing digital presentations, keying their finishing assignments, conducting online research etc. School boards encourage their schools to implement technology into teaching in all areas of the curriculum. Computer plans are in place; these plans are developed and implemented by schools. School computer plans usually include type of software programs to be used by students, amount of time to be spent on a computer or in the computer laboratory, locations of the workstations, time allocated to search for information online, special needs type software to be used, plans for acquisition of more hardware and software and wide area network (WAN) and local area network (LAN) improvement. The missing part is the consideration to the ergonomic set up of the student computer station. While schools use computer as an educational tool the conditions of computer usage is very important and vital enough for being investigated.

1.2. Aim of the Study

At present, Turkey's educational system is getting rapidly computerized. Schools become one of the most important places where IT penetrates. "Turkey's Ministry of Education initiated a computer-aided education (CAE) project in 1984, which took shape between 1984 and 1986. Its main aims were to spread computer literacy and the use of computers as one tool to compensate for the poor quality and persistent deficiencies of suitable teachers. In a country with a very young demographic structure, the project was to play an important role in creating a computer-literate work force central to future competitiveness of Turkey's economy" (Yedekcioglu, 1996).

While computers are that much vital for education, work environments of CAE become an important topic to do research about. The aim of this study is to make a proper definition of a computer workstation and what makes a CWS ergonomic. It is also aimed to find out how computer workstations (CWS) affect children at adolescence stage, CWS's impacts on children's posture and the problems they face with while working at CWS in their classrooms. It is also aimed to investigate whether there are CWS specially designed for children. If so, are these examples really ergonomic and fit to the child usage?

Children, computer workstation (CWS), ergonomics concepts are the main research areas related to the topic of the study. While focusing on these three main concepts, physical changes a child goes through during physical development, child-computer interaction, its importance and effect on education, ergonomics' effect on CWS design, work situation, physical problems faced at computer workstations are also investigated by the help of literature research, direct observations and applied questionnaire applications..

Some of the research's hypothesis' are as follows:

- The role of computers in educational systems is indispensable and can be seen as a part of teaching.
- Computers are multi purpose tools in educational systems.
- Computers can expand children's learning in many ways.
- By the help of computers, children learn to write better with a word processor, create pictures, and produce animations and special visual effects, which foster their creativity.
- Children have instant access to Internet where they can get any information on any topic.
- Computers also help children record and multiply their works.
- Work environments of computer laboratories affect the working task and user's comfort.
- The equipment used such as computers, monitors, scanners and printers dominates work environments of computer laboratories.
- Alternative ways of placing these equipments and considering cable management, affect the working task and users' comfort.
- Students may have negative or positive ideas about their own working environment in computer laboratories.
- Students' evaluations about CWS systems may be references for investigating whether the CWS systems, which they use, are ergonomically proper or not.
- Different age groups of children may evaluate their working environments' comfort differently due to physical differences.
- Prolonged computer usage can lead to strain on the eyes, neck, shoulders and muscles, lower back and carpal tunnel syndrome.
- The risk of these injuries can be greatly reduced with the use of proper ergonomic alignment of body and workspace.

1.3. Importance of the Study

School-aged children, much of the time, may spend their work hours at school, sitting. Moreover, there are apparently few researches of the school environment that focus on the student in terms of appropriate ergonomics. Compared to enormous amount of research on the workplace, problems faced by children at school have been widely ignored. "The introduction of computers has, moreover, added a new dimension, which probably means more physically constraining work than in the past for the pupils" (Linton et al., 1994).

In the beginning, since students have not traditionally used computers for extended periods of time as part of their curricula, it is generally believed that poor ergonomics posed little threat to them, as the use of computers in classrooms has increased over the years, that situation is changing. More and more students leave school and log onto the family PC for several more hours of surfing the Internet or playing video games, their ergonomic health has suddenly become a genuine concern.

In addition to this, kids will rarely complain about their ergonomic situations, and since most of the painful effects of poor workstation ergonomics develop over a long period of time, most won't even realize damage is being done until its too late. Therefore, it is up to school administration to take responsibility and try to provide the best ergonomic postures for their students. Students' health has to be considered for various aspects and solutions for comfortable computer working environments to be suggested by bearing the variability of students' body sizes and ergonomics in mind. By bearing these in mind some solution approaches can be made for existing situations.

1.4. Boundaries of the Study

This study took place at Şişli Terakki High School, Istanbul. Three classes of 6th, 7th and 8th graders (12-13-14 years old) were examined during computer lessons at two different types of computer workstations at two different computer laboratories. The whole observation process took 2 months time, 32 school hours. 72 students; 36 girls and 36 boys participitate to this study.The research was done by observation and questionnaire applications. Permission for this research was taken from the school administration. Video shoot during lessons was prohibited since the

administration thinks that it could be an attention- driving act that can affect the lessons in a negative way.

While comparing these two types of computer workstation models, expert opinions about children's cognitive and physical development, children computer interactions were reviewed in the study. Besides that, since the working posture in such a system is "sitting", expert opinions and evaluations about sitting and typing posture, the problems faced with while sitting also take place in the study. Moreover, this study tried to emphasize on children's needs, problems they face with while working with computers and their relation with their working medium.

2. TECHNOLOGY IN CLASSROOM MEDIUM

2.1. Computer Aided Education

Technology education and educational technology (ET) are often mixed with each other. According to Dewey (1966), technology education means knowing, applying and criticizing technology. McCormick (1992) believes that information technology (IT) must be a part of technology and it has to be considered in technology education.

ET means using computer based technology in order to support learning in education. Communication technology and computer technology combine as IT.

The most powerful and developed tools used in ET are computers. In 1970s the software and programming used in computer systems were complex and due to this, their use at education was limited. In 1980s new computer based tools were developed in order to support individual learning and easy usage. In 1990s technological development in computer systems were considered parallel to educational targets. Personal computers turned out to be fully equipped educational tools. In addition to this, use of Internet providing easy access to knowledge, made a revolutionary effect on education.

Allessi and Trollip (1991), define use of computers in education as "educational methodology set". According to them, as the computers are included into the educational process with guiding tutors. These computer systems guide children, help them to keep knowledge in mind and evaluate children's learning degree. They thought that computer aided education (CAE) can be organized in four categories such as teaching, doing exercise, doing applications and games.

Taylor (1980) emphasized that CAE has three main roles such as following;

- Tutor role- computer is used as a helping tool for teachers.
- Tool role- computer is used in learning as a tool.
- Learner role- meaning learning with computer

Means (1994) defines computer usage in educational technology in four categories:

- Usage as a teacher
- Usage as an explorer
- Usage as a tool
- Usage as communication

Fundamentally, all these approaches are based on learning and in the basis of learning lies the foresight of Dewey. "Learning is a situation occurred at aimless play"

2.2. Reasons for Using Technology in Education

The reasons for using ET can be summarized as follows:

- Children learn and develop at different rates.

Using ET personalizes education. Computer systems provide children to learn in many different ways according to their backgrounds, interests and motivations.

- Getting experienced in evaluation of knowledge

ET forces children to do exercise, to formulate their ideas, to think critically, to discuss, to solve the problems and to test the reality. Online tools and sources help children to make conclusions and evaluate their knowledge in an effective way.

- ET supports increasing the quality of children's thinking and writing

One of the successful results of using technology in education is developing the writing ability of children.

- ET develops children's talent in problem solving.

During CAE applications, databases, graphical programs and multimedia tools help children to analyze and organize on their own. Because of these, children can easily focus on problem solving, thinking, and defining new strategies for immediately reaching to the solution.

- Children use sources at home with educational techniques.

ET lets children to reach to worldwide knowledge in a fast and cheap way.

- ET provides opportunities for meaningful study.

ET connects children with other children in the world in order to reach new sources. Children exhibit their works by learning computer skills and this motivates children.

- Children get the chance of working with cutting edge high technology.

Laser discs, CD-ROMs, DVDs let the children get used to very different usage opportunities. Distant learning provides new learning experiences for children.

- Children feel comfortable while learning because of ET.

While learning by the help of ET, children have the feeling of control and this makes children feel comfortable.

- ET promotes equity.

In the case of several schools, serving students from low-income homes, technology innovators stressed the importance of giving these students the technology tools that would equip them to compete with children coming from more affluent homes where technology is in a commonplace.

- ET prepares children for the future.

The concern for equity is related to a major motivation for introducing technology--to prepare students for the future. A future is foreseen in which both higher education and the world of work would be infused with technology. Educators argue that schools have a responsibility to give students--and especially students from low-income homes--the confidence and skills in using such technology that they will need after graduation.

- ET supports changes in school structure.

Researchers have argued that technology has the potential to dramatically change the way in which our schools are structured--providing pressure to do away with the division of instructional time into small blocks and discrete disciplines and to rethink the way we use physical classrooms and teaching resources (Collins, 1990).

2.3. Computer Aided Education's Effects on Education

CAE simplifies learning since it helps children focus on one direction with efficient information. CAE helps children learn freely and provides multiplicity through

learning. Children learn to communicate without hesitation. Children perceive their acts' outcomes as "right" or "wrong" and are awarded for their rights immediately. Children learn by discovering with CAE and as a result they learn in a more permanent way. What lies beneath CAE is play. This is s very effective way for children to learn. Computer has limitless time and patience to play. Children have the opportunity to have fun while learning. By the help of CAE, children participate to knowledge process. They gain the ability to learn "how to think". Piaget claims that, children learn in attention driving environments and times. Children use their preceding knowledge while developing new ideas. It is stated that CAE can fulfill these ideas.

Learning is a way of communication. Since children can easily interact with computer, it can be stated that they begin to learn easily as a result. CAE personalizes learning and let every child to learn with his own pace. CAE helps children to develop control over their learning and as a result their self-respect increases. Children will have a positive manner towards learning. CAE lets the child to feel an inner and natural joy through out learning. CAE increases the curiosity and the desire to explore and this makes learning easy. Active learning is done by the help of CAE. The opportunity of choosing time, object and way of learning is given to the child.

Multimedia tools have nourished CAE. By the help of video and sound usage, CAE has become more dynamic, exciting and powerful. Interactive multimedia techniques provide us a new way of learning in learning children's natural reactions. The actuation of multimedia is permeable. It engages children to learn. Children have the opportunity to choose to what to learn and how to learn. As a result of this, learning is oriented to the direction of personal needs and attention. Children see computers as their friends. Computer technology is an enabler in the classroom, a means to help children develop competence and motivation.

3. PHYSICAL DEVELOPMENT OF CHILDREN

3.1. Physical Development of Children

During the whole developmental period between infancy and maturity, many demands are made on the growing child by its environment. Although it may be considered that much of the child's response to new situation is genetically programmed, its continuing growth and ability to survive depends on an elastic and adaptable physiology working to sustain an ever-greater mobility. This mobility is gradually attained by the extension and growth of the various organs and segments are not parallel but move different speeds from each other.

"One of the most actively investigated areas of child development; physical growth is guided by two classic principles. First the human infant is characterized by cephalocaudal development (cephalocaudal derives from Latin words for 'head' and 'tail'); that is growth in infancy occurs from the head downward. Thus the brain and neck develop earlier than the legs and trunk." (Parke, 1999) The brain approaches its adult size quite early. It reaches 80% of adult size between four and five years of age" (Croney, 1971).

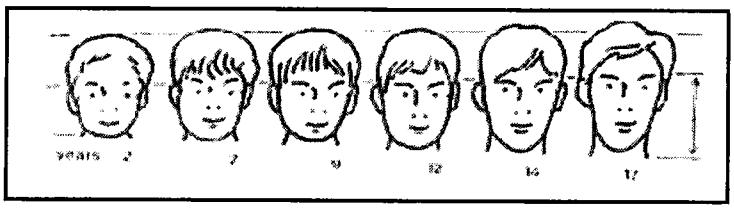


Figure 3.1 Comparative developments of child's face and head (Croney, 1971)

"Second, growth also follows a proximal-distal (towards the center-away from the center) pattern. In other words, development occurs from the center outward, for example, the internal organs develop earlier than the arms and hands" (Parke, 1999).

"There is often a wide variation of speed of growth between body parts, and always some variations while growth takes place. Externally this means that a child 's body

is continually changing its shape and therefore its proportions. So, it can be said that a child's body is liable and prone to change, and that these changes are normal and build up, stage by stage, towards a balanced mature condition.

The variation of the speed of growth between one body part and another is regulated so that each part reaches its size, proportional to the role it has to play in the body's physiology at the correct time. It is the alternation of the speed of growth between body parts that leads to a diversification and differentiation of one part of body structure from another. So it may be considered that the human body during development and growth changes in three ways: by increase in size, by differentiation of structure, and finally by the alternation of shape. The factors are three different types of dimensional increase: increase by length, increase by area and increase by weight.

When studying physical development, and leaving numerical age aside, difficulties are still met: With young children often the short ones grow more slowly; yet in adolescence the taller ones grow more slowly, and the shorter ones grow rapidly for a longer period of time. These types of changes in growth rates tend to accentuate the great variability of children's body measurements. For any numerical age, in either sex, it is likely to be presented with a wide range of body builds.

Throughout the growing period, there is an extensive remodeling of all the bones of the skeleton-taking place in this manner. This remodeling is paced by growth in the superficial tissues, and as the internal structure undergoes some corresponding alteration takes place in the external forms of the body. A child's figure is not like an adult's in miniature. It re-forms and almost seems to deform, as it progresses. The same number of parts of an adult is present, but they are continually being presented in different proportions. The law of alternation of growth suggests that there are times when feet seem to be too big for arms; or lower arms for upper arms; and these instances can be easily multiplied.

In early infancy there is a general chubbiness, with relatively large dimensions of the trunk and head. The upper part of the body is proportionately larger than the lower.

Until about six years the limbs appear relatively short and weak. After six, during the period of juvenile growth, the legs and arms increase in relation to the trunk. Throughout childhood the speed of growth for arms and legs remains different from

the speed of growth for the trunk and head. With the growth of the limbs the growing child begins to fulfill the fuller role of the upright primate; maintaining its upright posture with greater ease and developing an ever freer use of the fore-limbs for grasping, swinging and manipulation, and also showing an ever-increasing tactile appreciation with the hands. At a later stage of development, with a larger chest and longer clavicles and greater power to pronate and supinate the forearms, the growing child can obtain a greater vigor of the arm and an increased dexterity of the hand.

Until the end of the juvenile stage at about nine years the growth for both sexes is much the same. During pre-adolescent years growth is largely concerned with building up a strong skeleton and extending tissues. Between ten to eleven years, or the pre-pubertal period, more height is continually being gained by the continuing growth of the lower limbs. At about 12 years the cervical vertebrae lengthen and the neck becomes apparent for the first time. The waist, however, is becoming more defined and greater movement is possible between the pelvis and the thorax. At about this age the external physical differences between the sexes begin to make their appearance as a result of the processes of sexual morphological differentiation. The period of puberty comes at different times for boys and girls; girls being something like two years ahead of boys. Girls are generally heavier, taller and have

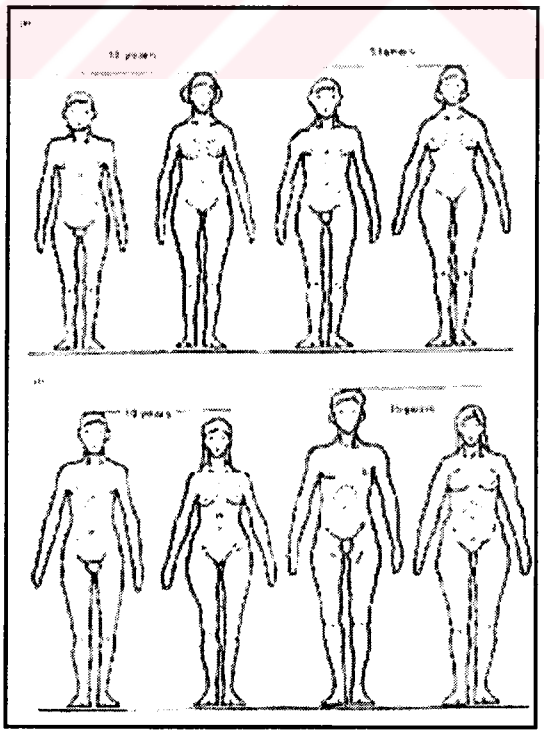


Figure 3.2 Physical comparisons between boys and girls at significant ages from 12 to 15. (Croney,1971)

a greater body surface area than boys in the early pre-pubertal period, but are then generally lighter than boys to puberty. Boys begin to assume extra weight in the later pre-pubertal period.

The adolescent growth spurt occurs later in the male than the female and continues for a longer period. The overall difference in size and proportion between adult men and women is largely the result of adolescent spurt of growth" (Croney, 1971). A comparison between boys and girls at significant ages can be seen in Figure 3.2.

Gender has a clear effect on height and weight, as it can be seen from Figure 3.3.

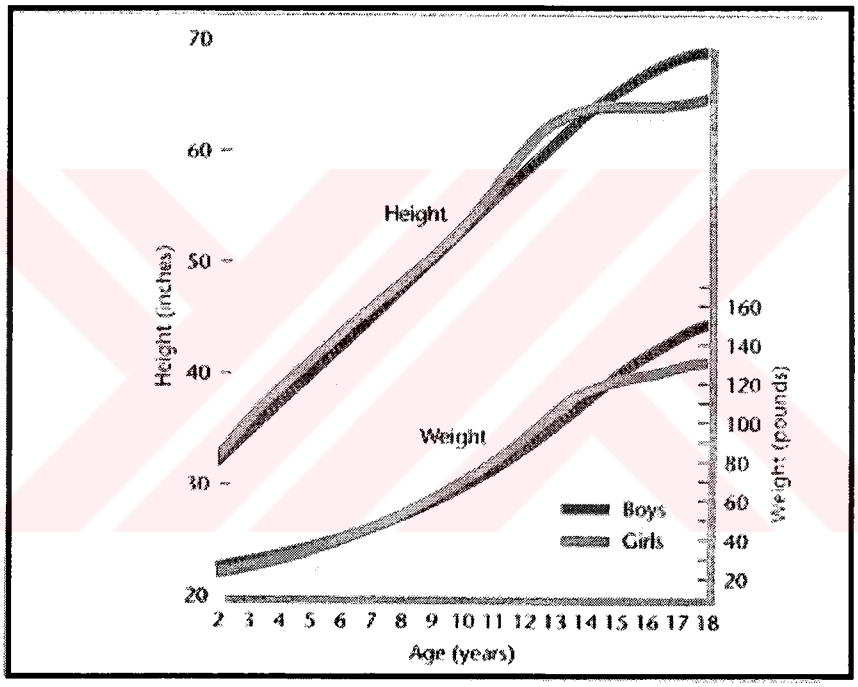


Figure 3.3 Male and female growth in height and weight. As they approach puberty, girls tend to gain in height and to a lesser degree in weight, faster than boys, but by the age of 14 or 15, boys surpass girls on both dimensions. (Source: National Center for Health Statistics, 1976)

Girls tend to be a bit taller than boys from the age of 2 until the age of 9, when boys catch up. At about 10 ½ girls experience a growth spurt, shooting well up above boys of their own age. At about 14, however girls' height seems nearly to plateau, whereas bys continue to grow taller until they are about 18 years old. The pattern for weight is not greatly dissimilar, although girls tend to weigh less than boys in the early years and then to exceed them in weight until about 14, when their weight gain slows down while boys' gain continues to accelerate (Tanner, 1990).

"Adolescent is a significant period of human growth and maturation, unique changes occur during this period and many adult patterns are established. Anthropometry is especially important during adolescence because it allows the monitoring and the evaluation of the hormone mediated changes in growth and maturation during this period" (WHO, 1995).

"During the period of the adolescent growth spurt there is a very marked increase in size of various body parts. The spurt of growth starts with an increase in foot length. In general growth spurts commence in the distal segments of the appendicular skeleton and proceed through to more proximal ones. In the leg legion, after the growth of foot length, the lower leg extends in length, and this is followed by more growth in the upper leg and thigh. At all ages of childhood the feet dimensions keep ahead of arm, leg and trunk dimensions and are nearer adult size. Increased spurts of growth in the feet may come a year to two years ahead of those of statue" (Croney,1971).

Exceptionally rapid growth in the feet is exclusive to girls; an for those girls who have attained marked increase of dimensions in this region early, subsequently their feet will then cease to grow much more. Maximum velocity of foot growth can be reached at 10 years of age for girls, whereas a boy's maximum is at about 12 or 13 years.

4. ERGONOMICS AND COMPUTER WORKSTATION DESIGN

4.1. Ergonomics in Design

The dictionary definition of ergonomics according to Webster Dictionary is an applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely.

Some of 130 definitions of human factors and ergonomics are discussed in a report by Licht et.al. (1991). The following definitions are just some of these remarks.
"Ergonomics is the science of the people who do it and the way it is done, the tools and the equipments they use, the places they work and the psychosocial aspects of the working situation." (Pheasant, 1996)

According to Chapanis (1995);"Ergonomics and human factors use knowledge of human abilities and limitations to design of systems, jobs, machines, tools and consumer products for safe, efficient and comfortable use."

Bridger (1995) states "Ergonomics is the study of the relationship between people and the tools of their occupation. In particular, ergonomics focuses on the physical interface between the user and the way he or she uses the tools of their job. A tool such as a computer workstation is said to have good ergonomic design when it can be easily adjusted to fit the user. With good ergonomics, the user does not have to comfort their body or perform repetitive movements in ways that could cause discomfort, strain, or injury."

In other words, ergonomics is the science of equipment design intended to maximize productivity by reducing user fatigue and discomfort. In a broad sense, ergonomics applies science to workplace design to maximize productivity while reducing fatigue and discomfort.

"If a product, a system or an environment is intended for human use, then its design should be based upon the physical and mental characteristics of its human users.

The objective is to achieve the best possible match between the product and its users in the context of the task that is to be performed. In other words, ergonomics is the science of fitting the product to the user.

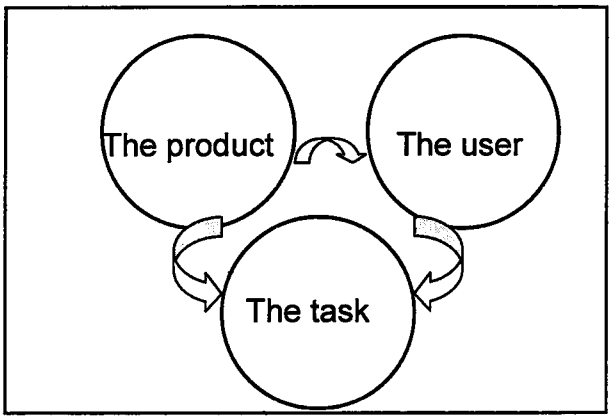


Figure 4.1 User centered design: the product, user and task. (Pheasant, 1996)

The main purpose of ergonomics is design. Ergonomics is thereby different from most of the bodies of knowledge that we use for supporting the discipline. Ergonomics is different from anthropology, cognitive science, psychology, sociology and a medical science since their primary purpose is to understand and model human behavior, but not to utilize the knowledge for design."(Helander, 1997)

What is meant when we say that a product is "ergonomically designed"? Here is a common sense way to recognize an ergonomically designed product, which is quoted from a pamphlet published by the Ergonomics Society entitled Ergonomics: " Fit for human use. Try using it. Think forward to all of the ways and circumstances in which you might use it. Does it fit your body size or could it be better? Can you see and hear all you need to see and hear? Is it hard to make it go wrong? Is it comfortable to use all the time or only to start with? Is it easy and convenient to use (or could it be improved)? Is it easy to learn to use? Is it easy to clean and maintain? Do you feel relaxed after a period of use? If the answers to all of these questions are "yes" then the product has been thought with the user in mind." (Pheasant, 1996)

Ergonomic approach to design can be described as user-centered design (UCD). "UCD seeks to base the decisions of design process upon hard data concerning the physical and mental characteristics of human being, their observed behavior and their reported experiences. UCD seeks to enroll the end-user of the product as an

active participant in the design process. It deals with people as they are rather than they might be. It aims to fit the product to the user rather than vice versa. UCD aims to achieve best possible match for the greatest possible number of people. It also recognizes that there may be limits to what is reasonably practicable in any particular case and seeks to reach the best possible outcome within the constraints imposed by these limits." (Pheasant, 1996)

4.2. Computer Workstation Design

Most work is carried out at a particular place using particular tools and methods. The place that people work at is generally referred to as a workstation. Workstations provide facilities such as:

- Work surfaces
- Storage areas
- Artificial lighting
- Input and output of work materials

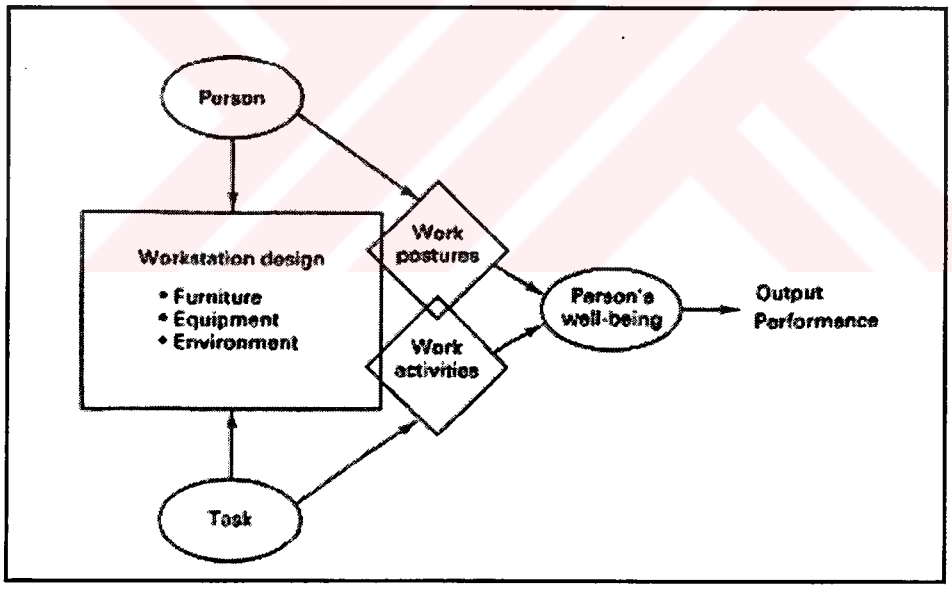


Figure 4.2 Interactions Among Person, Task, Workstation Design, and Performance (Kroemer, 1994)

The concept of a workstation is extremely broad, and ranges from a position on a factory assembly line to a CWS in an office that might include a desktop computer with CPU and drives, keyboard and mouse, monitor, and printer, plus various cables, power bars and peripherals.

A CWS is an integrated system of computer hardware (displays, controls, terminals and consoles) and furniture. During the usage of a CWS, an interaction between the user and the medium occurs and it can be demonstrated as in Figure 4.3.

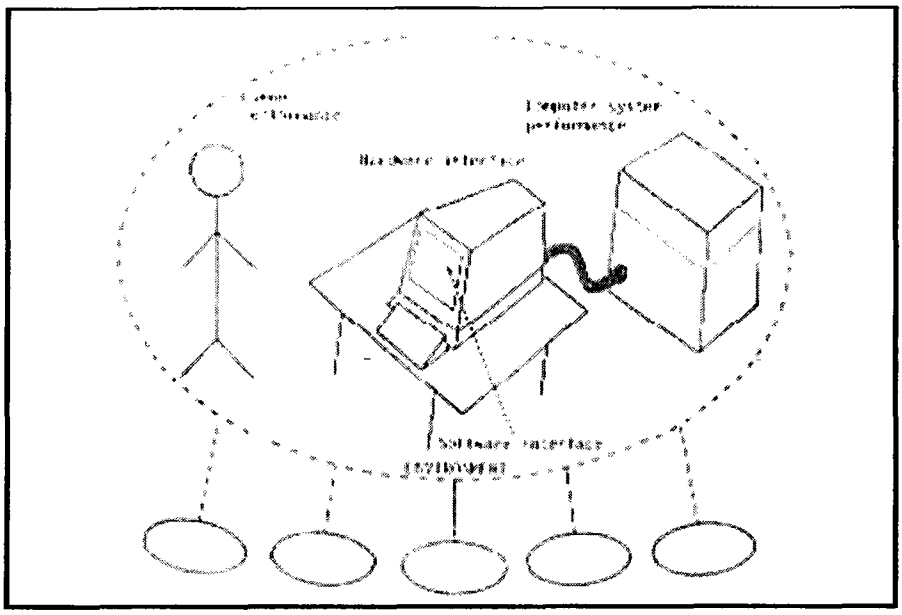


Figure 4.3 A synoptic view of Human Computer Interaction (Schackel, 1976)

4.2.1. Computer Workstation Components

The computer is comprised of a central processing unit, display monitor, keyboard and mouse. Components of the CWS may include the chair, desk, anti-glare screen, document holder, printer and any other equipment essential to working with computers. As computer workstations are examined, it is better to focus on each part of a CWS distinctively. A CWS can be grouped into components as Figure 4.4.

4.2.1.1. Manual Computer Input Devices

Keyboard

"Keyboard is the most frequently used input device for transmitting information from human to computer. It is primarily used for applications involving significant amounts of alphanumeric data. The role of the present keyboard has been to great extend taken from the outdated mechanical typewriter" (Bullinger et.al. 1997).

"The keyboard for typing letters was invented in 1868. It was a mechanical device that required a design of four parallel rows of keys. To operate these keys quickly the typist had to keep their hands parallel to the rows. With the development of electronics, the electronic one then replaced the mechanical typewriter. The

mechanical resistance of keys was much reduced and the operation of keyboard was made easier with the electronic keyboard" (Smith et.al. 1997).

The construction of current electronic keyboards gives special considerations regarding the shape the layout of the keyboard on account of secure ergonomical findings.

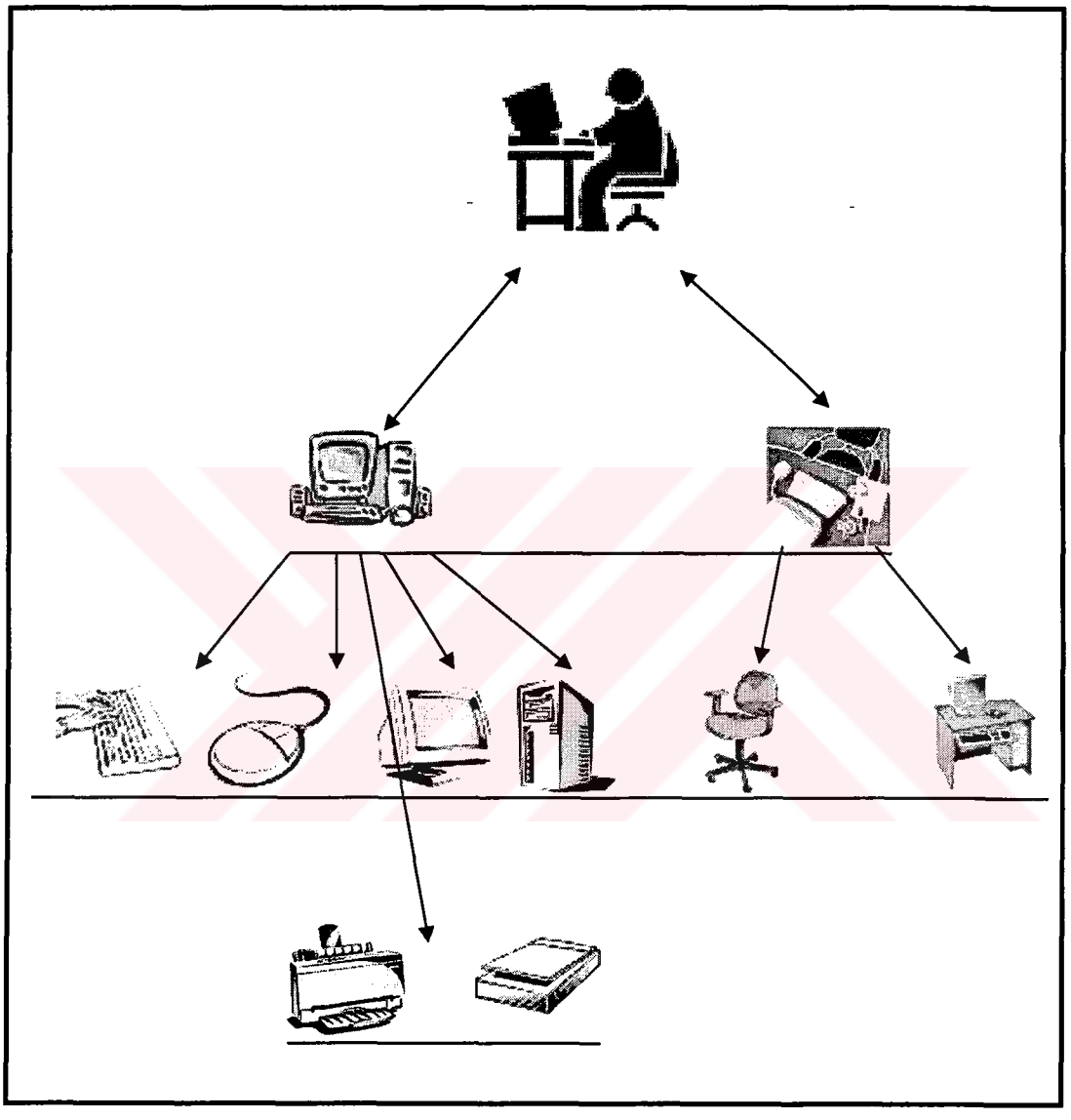


Figure 4.4 Components of a Computer Workstation

Keyboard Layout

The layout of the keys is considered according to their importance, function, and frequency of use and sequence of use. The standard keyboard usually includes alphanumeric, function, auxiliary numeric and cursor control key groups as in Figure 4.5.

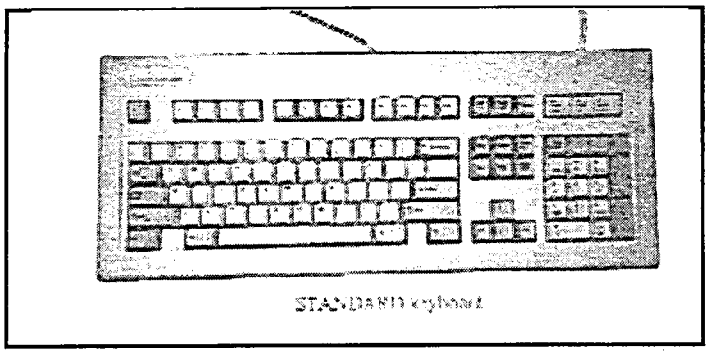


Figure 4.5 A Standard Keyboard (Salvendy,1997)

Most of the attention has focused on the layout of the alphanumeric group, composed of upper- and lowercase alphanumeric characters, i.e. numerals, punctuation marks, and special symbols. The function keys provide rudimentary functions such as mode changes (shift key) and communication (enter key). Frequently used functions such as these are typically included in the periphery of the alphanumeric key set. Other specialized functions, e.g., for the editing of the text may be offered by additional keypads on the same keyboard." (Bullinger et.al. 1997)

"The introduction of the electronic keypad has made it possible to do away with the traditional formal characteristic principles of mechanical typewriter. This had lead to multiple possibilities which have carried out for the adaptation of hardware for the anthropometrical and mental conditions of the user." (Cakir, 1995)

Alternative keyboard design occurs as a result of this thought. Some examples of alternative keyboards may be examined as in Figure 4.6 and 4.7.

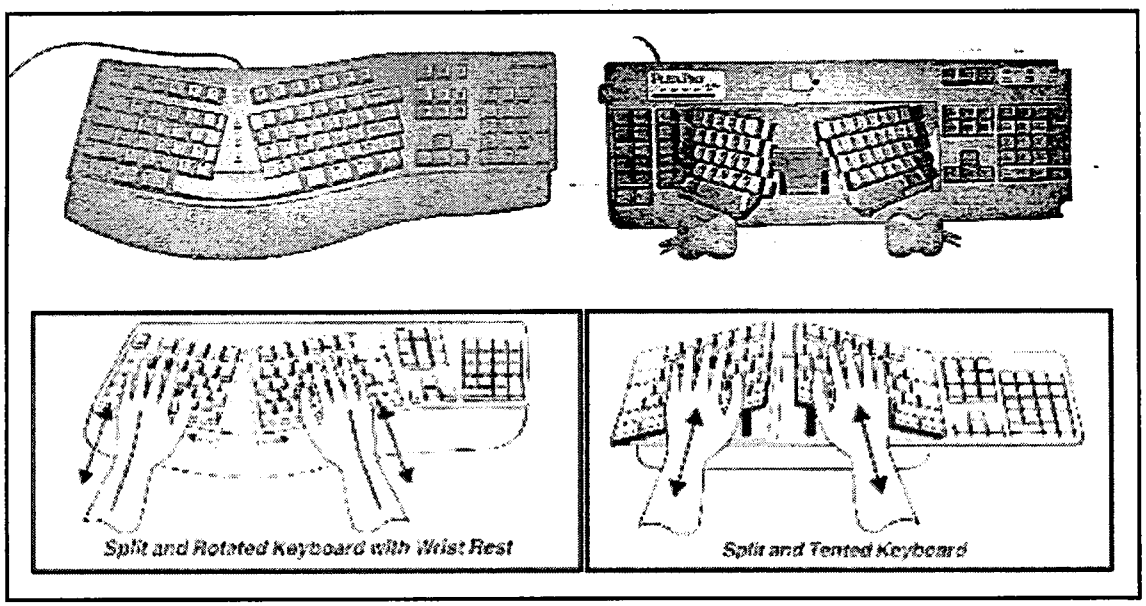


Figure 4.6 Alternative keyboards. (Salvendy, 1997)

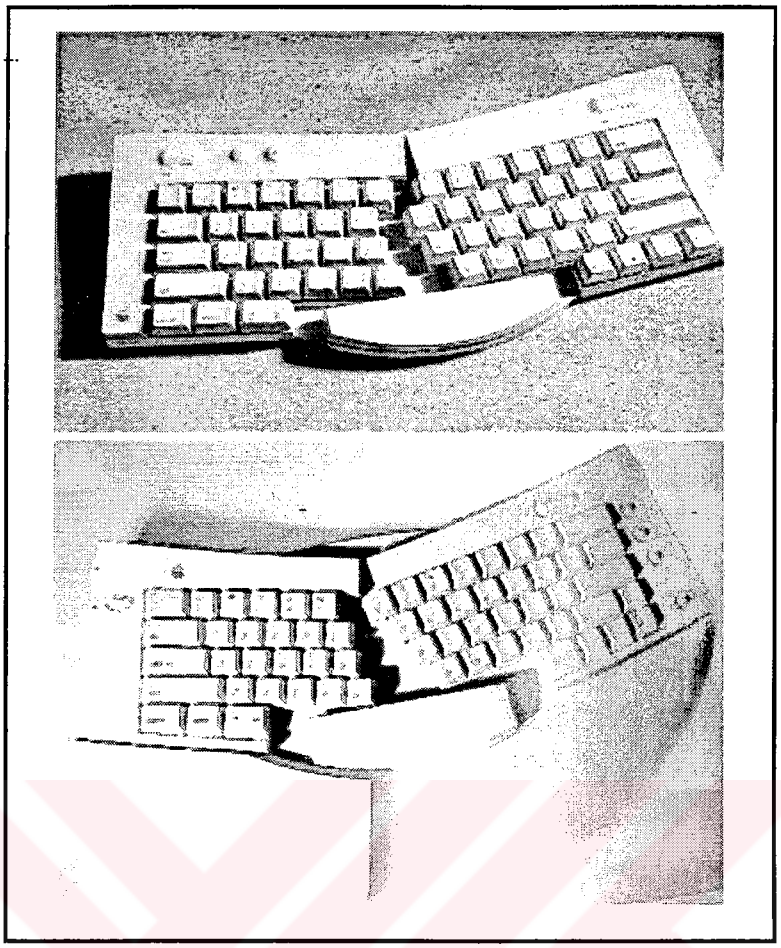


Figure 4.7 Alternative Keyboards by Apple Computer (Kunkel,1997)

Several alternative keyboards are now commercially available. The primary change from a conventional keyboard is that of providing geometric alterations (such as split half alpha/numeric keys and angling of the rows and/or columns). This changes the keyboard user's wrist angles of extension, pronation and ulnar deviation. The success of these keyboards in real life settings can be assessed as their use increases.

Mouse

"With the introduction of graphical user systems the role of the cursor system and the cursor control devices such as mouse has considerably increased. In graphical user systems, a function is usually activated by pointing the cursor on the required icon (graphical interacted object), and, if necessary, confirm or mark by clicking the function button.

A mouse is a handheld cursor control device, which is normally attached to the computer by a wire. Mice are small containers with rollers or sensors on the underside, which can be fit under the palm or fingertips. By moving a mouse across a surface (e.g. mouse pad), the cursor's position will change accordingly on the screen. On the upperside, a mouse may offer up to three press buttons, allowing the user to carry out functions such as changing menus and confirming inputs. Mice are typically used only as peripheral devices and not as the sole input device. Their features are best suited for pointing and selecting tasks with regards to menu-operated applications and dragging graphical objects around the screen, less so for drawing tasks . Mice are not suited for single character data entry." (Bullinger et.al. 1997)

Figure 4.8 Mice by Apple computer (Kunkel, 1997)

4.2.1.2. Output Device

Monitor

In computers, a monitor is a computer display and related parts packaged in a physical unit that is separate from other parts of the computer. Notebook computers don't have monitors because all the display and related parts are integrated into the same physical unit with the rest of the computer. In practice, the terms *monitor* and *display* are used interchangeably.

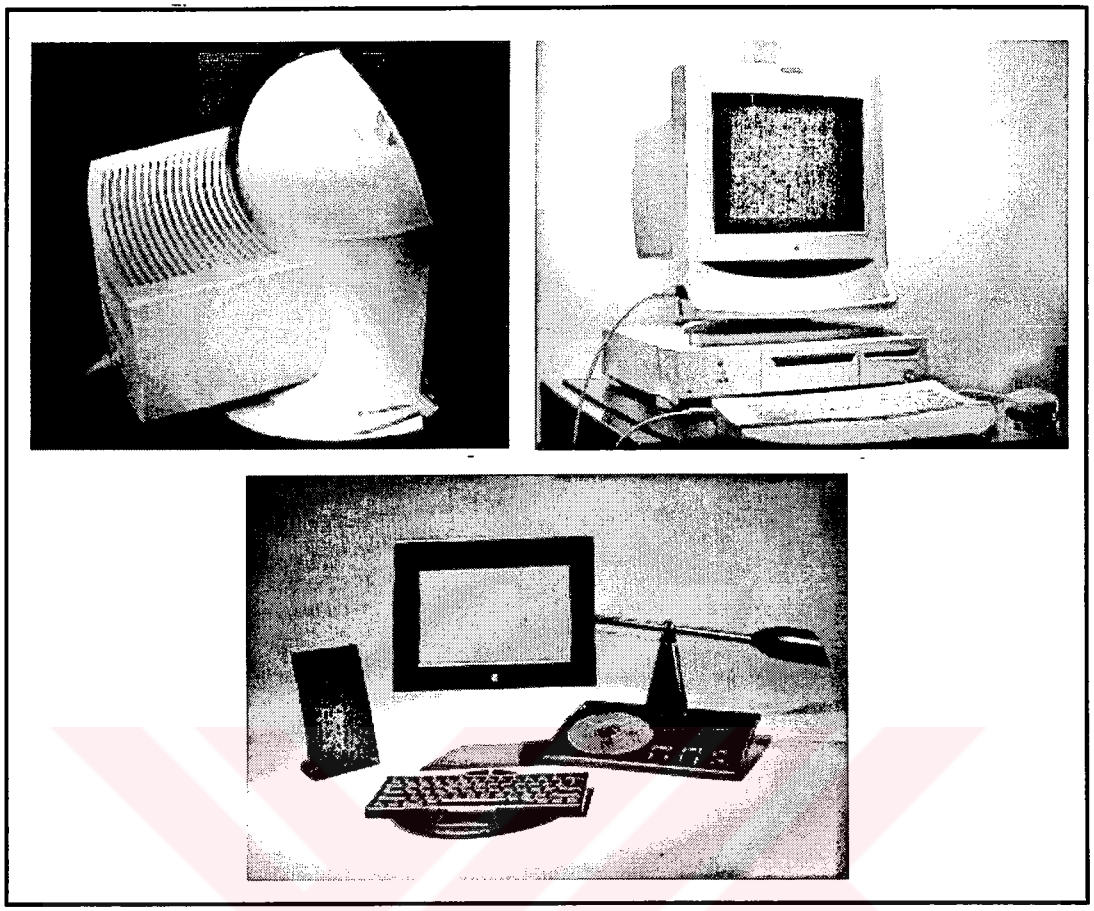


Figure 4.9 CRT and LCD monitors by Apple Computer (Kunkel, 1997)

A display is a computer output surface and projecting mechanism that shows text and often graphic images to the computer user, using a cathode ray tube (CRT), liquid crystal display (LCD), light-emitting diode, gas plasma, or other image projection technology. The display is usually considered to include the screen or projection surface and the device that produces the information on the screen. In some computers, the display is packaged in a separate unit called a monitor. In other computers, the display is integrated into a unit with the processor and other parts of the computer. (Some sources make the distinction that the monitor includes other signal-handling devices that feed and control the display or projection device. However, this distinction disappears when all these parts become integrated into a total unit, as in the case of notebook computers.) Displays (and monitors) are also sometimes called *video display terminals (VDTs)*. The terms *display* and *monitor* are often used interchangeably.

4.2.1.3. Computer Workstation Furniture

"In the beginning of the century, desks and chair were considerable pieces of furniture;they were made of wood, made by hand and made to last. However, the development of new materials and the introduction of computers made them chief targets for innovation. The traditional solid desk, with its high back and numerous drawers, has gradually been transformed into a simple workplace. (Figure 4.10 and 4.11)

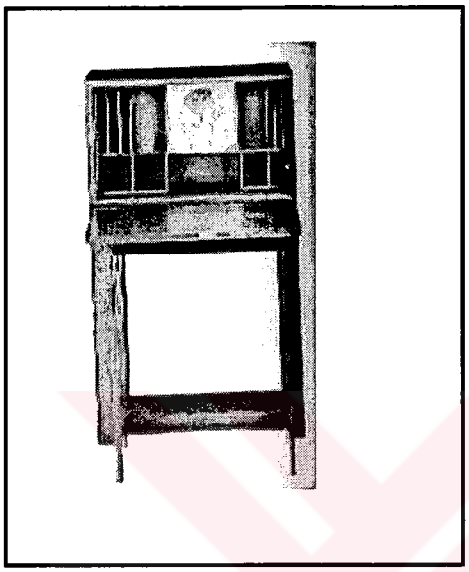


Figure 4.11 Mahogany bureau designed by a Machintosh in 1920's (Tambini,1997)

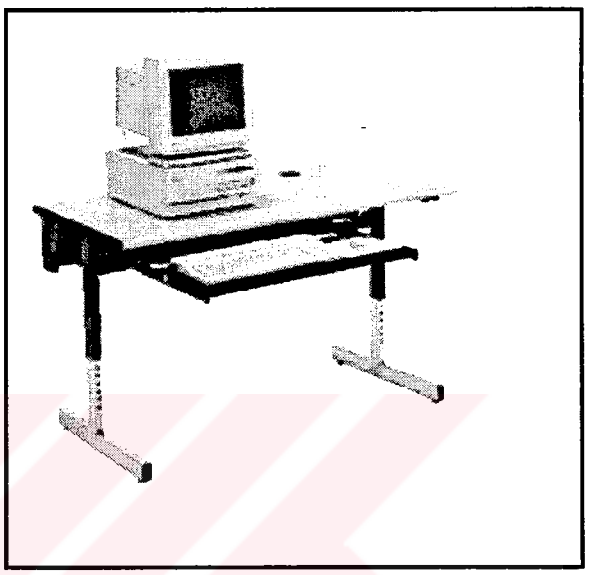


Figure 4.12 A contemporary computer desk (www.shawtec.com)

Chairs, the items of office furniture most vital to users' comfort and efficiency, now include unexpectedly comfortable hightech structures and ergonomic master pieces." (Tambini,1997)(Figure 4.12 and 4.13)

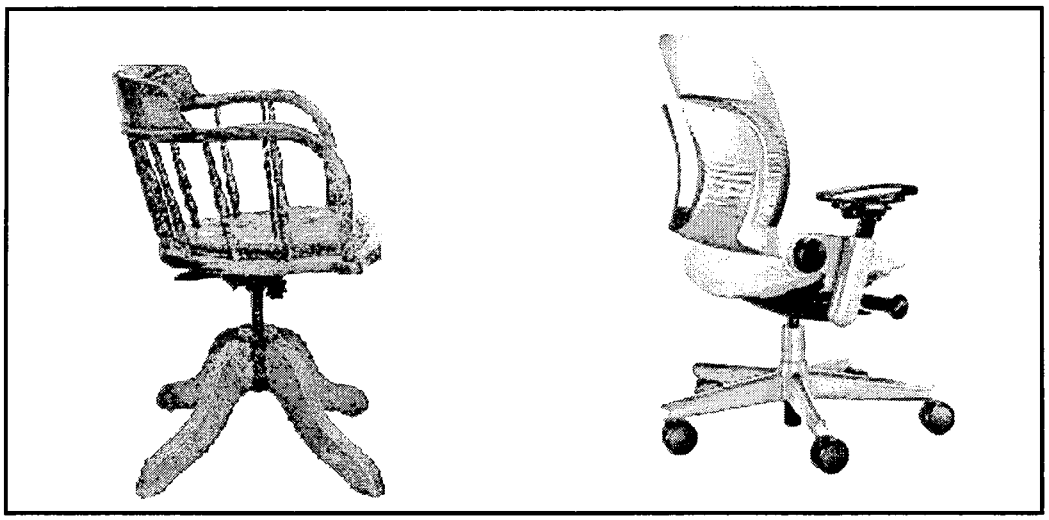


Figure 4.12 A chair from 1930s (Tambini,1997)

Figure 4.13 A contemporary chair designed by IDEO for Steelcase Company (www.steelcase.com)

In today's CWS environments, desks and chairs are structural elements, which have to maintain healthy and comfortable usage conditions for a variety of users. Ironically, just hardware on the desk summarizes CWS concept for many but it has to be more than this. Bearing this in mind, in next part, ergonomic considerations are made about each of the computer workstation components individually by focusing on ergonomic design concerns.

4.2.2 Ergonomic Considerations about CWS Components

4.2.2.1 Ergonomic Considerations for Manual Computer Input Devices

Most of the standard keyboards currently available are characterized by a straight-line arrangement of the key rows. Regarding the required flexibility and individual adjustment corresponding to the working posture and work task. The keyboard must be separated from the visual display unit.

"A number of keyboard features can influence an employee's comfort, health, and performance. The ANSI/HFS-100 (1988) standard provides guidance in the design and use of keyboards. This standard is currently undergoing revision, and new requirements should be available soon. The keyboard should be detachable and movable from screen, thus providing flexibility for independently positioning the keyboard and screen. The keyboard should be stable and have non-slip materials on its bottom surface to ensure that it does not slide when placed on a tabletop and being used. To assist in achieving a favorable arm height when keying, the keyboard should be as thin as practical. The slope or the angel of the keyboard should be between 0° and 25° measured from the horizontal. Adjustability of keyboard angle is useful to help in achieving good wrist posture. The shape of the key top must satisfy several ergonomic requirements, such as minimizing reflection, aiding the accurate location of the operator's finger, providing a suitable surface for the key legends and being neither sharp nor uncomfortable when depressed. The surface of the key tops, as well as the keyboard itself should have a matte finish to reduce reflections. The key top should be large enough to easily strike without striking adjacent keys (for instance ANSI/HFS-100 recommends a minimum horizontal width of 12 mm). ANSI/HFS-100 also suggests that the spacing between the key centers should be about 18-19 mm horizontally and 18-20 mm vertically for effective keying." (Smith et.al. 1997)

The ANSI/HFS-100 (1988) standard indicates that feedback of key actuation is important, since it indicates to the operator that the keystroke has been successfully completed. There are three types of keyboard feed back: visual, tactile an auditory. Visual feedback provides an indication on a display that the key has been depressed. It shows whether the key has been successfully depressed, because the content of that key is displayed on the screen. Tactile feedback can be provided by a collapsing spring that increases in tension as the key is depressed, or by a snap-action mechanism when key actuation occurs. The snap-action indicates the operator that the key has been actuated. Auditory feedback (e.g.. a "click" or "beep") can be also used to indicate that key has been actuated.

The proper position of the keyboard and mouse is essential in creating a comfortable workstation. Consideration of the following factors can help prevent musculoskeletal disorders such as carpal tunnel syndrome (CTS) and tendonitis:

- Height and Orientation
- Placement
- Design and Use

The potential hazard of height orientation is that, improper height and angle of the keyboard, mouse, or working surface can cause users to bend their wrists or lift their arms for extended periods. Possible solutions for such situations may be to raise or lower the work surface to keep the operator's arms in a comfortable position. This can be achieved by installing an adjustable keyboard extender or tray, by providing an adjustable table/working surface, or by raising the chair and providing a footrest if needed. If the keyboard and/or chair height is adjusted the user's elbows can hang comfortably at the side of the body, the shoulders are relaxed and the wrist is not bent up or down or to either side during keyboard use. The angle of the keyboard should also be considered when determining the preferred height. The preferred working position for most keyboard operators is with the forearms parallel to the floor and elbows at the sides; this allows the hands to move easily over the keyboard.

When the placement of the keyboard and the mouse is considered a keyboard or mouse that is not directly in front of or close to the body (Fig. 4.15) forces the user to repeatedly reach during use.

Figure 4.14 Mouse placed too far from the body (www.oscha-slc.gov)

With the phenomenal increase in graphics applications and Internet use, mousing has become a major cause of carpal tunnel syndrome (CTS). To combat these dangers, it is important always mouse within the neutral reach zone. Avoiding the extreme postures minimizes the possibility of shoulder abduction and wrist flexion/tension. Up to 10 pounds of force is needed to hold a mouse. This force stresses the muscle and connective tissue in the forearm. The further away from the body mouse is held, the more stress on the elbow, neck and shoulders.

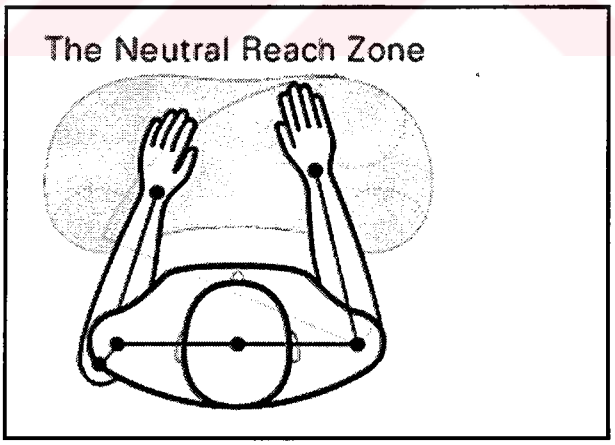


Figure 4.15 Neutral body posture is achieved when working with the Neutral Reach Zone, which is the "area that can be conveniently reached with a sweep of the forearm while the upper arm hangs in a neutral position at the side." (Sanders & McCormick, 1993)

The mouse has to be kept within the neutral reach zone. It should be positioned at the operator's side with his or her arm close to the body (Fig 4.17). A straight line

should be maintained between the hand and the forearm. The upper arm should not be elevated or extended while using the mouse. The employee should not have to reach to use the mouse.

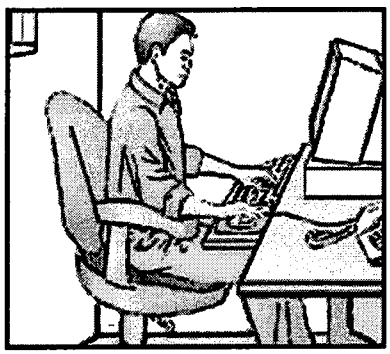


Fig 4.16 Mouse placed close to the body (www.osha-slc.gov)

Users should monitor their mouse hand and immediately begin mousing with their other hand at the first sign of any pain or tingling. Ideally, the mouse should be symmetrical so it can be used easily in both hands. Likewise, the keyboard platform should allow for mousing on both sides of the keyboard.

Poor mousing techniques can cause extension, flexion, radial deviation and ulnar deviation which impose abnormal forces on the tendinous structures of the wrist, which can lead to fatigue, pain and injury.

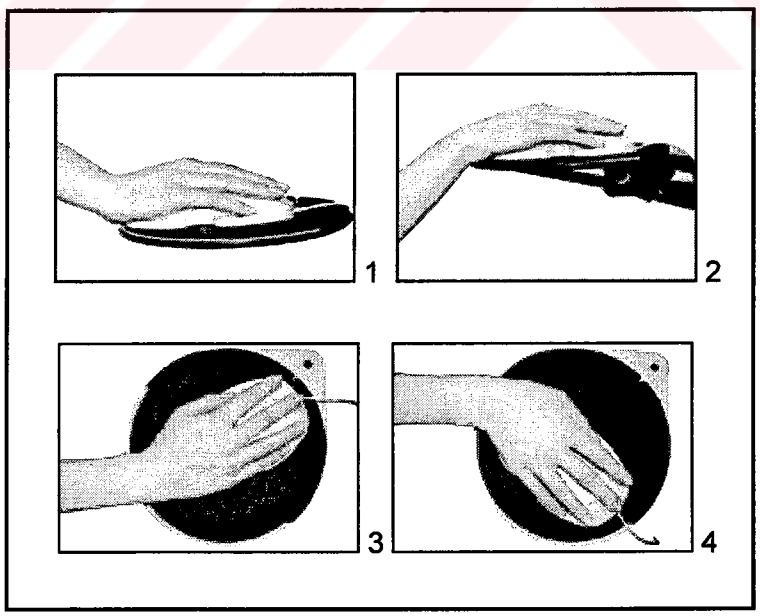


Figure 4.17 (1) extension (2) flexion (3) radial deviation (4) ulnar deviation

Ideally the wrist should be in a neutral position as in Figure 4.19, decreasing the stress on the wrist's tendon and structures.

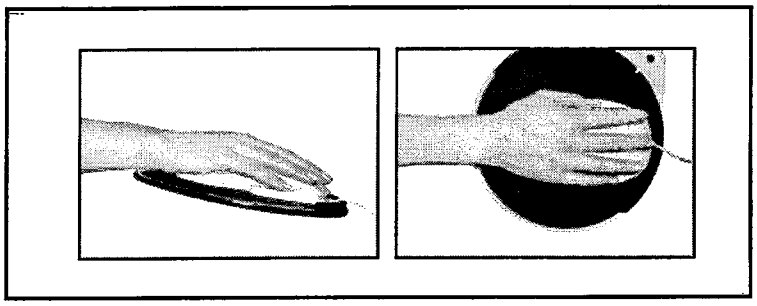


Figure 4.18 Sustainable mousing posture

Using a mouse platform that rotates above the keyboard while maintaining about the same plane can be considered. The design in the figure allows the mouse to be used above 10-key pad, which gives the user a better wrist angle and reduces reach

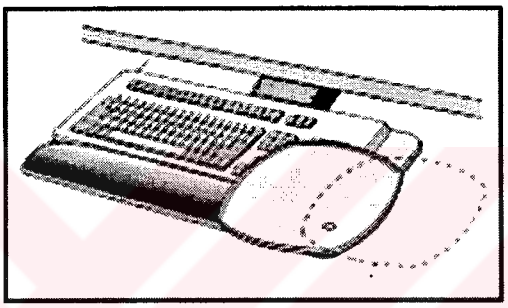


Figure 4.19 Rotating Mouse Platform (www.oscha-slc.gov)

Design and use is another important aspect that has to be emphasized. Bending wrists sideways or up and down while keying can be hazardous.

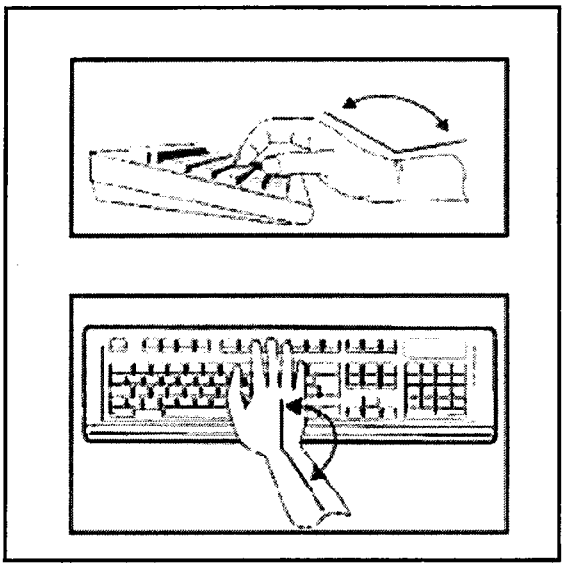


Figure 4.20 Hazardous upward and side bending of the wrist (www.oscha-slc.gov)

The fingers should be kept on their assigned home row keys as in Figure 4.22 Fingers should be slightly curved with the pad of the finger square on each key. Wrists should be slightly curved and off the bottom frame of the keyboard. This will minimize the amount of "finger-reaching" required and reduce fatigue.

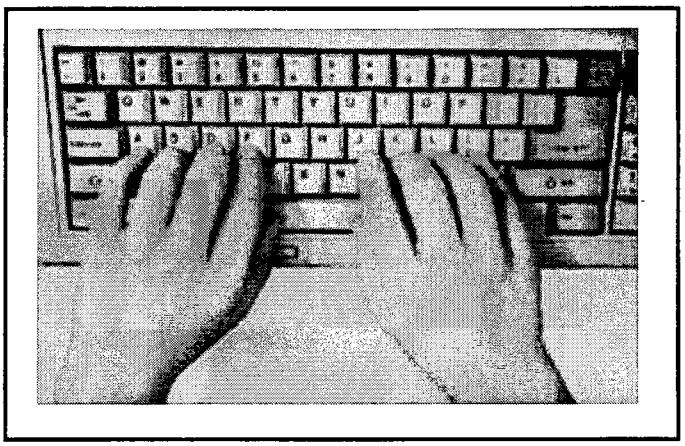


Figure 4.21 Fingers on their assigned home row keys (www.osha-slc.gov)

While using the keyboard, elbows must be kept close in, next to user's side. This will accomplish several things. First, with the fingers on the home row keys, you will be able to "train his fingers" in the correct finger touch typing key reaches. If the elbows are correctly "tucked in, next to his side" his fingers then have a more consistent "platform" from which to reach out and strike the key. If your elbows are not tucked in, close to his side, this places a "twist" on his wrists, which is fatiguing.

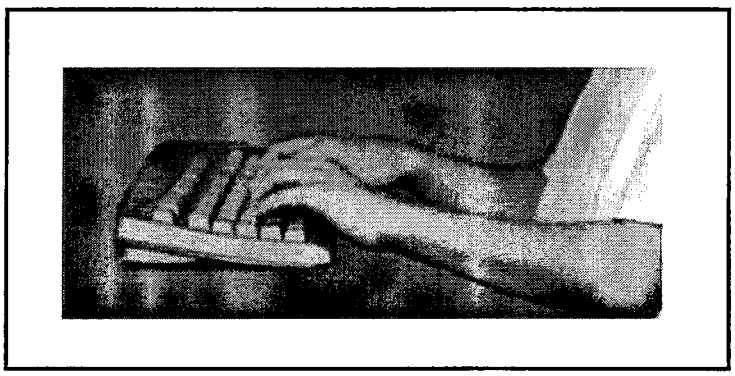


Figure 4.22 (www.osha-slc.gov)

When keying data, the wrists should be sloping upward, at the same slope as the keyboard. Wrists becoming "lazy" as shown must not be allowed. If the wrists rest on the desk, this transfers the additional "workload" to the fingers.

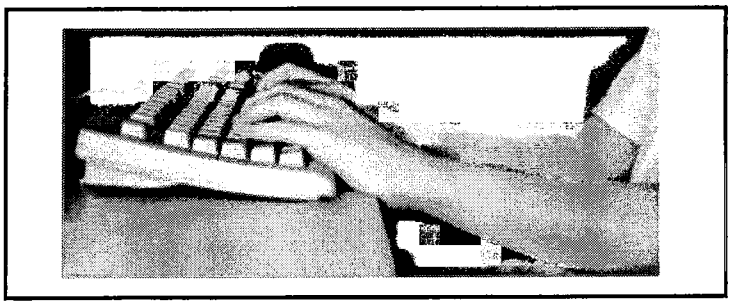


Figure 4.23 Wrists resting on the desk (www.osha-slc.gov)

"A mouse pad or wrist rest can be used to maintain straight wrists. Wrist/palm rests should not be used while keying, but to rest the wrists between periods of keying. The use of a wrist rest when keying can help minimize extension (backward bending) of the hand/wrist, but the use of a wrist rest for operator comfort and health has generated some debate. When the hand or wrist is resting on the wrist rest there is compression of the tissue that may create increased inter-carpal canal pressure. On the other hand, the wrist rest allows the hands and shoulders with less muscular tension, which is beneficial to computer operator comfort. As this time, there is no scientific evidence that the use of a wrist rest either causes or prevents serious musculoskeletal disorders of the hands, wrists or shoulders. Thus, the choice to use a wrist rest should be based on user comfort and performance consideration until scientific evidence suggest otherwise. If used, the wrist rest should have a fairly broad surface (5 cm minimum) with a rounded front edge to prevent cutting pressure on the wrist and the hand. Padding further minimizes skin compression and irritation. Height adjustability is important so that the wrist rest can be set to a preferred level in concert with the keyboard's height and slope." (Smith et.al, 1997)

Alternative keyboards may also be helpful in allowing the worker to maintain a neutral wrist position. Several alternative keyboard designs have been developed to address computer users' shoulder, arm and hand discomfort, pain and fatigue.

Ilg (1987) reported on a 5-year evaluation project to develop the optimal criteria for keyboard design. This research was conducted at the Fraunhofer Institute in Stuttgart. Fifteen design parameters of keyboards were investigated to define the optimal characteristics of each parameter. As each parameter was optimized, the next parameter was evaluated in a keyboard configuration that contained the

previously optimized parameters. Thirty subjects with varying keyboard experience were used to test the various parameters. Subject performance was examined regarding typing speed of accuracy and subject preferences were recorded. The following results were found to be noteworthy:

- Keyboard geometry- the alpha/numeric field was divided into two. The existing row layout was replaced with a key column key arrangement. It was found that the splaying of columns according to finger positioning had only a slight influence on performance.

- Key spacing- a key spacing of approximately 19 mm both horizontally and vertically was found to be preferable.

- Inclination of the keyboard- Lateral inclination of about 8° was optimal. The optimal frontal inclination was between 5° and 10°.

- Curvature- The result of longitudinal and transverse curvature for fitting the fingers was inclusive.

- Depth of key depression- 4 mm of key travel was advantageous.

- Force of key actuation- the result was not definite. The optimal was felt to be between 0.20N and 0.70N.

- Key design- the key surface should be concave with a minimum radius of 30 mm. The key should be a square with a side length of 14 mm.

- Hand-rest- all subjects found the rest desirable.

In order to evaluate hand posture, Hedge and Powers (1995) examined a negative slope keyboard and forearm supports using video-motion analysis. Twelve experienced female typists participated in a laboratory experiment where they typed on a computer keyboard for approximately 50 min under different arm support and keyboard slope conditions. The keyboard was a standard IBM keyboard, which was fitted into a fixture that provided adjustable negative angling. Subjects were tested in different conditions comparing the conventional keyboard flat on the desk, a condition in which the forearms were supported in movable arm supports with the

conventional keyboard flat on the desk and the negative sloping keyboard with wrist support. The findings indicated that there were no differences in subject postures between forearm supported condition and the conventional keyboard. The forearm-supported condition did not yield improved wrist postures. The negative sloping keyboard (Fig 4.24) produced improved wrist extension over the conventional keyboard. According to Hedge, in this position the arms, shoulders, neck and back can relax, especially during brief rest pauses. Also, in this slightly reclined sitting position the low back rests against the lumbar support of the chair, the elbow angle is opened to promote circulation to the lower arm and hand, the abdominal angle, and the popliteal angle (behind the knees) are opened to promote blood circulation. The feet rest firmly upon the floor.

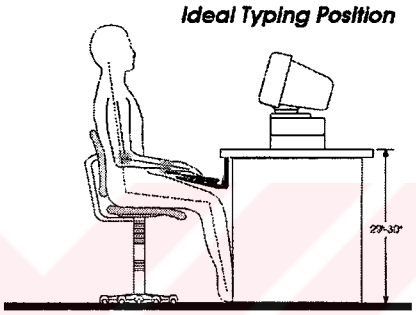


Figure 4.24 Negative slope keyboard (Hedge, 1995)

4.2.2.2. Ergonomic Consideration about Computer Display Devices

Monitor and document placement is important in creating a comfortable workstation. The following items have to be considered in order to reduce awkward head and neck postures, fatigue and/or headaches:

- Display
- Monitor placement
- Source Document Position

The human body has a neutral tendency to view an area from the horizontal to directly down in front of him. This is mainly because when we walk we need to provide the brain with the information about where to step. It is rare and unnatural to look up. A display screen that is too high, too low, or placed to the side of the user may, over time, cause awkward postures and increased stress on the muscles of the neck, shoulders, and upper back. Monitors that are too high should be avoided

since the head has to be tilted back and the eye muscles extended to extreme positions leading to eyestrain and fatigue. For avoiding such circumstances, monitor has to be kept directly in front of the user. The topmost line of the screen should not be higher than the user's eyes. Screens that swivel horizontally and tilt or elevate vertically enable the user to select a comfortable viewing angle. Generally, placing the monitor on top of the computer will raise it too high. Tilting the head back to read through the bottom portion of bifocal lenses can stress the neck, back and shoulders. Lowering the display or using single-lens glasses with a shorter focal length while viewing the monitor can avoid tilting of the head. Viewing distances that are too long or too short can cause stress and eye strain. The preferred viewing distance is 45 to 60 cm. If there is not enough table depth to accommodate this distance, a keyboard extender or tray may be installed underneath the desk .The table depth should generally be at least 75 cm from the wall to properly accommodate monitors. Tables and desks away from the wall and dividers have to be pulled to provide more space for monitors. Viewing the monitor for long periods of time can cause eye fatigue and dryness. The user has to rest his eyes periodically. He should stop, look away, blink and/or stretch at regular intervals.

Researchers overwhelmingly agree that the top line of text on the monitor should be at or slightly below eye level. That's because any portion of the monitor above eye level contributes to neck and shoulder strain. If your monitor is too high because it rests on top of the CPU, invest in a below-the-desk CPU holder. Placing the CPU below the desk not only allows for better positioning of the monitor, but also creates additional desk space. Alternatively, if the monitor is positioned too low, consider spacers or adjustable monitor arms to lift it off the desk.

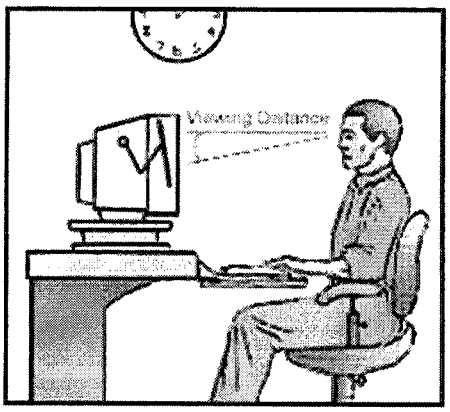


Figure 4.25 Preferred viewing distance (www.oscha-slc.gov)

The monitor also should be placed directly in line with the keyboard to minimize twisting of the neck and/or body. Again, maintaining body symmetry is a critical component of healthy work habits.

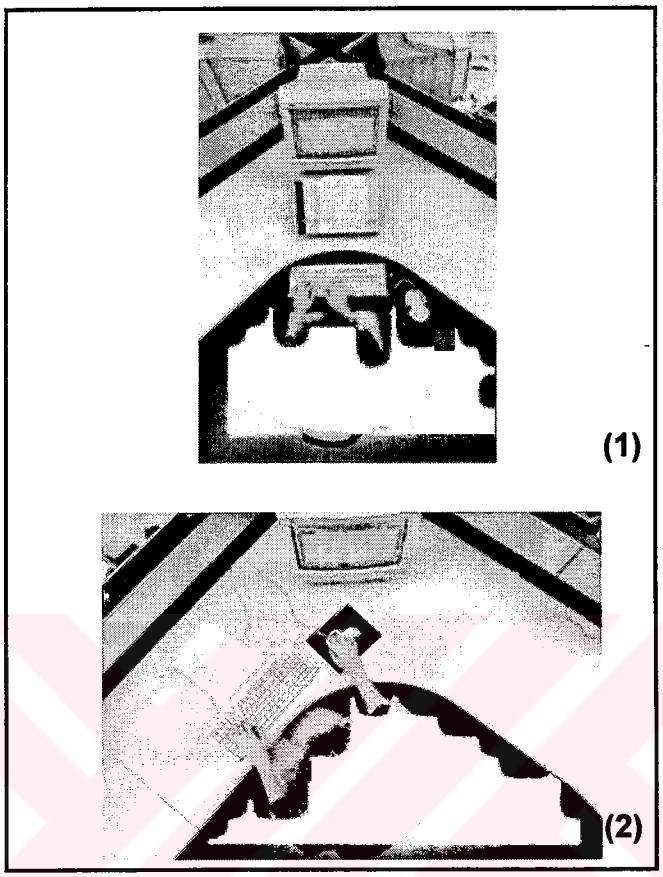


Figure 4.26 (1) Typical workstation set-up: keyboard, document and monitor are not aligned, which causes repetitive, one-directional twisting of the neck, shoulders and back - a long-term health danger. (2) Ergonomic workstation set-up: alignment of keyboard, document and monitor precludes dangerous twisting and minimizes the risk of associated injuries.

Awkward posture or frequent movement of the head and neck to look from the monitor to a document is a potential hazard. The provision of a holder for source document (so that they can be read at screen level and without turning the head) will reduce the postural loading on the neck muscles very considerably (particularly in data entry, copy typing tasks, etc.). "The preferred location of the document holder, relative to the screen, depends upon the task. In general, the item that the user looks at more frequently should be placed directly in front of him" (Phesant,1996). The screen and document holder should be close enough together so the operator can look from one to the other without excessive movement of the head, neck or back. (Figure 4.27)

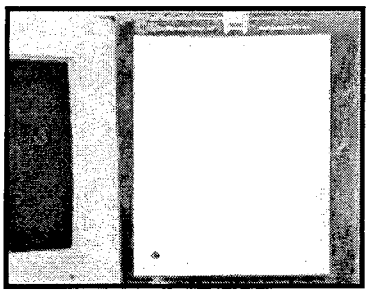


Figure 4.27 Screen and document holder are close together and same distance from the eye. (www.osha-slc.gov)

If writing needs to be performed, a document holder can be positioned directly beneath the monitor (Fig. 4.28). This provides a sturdy writing surface and prevents frequent movement of the head, neck or back.

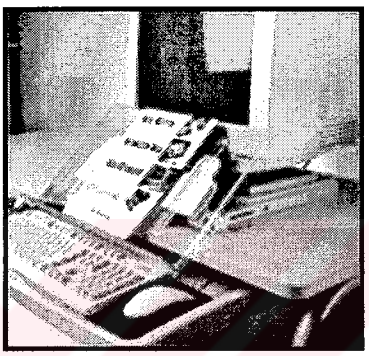


Figure 4.28 In-line document holders that allows for writing (www.oscha-slc.gov)

4.2.2.3. Ergonomic Considerations about Computer Workstation Furniture

"The relationship between the user and the machine is reciprocal; it is acting as a close system. One of the consequences of this is a restriction of space for physical activities that leads to constrained postures, together with long-lasting static contractions of several muscles of the back and the shoulders." (Smith et.al, 1997)

"In a computer workstation, the user has three points of physical contact with his workstation and environment: the desk (or keyboard), the seat and the floor. If a range of users, who vary in both size and shape, are to attain the same desirable working position then two out of these three must be adjustable. Ergonomically adjustable height desks are the preferred solution for office work, particularly if it is intensively screen based" (Pheasant, 1996).

Today, adjustable seat heights are much more preferred but there are also examples of adjustable desks. Adjustable desks can be classified into two main groups (Özkan, 1987) :

- Desks that can be adjusted as a whole
- Desks that can be adjusted partially.

Height-adjustable desks have been proposed (Ostberg et al., 1984) for use with height-adjustable chairs in order to increase the range of users accommodated by a workstation. (Figure 4.29)

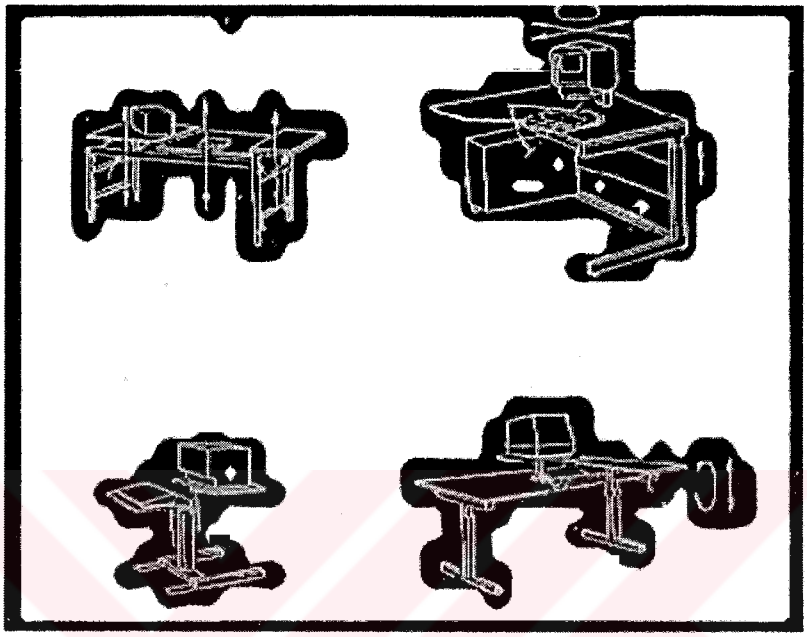


Figure 4.29 Examples of height-adjustable desks (Ostberg et al., 1984)

"The correct way to adjust one of these workstations is as follows:

- Adjust the chair height so that the feet are resting firmly on the floor
- Adjust the work surface height for comfortable access to the desktop or keyboard" (Starr, 1983).

The height of desks, which are not adjustable, is primarily based on average body measurements and makes no allowance for individual variation (Grandjean, 1987). "The recommended size of the work surface is dependent on the tasks, the documents and the technology. The primary working surface (e.g. those supporting the keyboard, display and documents) should be sufficient to: (1) allow the screen to be moved forward or backward, (2) allow a detachable keyboard to be placed in several locations, and (3) allow source documents to be properly positioned.

The tabletop should be as thin as possible to provide clearance for the user's thighs and knees. Moreover, it is important to provide unobstructed room under the

working surface for the feet and legs so the users can easily shift their posture. Knee-space height and width and toe depth are three key factors for the design of clearance space under the working surfaces.

Table height has been shown to be an important contributor to computer user musculoskeletal problems (Grandjean, 1983; Hünting et al., 1981.). In particular, tables that are too high (normal desk height 76 cm is too high for most people) cause the keyboard to be too high for many users. This puts undue pressure on the hands, wrists, arms and shoulders and neck. It is desirable for table heights to vary with the height of the operator, particularly if the chair is not height adjustable. Height-adjustable working surfaces are effective for this. Adjustable multi surface tables enable good posture by allowing the keyboard and the display to be independently adjusted to appropriate keying and viewing for each individual and each task. Tables that cannot be adjusted easily are a problem when used by several individuals of different sizes, especially if the chair is not height adjustable either. When adjustable tables are used, the ease of adjustment is essential. Adjustments should be easy to make and users should be instructed how to adjust the workstation to be comfortable" (Smith et.al, 1997).

What is desired for a healthy computer desk can be summarized as follows:

- It should provide sufficient leg room

Lack of foot space may also be problem for tall users. Mandal (1981,1991) has recently called for an increased in desk heights to overcome these problems and to account for the increasing height of population. " It is important that desks allow plenty of space for leg movement and it is an advantage if the legs can be crossed without difficulty. For this reason there should be no drawers above the knees and no thick edge to the desktop " (Grandjean, 1987).

The space for legs can be formulated by considering a person of buttock- popliteal length B, popliteal height P and foot length F sitting on a seat height H. (Figure 4.30). Sitting person streches out his legs so that his popliteal region is level with the seat surface (i.e. his thighs are approximately horizontal) the total horizontal distance between buttocks and toes (D) is approximated by D= B $+\sqrt{P^2 - H^2 + F}$.

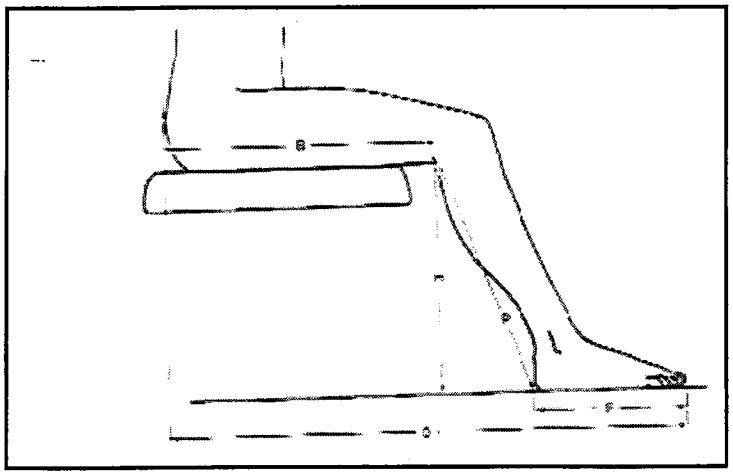


Figure 4.30 Calculation of forward legroom (Pheasant,1996)

- It should allow for adjustable height.
- It should have enough surface to support the computer equipment and space for documents.
- It should have rounded corners and edges.

For thousands of years, designing chairs was mainly a question of form. Even in the early twentieth century, chairs tended to be status symbols rather than useful or comfortable. Only in the last few decades have sitting posture and seats become topics for scientific research, especially for ergonomics. Studies have revealed that the sitting position reduces static muscular efforts in legs and hips, but increases the physical load on the inter-vertebral discs in the lumbar region of the spine. Figure (4.31)

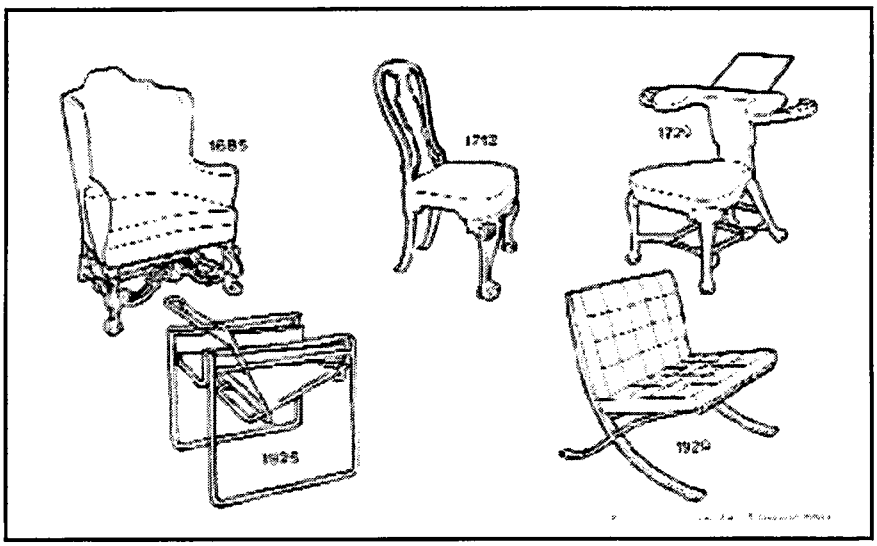


Figure 4.31 Form and function: eighteenth century style and twentieth century style. (Upper row left to right) William and Mary winged armchair, Queen Anne dining chair, and early Georgian library chair. (Lower row) 'Wassily' chair by Marcel Breuer, 'Barcelona' chair by Mies van der Rohe (Pheasant, 1996).

Today, in designing a chair, the objective is to support the lumbar spine and its neutral position (i.e. with a modest degree of lordosis) without the need of muscular effort, thus allowing the user to adopt a position that is both physiologically satisfactory and comfortably relaxed.

"Poorly designed chairs as in Figure 4.32 can contribute to computer user discomfort. Chair adjustability in terms of height, seat angle and lumbar support helps to provide trunk, shoulder, neck and leg postures that reduce strain on the muscles, tendons and discs. The postural support and action of the chair help to maintain proper-seated posture and encourage good movement patterns. A chair that provides swivel action encourages movement, whereas backward tilting increases the number of postures that can be assumed. The chair height should be adjustable so that the user's feet can rest firmly on the floor with a minimal pressure beneath the thighs "(Smith et.al, 1997).

"As the height of the seat increases, beyond the popliteal height of the users, pressure will be felt on the underside of the thighs. The resulting reduction of circulation to the lower extremities may lead to "pins and needles", swollen feet and considerable discomfort. As the height decreases the user will (a) tend to flex the spine more (due to the need to achieve an acute angle between thigh and trunk); (b) experience greater problems in standing up and sitting down, due to the distance through which center of gravity must move (c) require greater leg room. In general, therefore, the optimal seat height for many purposes is to close to the popliteal height" (Pheasant, 1996).

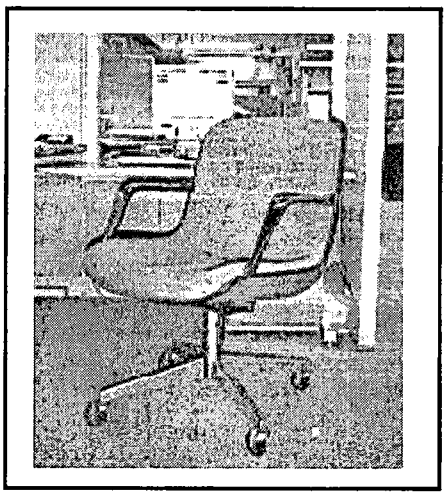


Figure 4.32 An example of poor chair design. Note the wide and deep seat pan, wide backrest, lack of lumbar support, thin armrests too far apart, lack of adjustability and four legged base. (Salvendy,1997)

"To enable very small users to sit with their feet on the floor without compressing their thighs, it may be necessary to add a footrest. A well designed footrest has the following features: (1) it is inclined upwards slightly (about 5-15°); (2) it has a nonskid surface;(3) it is heavy enough that it does not slide easily across the floor;(4) it is large enough for the feet to be firmly planted; (5) it is portable; and (6) it is height adjustable.

The seat "pan" is the part of the chair that directly supports the weight of the buttocks. The seat pan should be wide enough to permit users to make slight shifts in posture from side to side. This does not only help to avoid static postures, but also accommodates a large range of individual buttock size. The seat pan should not be too U-shaped because this can lead to static sitting postures. The minimum seat pan width should be 45 cm and the depth between 38-43 cm (ANSI/HFS-100, 1988). The front edge of the seat pan should be well rounded downward to reduce pressure on the underside of the thighs that can affect blood flow to the legs and feet. This feature is often referred as a "waterfall" design chair. (Figure 4.34) The seat needs to be padded to the proper firmness that ensures an even distribution of pressure on the thighs and buttocks. A properly padded seat should compress about ½ to 1 –in when a person sits on. Seat pan adjustments should be accessible and easy to use (from a seated position).

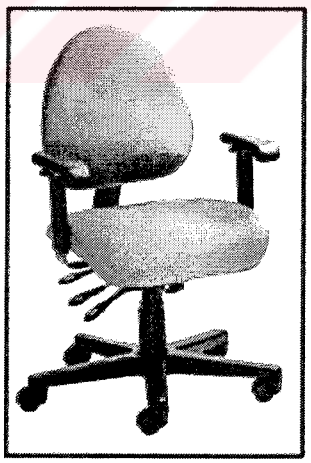


Figure 4.33 Seatpan with a rounded, waterfall edge (www.osha.com)

The tension and tilt angle of the backrest should be adjustable. Inclination of chair backrest is important for users to be able to lean forward or back in a comfortable manner. Backrest tilt adjustments should be accessible and easy to use. The advantage of having an independent tilt angle adjustment is that the backrest tilt will

then have little or no effect on the front seat height or angle. This also allows the user to shift postures readily.

The function of the backrest is to stabilize the trunk. Chairs with high backrests are preferred since they provide both lower back and upper (shoulder) back support. This allows the user to lean backward or forward, adopting a relaxed posture and resting the back and shoulder muscles.

For most computer workstations, chairs with rolling castors are desirable: they are easy to move and facilitate postural adjustment, particularly when the user has to reach for equipment or materials that are on secondary working surfaces. Chairs should have five supporting legs.

Armrests are another important chair feature. Both pros and cons to the use of armrests at computer workstations have been advanced. On one hand, some chair armrests can present problems of restricted arm movement, interference with keyboard operation, pinching of fingers between the armrest and table, restriction of chair movement, such as under the worktable, irritation of arms or elbows, and adoption of awkward positions. On the other hand, well-designed armrests or elbow rests can provide support for resting the arms to reduce arm, shoulder and neck fatigue. "Armrests should not have sharp edges. They should be broad and padded and support the "fleshy" portion of the forearm. They should be easy to adjust. It is not widely recognized that many users do not adjust their chairs. It has been learnt that adjustability alone is not enough. People must be aware that their chair adjusts.

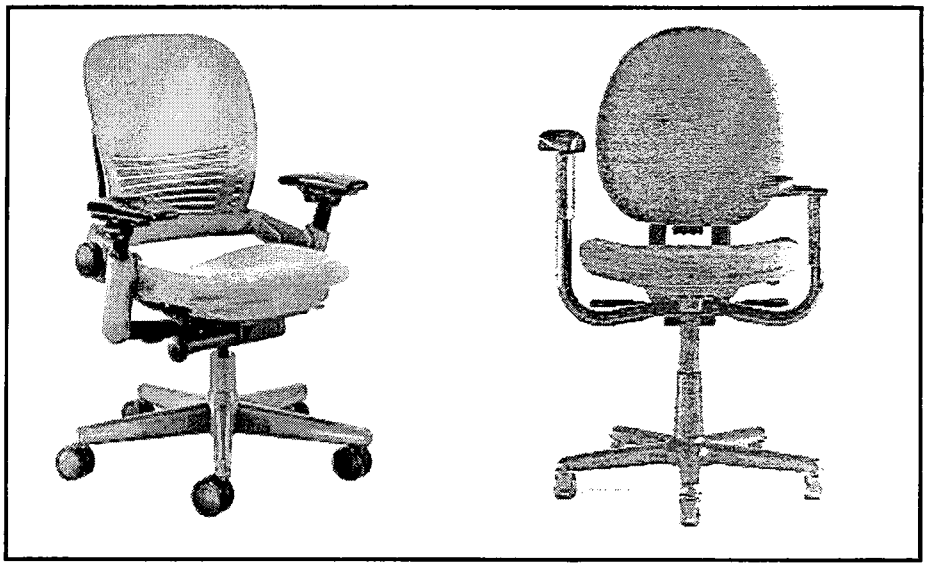


Figure 4.34 Chairs with adjustable armrests (www.steelcase.com), (Salvendy,1997).

They must also know why it is important to perform the adjustments" (Lueder, 1999). Properly designed armrests can overcome the problems mentioned above. Removable armrests are an advantage because they provide greater flexibility for individual preference. Many chairs have height adjustable armrests that are helpful for user comfort as in Figure 4.34.

As a summary, it can be said that, a well designed chair for computer tasks:

- Should support the back
- Should have a vertically adjustable independent backrest that returns to its original position and has tilt adjustment to support the lower back
- Should have a pneumatic height adjustment, so that the chair height can be adjusted while the user is in a seated position
- Should be adjusted so the back crease of the knee is slightly higher than the pan of the chair (use a footrest or a stack of books to elevate the feet if the chair is too high and not adjustable)
- Should be supported by a five prong caster base
- Should have removable armrests that are adjustable in all three dimensions
- Should have a contoured seat with breathable fabric and rounded edges to distribute the weight and should be adjustable to allow the seat pan to tilt forward or back

4.2.2.4 Ergonomic Considerations about Lighting

Lighting is an important aspect of the visual environment that influences CRT screens and hardcopy readability, glare on the screen and viewing in the general environment.

Lighting that is not appropriate for computer work is a major factor in visual discomforts such as eyestrain, burning or itchy eyes, headaches and blurred or double vision. Lighting should be adequate for the user to see the text and the screen, but not so bright as to cause glare of discomfort.

"There are four types of general workspace illumination of interest to the computer user's environment.

1. Direct radiants. Direct radiants are the main source of workspace lighting. These can be incandescent or fluorescent lights. Fluorescent lights are more

prevalent in workplaces. Direct radiants direct 90% or more of their light toward the object(s) to be illuminated in the form of a cone of light. They have a tendency to produce glare.

2. Indirect lighting. This approach uses reflected light to illuminate work areas. Indirect lighting directs 90% or more of the light onto the ceiling and walls, which then reflects back into the room. Indirect lighting has the advantage of reducing glare, but supplemental lighting is often necessary for hardcopy tasks when indirect lighting is used.

3. Mixed direct radiants and indirect lighting. With this approach, part of the light (about 40%) radiates in all directions, while the rest is thrown directly onto objects to be illuminated or indirectly onto the ceiling and walls.

1. Opalescent globes. These lights give illumination equally in all directions. Because they are bright they often cause glare. Modern light sources used in the four general approaches to workplace illumination are typically of two kinds: Electric filament lamps and fluorescent tubes. The following are advantages and drawbacks of these two light sources:

2. Filament lamps. On the one hand the light from filament lamp is relatively rich in red and yellow rays. It changes the apparent colors of objects and thus is unsuitable when correct assessment of color is essential. Filament lamps have the additional drawback of emitting heat. On the other hand, users like the warm glow of filament lamps that is associated with evening light and a more natural, cozy atmosphere. Filament lamps are less energy efficient than fluorescent lights and hence are more expensive to operate

3. Fluorescent tubes: fluorescent lighting is produced by passing electricity through a gas. Fluorescent tubes usually have a low luminance and thus are less of a source of glare. They have the ability to match their lighting spectrum to daylight, which users may find preferable. Standard spectrum fluorescent tubes, however, are perceived as cold, pale light and may create an unfriendly atmosphere. Fluorescent tubes may also produce flicker especially when they become old and or defective.

The intensity of illumination or luminance being measured is the amount of light falling on a surface. In practice, this level depends on both, the direction of flow of

the light and on the spatial position of the surface being illuminated in relation to the light flow. Illumination is measured in both the horizontal and vertical planes. At computer workplaces, both the horizontal and vertical are important. A document lying on a desk is illuminated by the horizontal illumination whereas the computer screen is illuminated by the vertical illumination." (Smith et al. 1997)

The German DIN standard recommends an illumination level of 500 lx for working environments with computers. Recommended illumination levels at computer workstations for horizontal plane is as in table 4.1.

Working conditions	Illumination levels (lx)
Conversational tasks with well printed Source documents	300
Conversational tasks with reduced Readability of source documents.	400 – 500
Data entry tasks	500 - 700

Table 4.1 Recommended illumination levels at computer workstations. (Grandjean, 1990)

The illumination in workplaces that use computer screens should not be as high as in workplaces that exclusively use hardcopy. Lower levels of illumination will provide better computer screen images quality and reduced screen glare. The lighting level should be set up according to the visual demands of the tasks performed.

"Luminance is a measure of the brightness of a surface, the amount of light leaving the surface of an object, reflected by the surface (as from a wall or ceiling) emitted by the surface (as from CRT characters), or transmitted (as light from the sun that passes through translucent curtains.) Luminance is expressed in units of candela per square meter (cd/m^2). High- intensity luminance sources (such as windows) in the peripheral field of view should be avoided. In addition, a balance among luminance levels within the computer user's field of view should be maintained. The ration of luminance of a given surface or object to another surface or object in the central field of vision should be around 3:1, while the luminance ration in the peripheral field of vision should not exceed 10:1." (Smith et al. 1997)

For optimal comfort and performance in CWS mediums, the following factors should be considered:

- Amount of Light
- Contrast of Light with Environment

Problems can occur when bright light on the display screen "washes out" images and makes it difficult for users to clearly see the work. Possible solutions for such a problem may be using light diffusers so that desk tasks (writing, reading papers) can be performed without direct brightness on the computer screen. Placing rows of lights parallel to the operator's line of sight. Using operator adjustable task/desk lighting. If diffusers or alternative lights are not available, removing the middle bulbs of 4-bulb fluorescent light fixtures can also reduce the brightness of the light.

Another potential hazard may be bright light in the user's field of view as in figure 4.35.

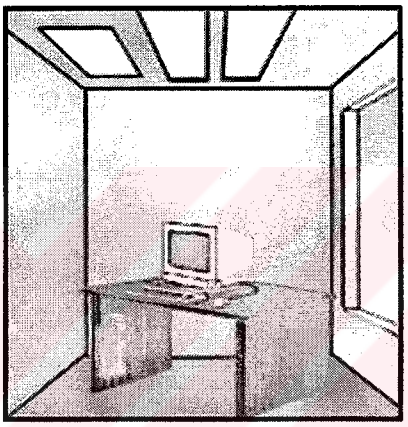


Figure 4.35 Bright light entering from a window (www.osha-slc.gov)

Possible solutions for such a circumstance may be to;

- Use blinds or drapes on windows to eliminate bright light. Blinds should be adjusted during the day to allow light into the room, but not directly into the operator's field of view (Fig. 4.36).

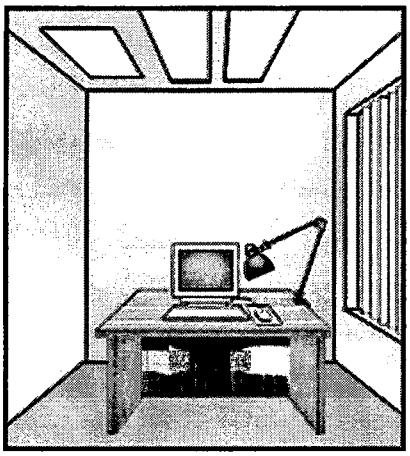


Figure 4.36 Blinds on the windows and the monitor placed at different angles (www.osha-slc.gov)

- Lamps should have glare shields or shades and the line of sight from the eye to the light should be at an angle greater than 30 degrees.
- Reorient the workstation so that bright lights from open windows are not in the field of view. (Fig. 4.36).
- Use indirect or shielded lighting where possible and avoid intense or uneven lighting in the field of vision (Fig. 4.36).

High contrast between light and dark areas of the computer screen, horizontal work surface, and surrounding areas are also problems that can be faced with. For computer work, well-distributed diffuse light is best. The advantages of diffuse lighting are two-fold: There tend to be fewer hot spots, or glare surfaces, in the visual field, and the contrasts created by the shape of objects tend to be softer. Light, matte colors and finishes on walls and ceilings in order to better reflect indirect lighting and reduce dark shadows and contrast.

The surface of the screen is made of glass that reflects about 4% incident light and this suffices to reflect clear images of the surrounding such as lights, the keyboard or the operator. The luminance of reflections decreases character contrasts and disturbs legibility; it can be so strong that it produces a glare. Image reflections are annoying, especially since they also interfere with focusing mechanisms; the eye is induced into focusing alternately the text and the reflected image. Thus, reflections are also a source of distraction. (Fig 4.37and Fig 4.38)

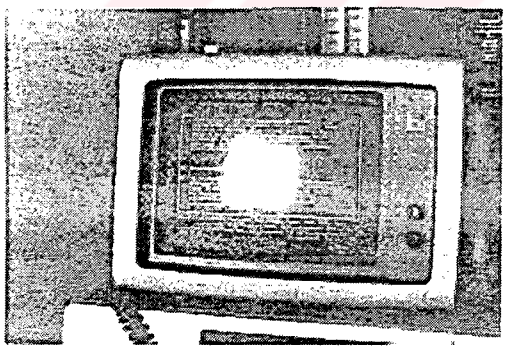


Figure 4.37 The reflected image of a window behind the back of the operator is superimposed on the screen text and disturbs reading (Grandjean, 1987).

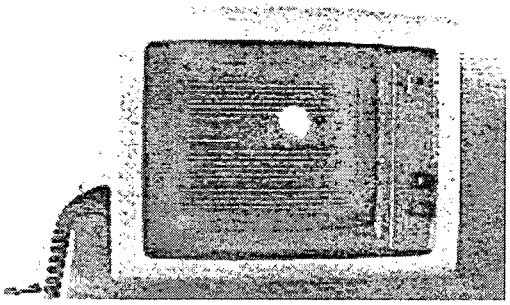


Figure 4.38 Alight source, reflected on the screen, generates glare and impairs reading (Grandjean, 1987).

Glare on the viewing screen may cause eyestrain, headaches and/or fatigue. Especially children may not be conscious of the irritation; however, over the course of a long day, it can cause problems. Glare can be classified into three main groups:

- Direct glare is caused by bright windows or strong light sources that are in the visual field of the computer operator (i.e., a strong light shining in your face as you look at the monitor)
- Spectacle glare is reflection that appears on the glass surface of the display screen similar to a mirror like image.
- Diffuse glare is patches of the screen that are washed out and have lost contrast due to light bouncing off the inner phosphor layer of the monitor surface, similar to washout that occurs to a television image from bright sunlight.

Direct or reflected sources of light may cause glare. Direct light sources (e.g., windows, overhead lights) that cause a reflected light to show up on the monitor.

Blinds or drapes on windows can be used to help reduce glare. Monitor must be cleaned frequently. A layer of dust can contribute to glare. Screen glare filters that attach directly to the surface of the monitor can reduce glare. Generally, a large number of low powered lamps rather than a small number of high-powered lamps will result in less glare. Reflected light from polished surfaces (e.g. keyboards) may cause annoyance, discomfort or loss in visual performance and visibility. Workstation and lighting should be arranged to avoid reflected glare on the display screen or surroundings. A window in front of an operator disturbs through direct glare, behind it produces reflected glare. For this reason, CWS must be placed at right angles to the window.

5. POSTURE EVALUATION IN CWS ENVIRONMENTS

There are two kinds of muscular effort: dynamic effort and static effort. Dynamic effort is cranking a wheel, the static one, supporting a weight at arm's length. Dynamic muscular work is characterized by a rhythmic alternation between constructions and relaxation of muscles.

Static muscular work is characterized by a prolonged state of contraction, which usually implies a postural stance or constrained postures. During static effort the muscle is not allowed to relax, but remains in a state of heightened tension. With static work no outward performance is visible.

There is a fundamental difference between static and dynamic muscular effort: during static work the blood vessels are compressed by the internal tension of muscle tissue, so that blood no longer flows through the muscle.

During dynamic work, on the other hand, the muscles act as a pump to the blood circulation. Compression squeezes blood out of the muscles and the following relaxation releases a fresh flow of blood into it. A muscle performing dynamic work is therefore flushed with blood and is continuously supplied with high-energy sugar as well as oxygen, while at the same time waste products are removed. That is why dynamic effort can be carried on for a very long time without fatigue, provided a suitable rhythm is chosen.

In contrast to dynamic work, a muscle that is performing hard static work does not receive sugar or oxygen from the blood but must depend on its own reserves. This is by far the most serious disadvantage waste products are not being removed. Quite the reverse: waste products, such as carbon dioxide or lactic acid, are accumulating and produce the acute pain of muscular fatigue, often called localized fatigue.

For this reason it is hardly possible to continue static muscular effort for a very long time: the pain will compel one to desist. In everyday life the human body must often perform static work. In sitting posture the static work of the legs is relieved but a

certain amount of static work is still required to maintain an erect position of trunk and head. In many cases no sharp distinction between dynamic and static effort can be made. A particular task can be partly static and partly dynamic. Typing is an example of a combination of both types of muscular work: the shoulders and arms do mainly static work when holding the hands in the typing position, while the fingers perform mainly dynamic work when operating the keys.

5.1. Sitting Posture

Sitting posture has its origins in Egypt and Greece as a posture of high-status individuals. "Many primitive people had no knowledge of seats of any kind, they crouched, knelt or squatted on the ground. The deep squat was a common working and resting posture worldwide" (Bridger, 1995). Seats originated at least in part, as status symbols, only the chief had the right to be raised by a chair.

At the beginning of the present century, it was gradually, realized that well-being and efficiency could be improved and fatigue reduced if people sit at their work. The reason is a physiological one: as long as a person is standing a certain static muscular effort is required to keep the joints of the feet, knees and hips in a fixed position, such muscular effort ceases when the person sits down.

This led to an increased application of medical and ergonomic ideas to the designs of seats for work. The developments gained in importance as more and more people sat down at their schools and work.

The advantage of sitting, is taking the weight off the legs. In sitting, there is the possibility of avoiding unnatural postures. Energy expenditure is reduced and there is a lower demand on blood circulation.

But on the other hand, prolonged sitting leads to a slackening of the abdominal muscles ('sedentary tummy') and to a curvature of the spine, which, in turn, is unfavorable for the organs of digestion and breathing. The most serious problem involves in the spine and the muscles of the back, which in many sitting positions are not only relaxed but also positively stressed in various ways.

5.1.1. Spinal Problems of Sitting

"The spine is a column made up of 24 vertebrae, separated by fluid filled discs that act as shock absorbers" (Allie, 2001). In other words according to Pheasant (1997), the human vertebral column (backbone) consists of twenty-four movable bony vertebrae separated by deformable hydraulic pads of fibrocartilige known as intervertebral discs. "An intervertebral disc is a sort of cushion, which separates two vertebrae, and collectively they give flexibility to the spine. A disc consists of a viscous fluid enclosed by a tough, fibrous ring, which encircles the disc" (Grandjean, 1987). A schematic representation of a disc between two vertebrae and its connections with spinal cord and the nervous tracks is given in figure 5.1.

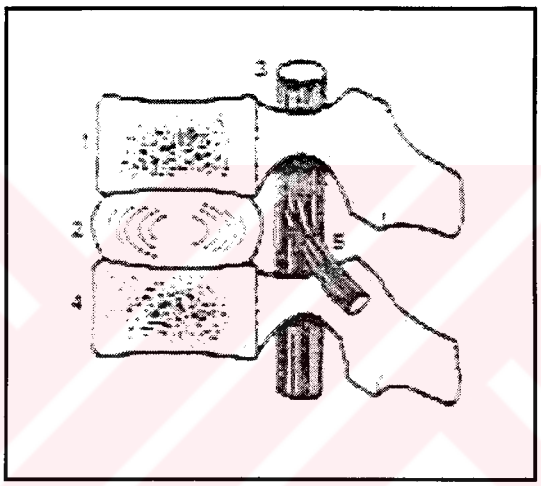


Figure 5.1 Diagram of a section of the spine. The disc (2) lies between two vertebrae, (1) and (4); behind the spinal cord (3) and a nervous track (5). The disc is like a cushion, which gives flexibility to the spine. (Grandjean, 1987)

"The spinal column is surmounted by the skull and rests upon the sacrum, which is firmly bound to the hipbones at the sacroiliac joints. The vertebrae can be naturally grouped into seven cervical (in the neck), twelve thoracic (to which the ribs are attached) and five lumbar (in the small of the back, between the ribs and the pelvis). The spine is a flexible structure, the configuration of which is controlled by many muscles and ligaments" (Pheasant, 1996). (Figure 5.2)

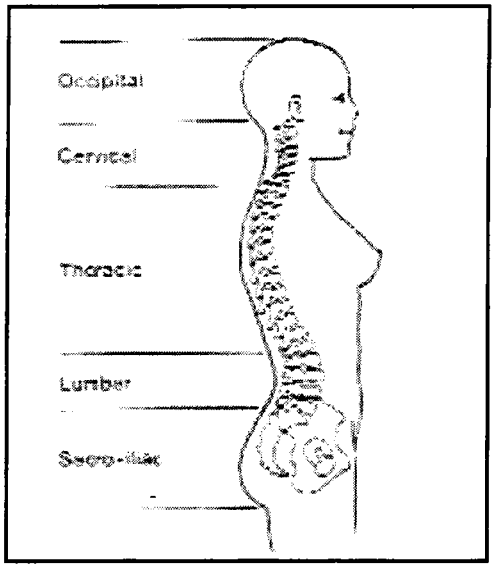


Figure 5.2 Human spines. (Pheasant, 1996)

Sitting changes the natural curve of the spine, increases strain on the muscles and ligaments as well as the pressure in the fluid filled discs. What is more, when seated, the pelvis rolls backward adding to the stress on the muscles and ligaments. This position (with pelvis rolled backward) causes us to sit with a flattened lumbar curve known as lumbar kyphosis. These strains exerted over time can be harmful to the discs, ligaments and muscles(Allie, 2001). (Figure 5.3)

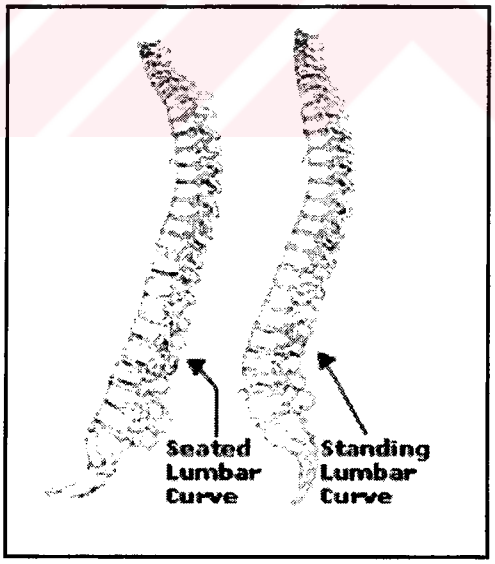


Figure 5.3 Seated and standing lumbar curve. (Allie,2001)

When you are seated, your spine changes shape with every movement. When leaning forward, the spine's shape becomes rounded. When sitting in a relaxed posture or when you sit upright the curve of your lower spine can flatten. And, as

you recline against the chair's backrest the curve of your lower spine increases. (Fig 5.4)

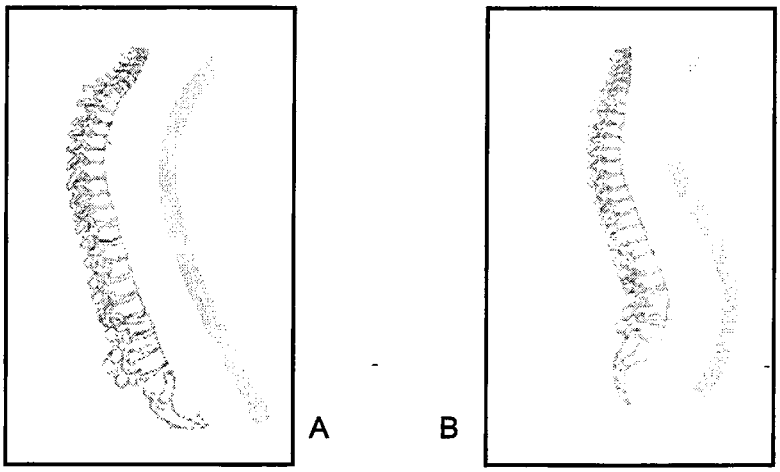


Figure 5.4 (a) the spine's shape can range from a rounded "c" known as Kyphosis (b) ...to a more stress-free "s" shape when lumbar lordosis is maintained. (Allie,2001)

Studies have revealed that the sitting position reduces static muscular efforts in legs and hips, but increases the physical load on the intervertebral discs in the lumbar region of the spine. An important question suggests itself here. Is the upright seated posture is healthy and therefore recommended, or is the relaxed position with the backward- leaning trunk more comfortable and hence, preferred? For the last century, work chairs in schools, factories and offices have been designed for sitting upright, with the hip, knees and ankles all at right angles.

Most ergonomic standards for CWS are based on traditional views on healthy sitting postures. Mandal reports that the " correct seated position" goes back to 1884 when the German surgeon Staffel recommended the well-known position. (Figure 5.5) Mandal stated with exaggerated subtlety:

But no normal person has ever been able to sit in this peculiar position (upright trunk, inward curve of the spine in the lumbar region and thighs in a right angle to the trunk) for more than 1-2 minutes and one can hardly do any work, as the axis of vision is horizontal. Staffel never gave any real explanation why this particular posture should be better than any other posture. Nevertheless, all experts all over the world have accepted this posture ever since quite uncritically as the only correct one.

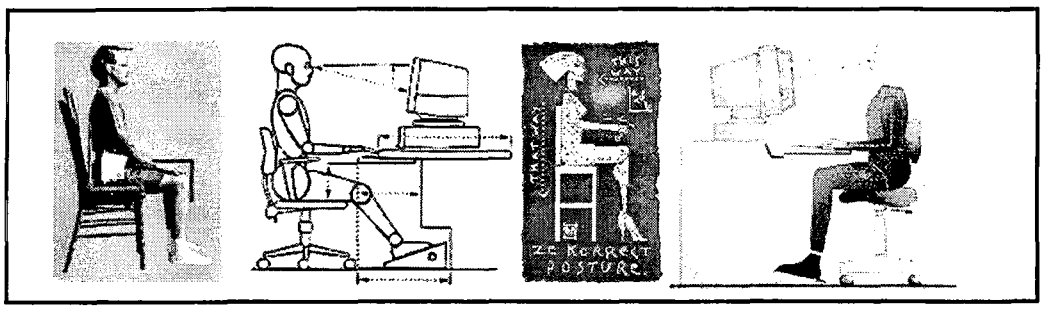


Figure 5.5 Upright position (www.metamorphosis.com)

Until recently, it was widely believed that people sat with a 90-degree bending of the hip joint while preserving lordosis (concavity) of the back. (Figure 5.6)

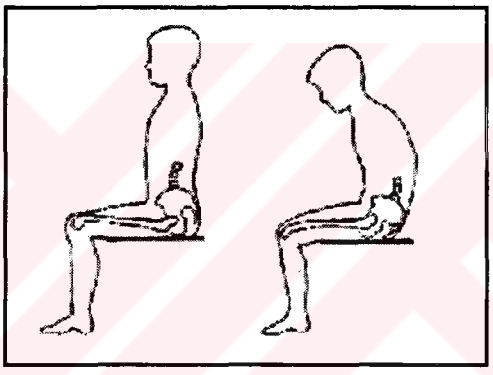


Figure 5.6 Lordosis of the back (Bridger,1995)

But most people are unable to sit erect in 90° postures for long periods and as soon adopt a slumped posture. It is indeed a fact that the sitting posture of students in the lecture hall or of any other audience is very seldom a "correct upright position of the trunk". On the contrary, most people lean backward (even with unsuitable chairs) or in some cases lean forward with elbows resting on the desk. (Figure 5.7) It is most probable that these two preferred trunk positions are associated with a substantial decrease of intervertebral disc pressure as well as lessened tension of muscles and other tissues in the lumbar and thoracic spine (Figure 5.8) (Andersson et.al.1974, Nachemson et.al. 1970).

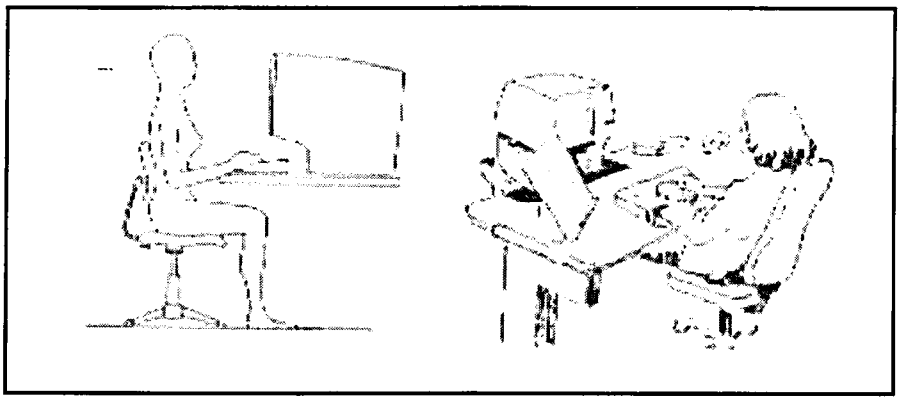


Figure 5.7 Recommended and typical postures at CWSs. The left drawing illustrates "wishful thinking" where the trunk is an upright posture with the elbows down and forearms nearly horizontal. The right drawing is most commonly observed for computer work and represents the preferred body posture. (Salvendy,1997)

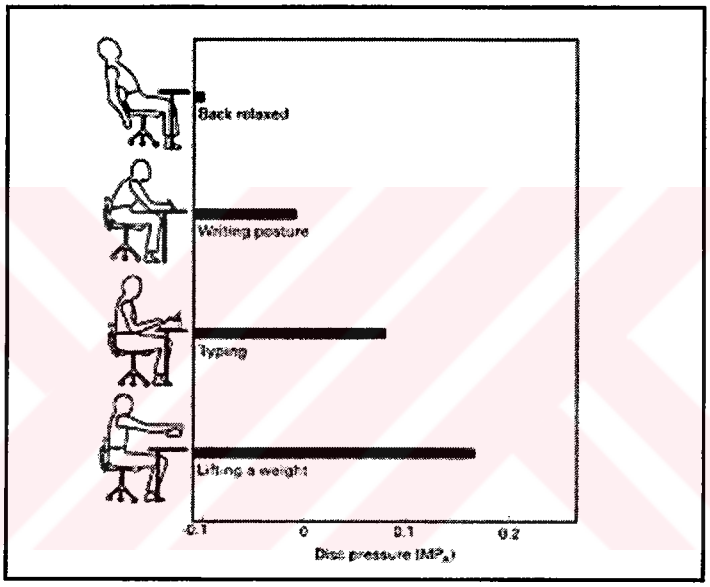


Figure 5.8 Disc pressure in the spine varies with the different seated postures assumed during a typical workday. As shown, the spine sustains far less pressure when reclined, which translates into more comfort and less risk of injury. (Grandlean, 1987)

Any factors, which reduce the physical strength of body parts, will increase the risk of injury. If a physical task is to be carried out in a safe and comfortable manner, a number of physical requirements must be met. First, the body must be stable. Stability depends on the relationship between the body parts and the base of support provided by the feet, the seat, and any other surfaces in the workplace, which can be used to support the body weight. The design of the workspace can determine the range of stable postures, which can be adopted and can be evaluated from this point of view.

5.1.2. Musculoskeletal Problems of Sitting

The relationship between the user and the computer is reciprocal; it is acting as a close system. One of the consequences of this is a restriction of space for physical activities that leads to constrained postures, together with long-lasting static contractions of several muscles of the back and the shoulders. Such static effort reduces blood irrigation of muscles of the muscles and creates local fatigue. This leads to symptoms of tiredness, pain and even cramps (Smith et al., 1997).

These postural repetition problems lead to reduce performance and in the long run, they may also affect user well-being and health. In fact, if these adverse ergonomic conditions are repeated daily over a long period of time, more or less permanent aches and pains may affect upper extremities and back and may involve not only muscles but other soft tissues such as tendons and nerves. Thus, long-lasting, adverse ergonomic conditions may lead to a deterioration of joints, ligaments and tendons. Field studies (Grandjean, 1987; Hadberg et al., 1995) as well as general experience, have shown that these conditions may be associated with a higher risk of:

- Inflammation of joints
- Inflammation of tendon sheaths
- Inflammation of the attachment-points of tendons.
- Symptoms of degeneration of the joints in the form of chronic arthroses.
- Painful indurations of the muscles.
- Disc troubles.
- Peripheral nerve disorders.

Workstation design is a major element in ergonomic strategies for improving user comfort and particularly for reducing musculoskeletal problems. When a person is working in a sitting position, the spinal motion segments, particularly the lumbar motion segments, are susceptible to extreme postures. The risk of injury to muscle-joint system is greatest when they are in extreme postures and least when around the midpoint of the range of motion (Bridger, 1995).

Genaidy and Karwowski (1993) investigated the discomfort associated with joint postures, which deviated from the neutral position. Their subjects moved, in turn,

each body part from the neutral position to the end of its range of motion, held the posture for 30 seconds, and then rated the discomfort associated with the posture on a 10-point scale. This investigation enabled a number of extreme postures to be identified, which were high in perceived stress and therefore risk factors for the onset of acute musculoskeletal pain.

For the shoulder joint, high levels of discomfort were perceived when the arms were elevated in any direction away from the body. For the elbow, supination was perceived to be the most stressful posture, followed by pronation, with flexion and extension the least stressful. Lateral bending of the neck was perceived to be more stressful than neck flexion, extension and rotation. In sitting, flexion of the back was the least uncomfortable of the extreme postures- presumably because the spine muscles are relaxed when the spine is in full flexion (Floyd and Silver 1955). If these extreme postures are designed out, the risk of musculoskeletal pain can be reduced.

5.1.2.1. Low Back Pain and Muscular Fatigue

Low back pain (LBP) is a major health problem in the industrialized countries. (Figure 5.10) The sitting position is found to be the most troublesome situation in connection with LBP (Salmizen et.al.1992). Sitting in the same posture in a forward bending position for a long time puts an extremely undesirable physiological strain on the muscles, ligaments and in particular on the discs (Keegan 1953, Mandal 1981)

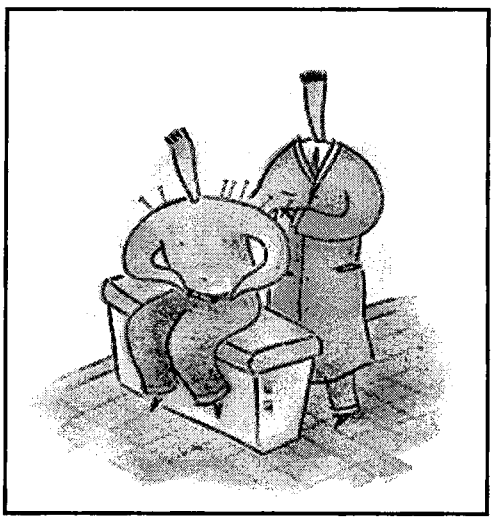


Figure 5.9 Low Back Pain

Keegan (1953) was one of the first authors to discuss the anatomy of the sitting position in relation to the problem of low back pain in sedentary work. In the sitting position, the increased pull of hamstrings and gluteals against the weakened hip flexors cause the increased pelvis to tilt rearward and lumbar lordosis to be lost. Loss of lumbar lordosis occurs reflexively, as a way of compensating for the rearward tilting of the pelvis, which occurs in the sitting position. As the pelvis tilts rearward when a person sits down, the lumbar spine flexes to keep the trunk and head erect.

When the lumbar spine is flexed, the front part of intervertebral disks is compressed and the rear part stretched. This "wedging" action causes the disks to be extruded rearward, pressurizing the posterior spinal ligaments and possibly the nerve roots. This may result in a sensation of pain in the low back and referred pain in the legs respectively.

According to Bridger (1995), pain in the lower regions of the back is one of the most common sources of work-related discomfort. It can also occur as a result of many everyday activities, such as car driving, housework or gardening. Although the anatomy of the spine is well known, finding the cause of low back pain can be a much more elusive problem for clinicians. Pain is unlikely to arise from the intervertebral disks themselves since they do not contain nerve endings in the adults. Likely sources of pain are the posterior ligaments and other soft tissues. These may be irritated by mechanical trauma due to damage to degeneration of bony structures. Nerve root compressions can also be a source of pain. Kumar (1990) has shown the mechanical loaf is a risk factor for low back pain.

School-based surveys have shown a high prevalence of backache, and particularly low-back pain, ranging from 20 to 51% among children (Burton et al.1996). Several factors have been associated with non-specific LBP in the young such as gender, family history of low-back pain, anthropometric parameters, spinal and joint mobility, posture and muscle flexibility, muscle strength, sport activities, school performance (Troussier et al., 1999).

Schoolchildren find the sitting position to be unpleasant. Several researchers have demonstrated this. (Salminen 1884, Balague et al. 1988,Salminen et al. 1992, Troussier et al.1994). Salminen (1984), in his first survey of 370 children aged from 11 to 17 years, finds that 58.9% of the LBP sufferings had LBP in the sitting position.

Sitting is found to be the most troublesome situation in connection with LBP. Furthermore, Balague et al. (1988) and Troussier et al (1994) have shown among schoolchildren that LBP increases with the duration of the sitting position at school.

The lumbar muscles of chronic low back pain sufferers fatigue more rapidly than those of nonsufferers. Presumably, pain occurs both directly, as a result of stimulation of pain receptors in the muscles due to the biochemical changes, which accompany fatigue, and indirectly as a result of the increased load on soft tissues in the lumbar spine itself Bridger (1995).

5.1.2.2. Other Causes of Back Pain

However pains in the low back can occur for entirely different reasons and from unrelated structures such as the kidneys. Colds and flu may cause complaints of pain in the back. Back pain is a complex problem (Waddell, 1982) and detailed investigation of back problems is best left to expert clinicians.

Low back pain is a major problem in the industrialized world. Frequently, the pain is of an acute form and is due to muscular fatigue. This type of pain usually subsides within hours or days if the sufferer rests. Many researchers now acknowledge the health problems are often exacerbated, if not caused, by habitual daily activities. It is known that low back problems have a higher incidence among certain group of individuals. Magora (1972) carried out an epidemiological survey to investigate the incidence of low back pain in relation to the occupational requirements for sitting. Low back symptoms were higher among those with uniform occupational requirements than those whose daily activities were more varied (who were able to alternate between standing and sitting). Gilad and Kirschenbaum (1988) investigated back pain across a broad spectrum of jobs. More back pain was found in groups who worked in unusual body positions or with the trunk flexed laterally or forward in sitting.

Although the etiology of musculoskeletal problems involves several factors, it is known that pain can be caused or exacerbated by excessive loading of joints and muscles. This can occur not only as a result of traumatic events but also because of sustained exposure to particular working postures. Nachemson (1966) found out that disk pressure was higher in sitting than in lying down but was reduced when the sitter reclined against a backrest.

5.2. Typing Posture

Typing at a keyboard on a desk is a common work posture for many computer users. While typing it is difficult to maintain the wrist is in a neutral posture, because the forearms sag as they tire and this puts the wrists into greater wrist extension. Also, most users have to work with their elbows flexed, which can compress the median and ulnar nerves at the elbow and restrict blood flow to the hands. Working with the forearms sloping up increase muscle loads in the upper arms, shoulders, and neck. Working in this position for more than 3-4 hours invariably leads to muscle fatigue.

For an ideal typing posture both static and dynamic muscle loads must be minimized. According to the researches done at Cornell University Ergonomics Department. For a neutral keyboarding posture, upper and lower back must be well supported by chair. Chair height must be set properly so that the chair seat does not compress the back of the knees. Feet must be firmly planted on a surface for support. (Floor or footrest). Head must be balanced on neck (not tilted back or too forward) upper arms close to body and relaxed (not abducted to the side or flexed forward)

Figure 5.10 relaxed sitting position

According to Hedge et.al (1999), this ideal typing posture is achieved when the keyboard is below seated elbow height and the keyboard base is gently sloped away from the user so that the key tops are accessible to the hands in a neutral posture. In this position the arms, shoulders, neck and back can relax, especially during brief rest pauses. Also, in this slightly reclined sitting position the low back rests against the lumbar support of the chair, the elbow angle is opened to promote circulation to the lower arm and hand, the abdominal angle, and the popliteal angle

(behind the knees) are opened to promote blood circulation. The feet rest firmly upon the floor. (Figure 5.12)

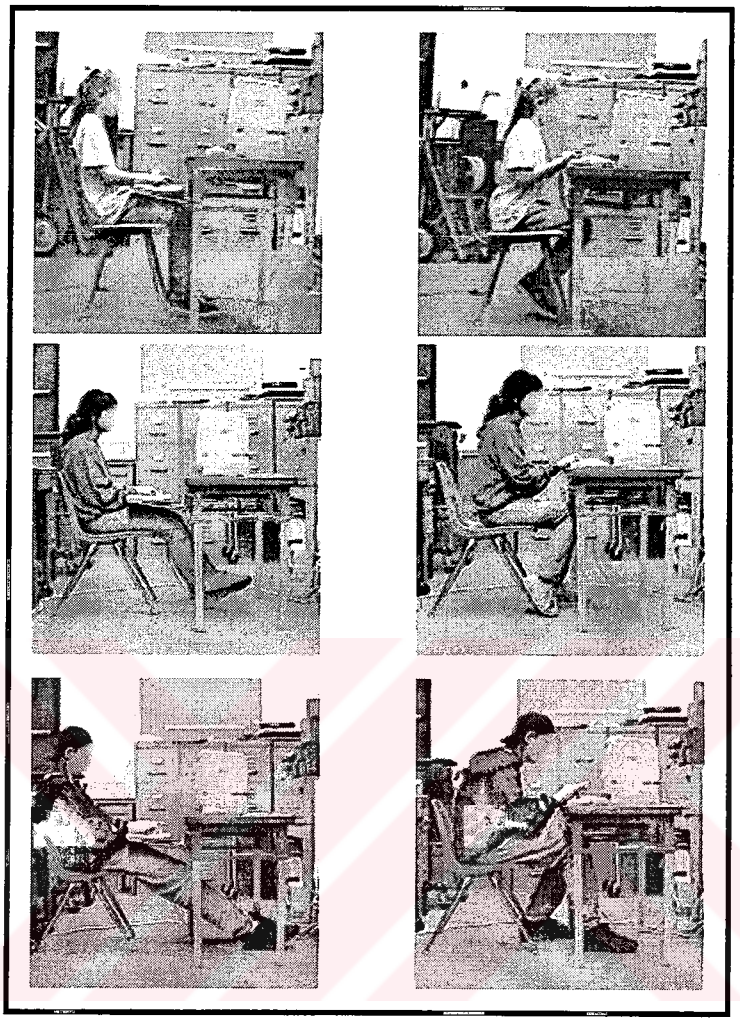


Figure 5.11 Conventional and ergonomically improved keyboard arrangement (http:// ergo.human.cornell.edu)

5.2.1. Problems of Typing

There is a hidden human cost to high-volume data entry that we are just beginning to realize. Prolonged use of the keyboard, such as in high-volume data entry, or high-volume typing, can cause Repetitive Strain Injury (RSI). Technically, any repetitive motion can cause RSI. However, since touch typing - keyboarding is one of the most dominant office activities, RSI is commonly associated with this activity. RSI is the term given for injuries that occur as a result of repeated physical movements; doing damage to nerves, muscles, tendons and other issues. The best way to visualize RSI is to think of each of your joints as a bucket. Micro-trauma from

a variety of activities drips into your joint's trauma bucket. Fortunately, the body can heal with time and safely absorb a certain amount of trauma. But if more traumas are placed into the bucket than the natural healing process can absorb it, the result can be pain and impaired movement. (Figure 5.13)

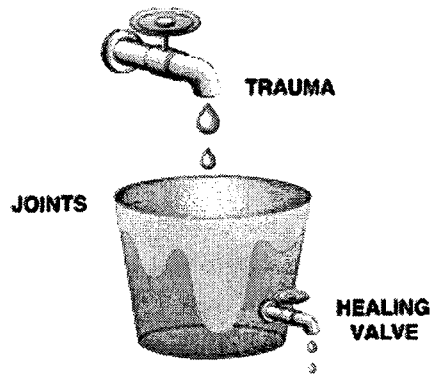


Figure 5.12 Relationship between trauma and joints (www.apple.com)

Signs and symptoms include swelling, inflammation, headaches, sore backs and necks, painful joints and forearms, tingling in the hands and weakness. Computer users are at risk, the rise of computer use in schools is cause for concern.

Carpal Tunnel Syndrome is a 'particularly painful' form of an RSI injury. It is one of the most serious and best-known cumulative trauma disorders (CTD). A scientific description of CTD appeared in Gray's Anatomy of 1893: " The tendons of extensor muscles of the thumb are liable to become strained and their sheaths inflamed after excessive exercise, producing a sausage-shaped swelling along the course of tendon and giving a peculiar creaking sensation to the finger when the muscles act. In consequence of its often being caused by such movements as wringing clothes, it is known as 'washerwoman's sprain. One of the earliest accurately diagnosed cases of carpal tunnel syndrome was assessed in 1910 at Mayo Clinic.

The tendons must ravel through a tunnel formed by the bones of the wrist and connective tissues, notoriously known as the carpal tunnel. Running through the center of the carpal tunnel and surrounded by the tendons in the median nerve. (Figure 5.14)

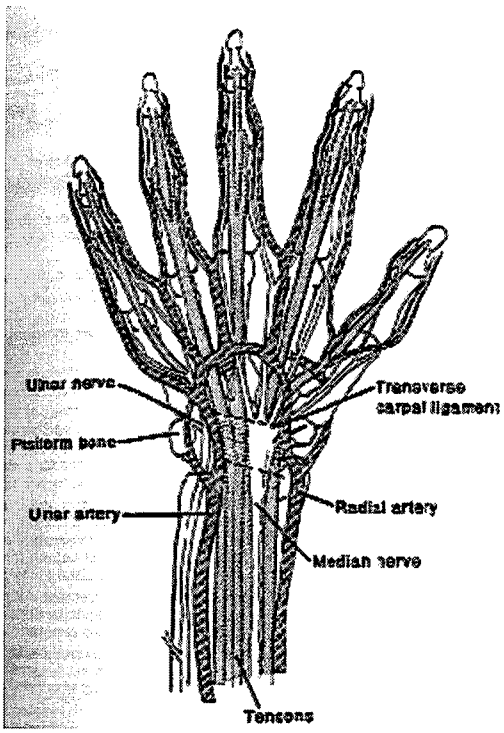


Figure 5.13 Cross-section of the hand (Salvendy,1997)

The movement of the wrist greatly affects the size of the carpal tunnel and the pressure on the tendons. The tunnel is opened the most and tendon tension is at least when the wrist is in a straight (neutral) posture. When the wrist is bent, particularly flexed or extended, the carpal tunnel is constricted. In such cases, the tendons, nerves and blood vessels have less room which causes increased presssure with in the tunnel. The increased pressure creates increased tension in the tendons, causing damage. This damage creates scar tissues and more inflammation, which progressively decreases the spine in the tunnel and leads to increased pressure. The pressure increase eventually compresses the nerve and blood vessels running through the tunnel, causing nerve dysfunction and damage-better known as carpal tunnel syndrome.

Repeated forceful movements made by the hands while in deviated postures (flexion, extension, ulnar radiation, and radial radiation) (Figure 5.15) are known to dramatically increase the risks of developing this syndrome. Ulnar and radial deviation contribute to CTDs, but it is flexion and, particularly, extension that are the real culprits.

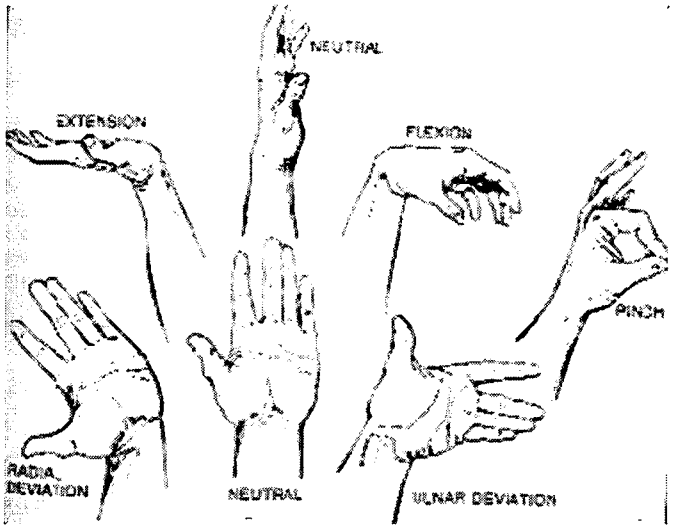


Figure 5.14 Hand and wrist postures (Pheasant,1997)

In their milder forms, CTDs may involve injury to the tendons and their sheaths within the hand and wrist area, which may cause:

- Discomfort
- Tenderness to touch
- Inflammation
- Weakening of the tendons

The more serious CTDs may lead to the following symptoms in the hands, fingers, and arms:

- Pain
- Numbness
- Tingling
- Loss of sensation

Although there are few statistics on children and CTDs, with so many children starting to use computers at such an early age, there is no telling whether this may accelerate the incidence of CTDs.

5.3. Visual Problems

Using computers for extended periods can cause visual discomfort, headaches and vision challenges. It is very unlikely that you will suffer permanent changes or damage to users' eyes. Rather, they may experience these symptoms whenever they use a computer intensively for periods of a couple of hours or longer; the

symptoms will diminish soon after they stop working on the computer. Typical symptoms of vision challenges include:

Eyestrain refers to ocular fatigue, eye discomfort and headaches associated from intensive use of the eyes. Common causes include:

- Glare on the computer screen
- Poor visual correction (out of date eyeglass prescription)
- Reading small character sizes on the screen
- Poor contrast between text and background on the monitor
- Noticeable screen flicker
- Dry eyes

Blurred vision can be caused by normal physiological changes in the eye (i.e. aging or disease). Constant focusing on objects within 30 cm of the eyes, which often occurs when reading in low light can also cause it.

Dry and irritated eyes occur when there is insufficient fluid in the eyes to keep them moist. Eyes are kept moist and refreshed by a normal blink reflex, which is present from birth. Blink rates vary with different activities and can become slower when concentrating. Eyes can become red and itchy. Common causes include:

- Reduced blinking when using the computer
- Air movement that is noticeable in the face area

Bifocals and contact lens users must be very careful during working at CWS environments since bifocals are designed for reading at an approximate distance of 40 cm. The typical computer monitor is positioned 45 cm to 75 cm away from the user. Bifocals are angled downward at a 25-degree angle for comfortable reading; the optimal viewing angle for the computer screen has generally been thought to be 10 to 15 degrees below horizontal. As a result, bifocal users must tilt their necks and heads in order to see the screen. Bifocal wearers should measure the distance from their eye to the computer monitor and inform their eye doctor of this information for proper adjustment of bifocals for computer use. It is also a good idea to lower the monitor so that the neck can remain in a neutral position while looking out of the glasses. Individuals who wear contact lenses blink less than people who have normal vision or wear glasses. Contact wearers must be educated to blink often and use artificial tears to reduce eye irritation.

In order to avoid visual discomforts users must rest their eyes for at least 20 seconds every 30 minutes at minimum, change the distance of their focusing during rest periods, keep the screens clean with proper contrast and reduce glare on their screens by eliminating or reducing overhead, direct lightning or direct glare for windows.

6. CWS DESIGN FOR CHILDREN

In the previous section, CWS concepts, ergonomic concerns about CWS usage, types of discomforts faced at improper CWS mediums are the topics that have been focused on. Bearing all the previous knowledge in mind, in this section it is tried to explain the key points about CWS for child use. Some examples of existing CWSs will be examined and discussed. Their pros and cons from ergonomical design approach will be mentioned.

A CWS for a child is not very different from a CWS designed for adult use. The important point lying there is to consider the needs of children at these mediums as users. That is the point, which makes the difference.

6.1. Designing an Ideal CWS for Children

"CWS is more than just making computer interfaces easier to use or making furniture adjustable in various dimensions. It also involves integrating design considerations with the work environment task requirements and users' preferences and needs" (Smith et.al.1997). This consideration must be valid for children.

While trying to explain the requirements of an ideal CWS for children, a deductive approach is assumed. In other words, at first considerations about computer classrooms will be made and then as the smallest unit of this medium CWS design requirements will be focused on.

Because of the gradual introduction of computers into classrooms, careful planning is needed to ensure that the computer furniture selected can follow the transition to a fully electronic classroom. Over the coming years most classrooms may have small computing "zones" with perhaps 4 to 6 computers. These computer work zones supplement the normal teaching roles and students take turns in accessing them. Beyond this number of computers, the room turns into a dedicated computer lab with students either sharing or having a computer to them. It is certain that the role of Computers in Education will dramatically change over the next few years. A

key point in planning is to maintain flexibility in the arrangement and use of computers as their number and there usage changes. So the range of CWSs should provide the flexibility to manage this transition. While they may be configured as single user workstations, the modules must be equally suitable as the basis for computer laboratories in the future.

The style, shape and orientation of desks for classroom computers will be influenced by the *focus* of your computer-teaching program. Will students work most of the time as *individuals*? Will they work collaboratively in *groups* of two or three? Or both? Will there be *presentations* to everyone in your classroom? Or *discussions* take place involving all students? Is space needed for *non-computer activities*? With some computer labs, it seems that it is a classroom of monitors not students! In some situations students are able to "hide " behind the computer or miss important information and teachers cannot gauge the effectiveness of presentations and lectures. A layout that does not impede eye contact between the student and the instructor should be considered.

When a few computers are introduced to a classroom there are generally a number of constraints regarding position.

- Location of power supplies, network and Internet cable.
- Available space. As class sizes can at times be at their maximum, there may be very limited additional space.
- If small computing zones are to be formed they should have some separation from the main teaching areas.

There is much more scope for designing a dedicated computer lab. Some points to consider are:

- Conventional rows. These are advantageous for lectures, group training, and full time applications where there is not the need for interaction between students or individual attention from the instructor to the student. Rows can accommodate height adjustable desks or desks with different heights that can accommodate small students or students in wheelchairs.
- Perimeter arrangements. This arrangement can leave the center of the room free for other activities. It is also the easiest for cable management.
- Cluster Grouping. Its possible to arrange clusters of various desk modules that results in highly efficient space utilization. The general test for space efficiency is to consideration is how much space surrounds the computer

equipment that cannot be accessed by the student. Clusters may allow for efficient cabling if they can be served by a single entry and exit point. Clusters may take the following forms:

- "L" configurations
- "U" configurations
- "Star" shapes
- Clusters of 4 desks
- Clusters of 6 desks

There is a fine line between wanting to provide enough space for each student to work comfortably and trying to get the most students into a given space. It is better to try to keep a distance of 1.5 - 2.0 m from the first row of desks to the front of the room. This should allow enough space for a teacher to stand and it is also the distance required by most overhead projection systems.

The ideal depth of desk that accommodates a conventional computer varies between 800mm and 900mm. This allows some degree of adjustment for eye to screen distance. In many situations space constraints force the desk depth to 700mm but allowance for the screen to extend past the back of the desk is made.

There is much debate regarding "correct "ergonomics as applied to students at PCs in a classroom environment. Since this is multi - activity application, there are conflicting demands for visibility to the screen, work materials and demonstration screens often at the front of the classroom.

Recommendations that originate from The International Standards Organization (ISO) were based exclusively on static anthropometric measures -a very unnatural posture. This particularly erect posture, which has been mentioned in the previous section, with a horizontal axis of vision, can only be maintained for a few minutes. It is important to assess student posture in the classroom and take steps to correct for poor ergonomics- particularly when computing is involved.

When setting up, at first, the monitor should be placed on a work surface, and then the monitor should be angled upward so that a line drawn from the user's eyes towards the center of the screen intersects the surface of the screen at a 90° angle. This sightline should *slope 10° to 15° downward* from the user's eyes. The *low* position of the monitor reduces eye movement & focusing adjustment when the user looks from the screen, to the keyboard, to reference materials beside the keyboard,

& back to the screen. The upward, 90° intersect angle provides a *distortion-free view of images* on the screen. This placement is especially helpful to anyone wearing bi-focal glasses. Comfortable eye-to-screen distance varies from individual to individual. For normally sighted people, it ranges from a minimum of 450 mm to 800mm or more. That is why monitors must be placed as far back in the workspace as possible; if they're not, a too-close screen location forces the user back from the tabletop edge, with the likelihood that hands, wrists & elbows won't be supported.

The CWS furniture should provide a range of height adjustability. Most office and commercial workstations are built to a standard height of 720 mm but for children who continue their growth through education, work surface heights must have the chance of being adjustable to a height under 720 mm when the wide range of child users are considered.

A CWS designed for child use should have the modularity property. Advantage of a modular desk system is that you can add to, divide up, & reconfigure arrangements of student stations as your program changes & instructional technology evolves.

Cable management is a critical issue. Anyone who has set up a computer will know that cables create a cluttered and messy looking environment that can also be a safety hazard. Cables left unmanaged can be tripped over causing harm to both child and hardware alike. A CWS may provide desk surface cable ports to route cables under the desk surfaces. In addition there may be a number of cable management channels that support and direct the cables as required.

Ideally seats used in CWS classrooms must be adjustable in height, backward inclination and armrest elevation. Unless armrests are adjustable, the chair must be at least with chair height and back support adjustment mechanisms. If the back tension of chair does not adjust, it has been make sure that the lower back is firmly supported. The features have to be easily adjustable so a child facing an unwanted discomfortable posture can easily change his posture without any help. A swiveling capability allows students to turn from their workstations to the front of the class without getting up from their chairs.

6.2. CWSs Designed for Children

The following examples of CWSs for children are some computer workstations on market. The CWSs, which are evaluated by telling their pros and cons from design point of view.

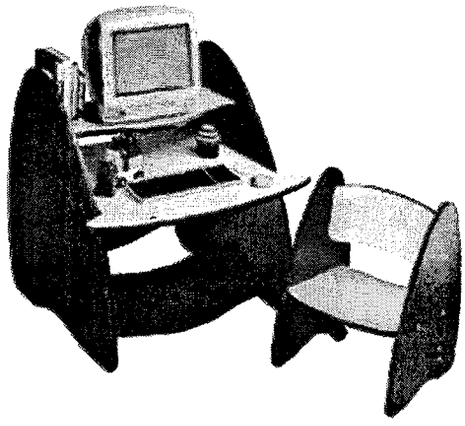


Figure 6.1 A CWS design by Kidstation. (www.kidstation.com)

The pro of the CWS in Figure 6.1 is the apparent color and form use (round corners) sending the message that these products are designed for children. When we come to the cons, for this CWS, it is beneficial to ask whether the form follows the function. As this furniture is examined, " are they really ergonomic?" question comes into mind. Only seat height can be adjusted but not easily adjustable. Back support adjustment is not thought. There are no supportive armrests. The flat surface of the chair after some time may cause discomfort. There is not any evidence of cable management.

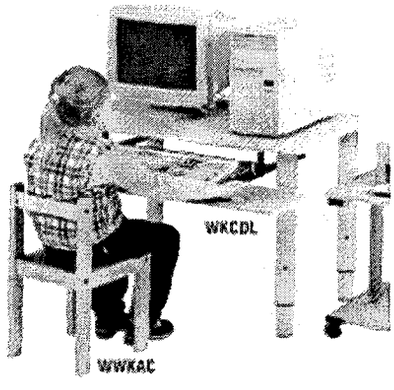


Figure 6.2 A CWS design by Wood ware by design company. (Www.wbdi.com)

The pro of the CWS in Figure 6.2 is an additional work surface area for a mouse, which is not placed far away. There is keyboard elevation. There is not any sign of adjustability, neither in the desk nor in the chair. Especially chair is not appropriate for computer usage. There is not any footrest.

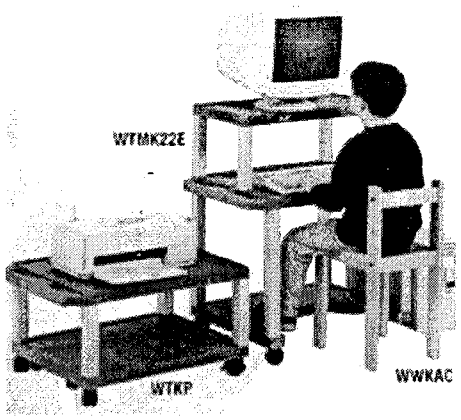


Figure 6.3 A CWS design by Wood ware by design company. (Www.wbdi.com)

For the CWS in Figure 6.3, there is unit, which may be used as a footrest. Although there is a footrest unit cannot be tilted. The monitor is placed too high. There is not a sign of adjustability neither on desk not the chair. From the picture it is so obvious that the child's neck is in a very erect posture, which will cause discomfort after sometime. The CPU unit has not been thought with the other components. It is just placed on the floor near the desk. There is no sign of cable management.

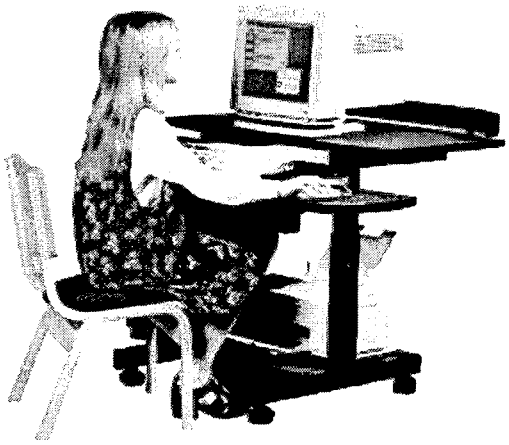


Figure 6.4 Figure 6.3 A CWS design by Wood ware by design company. (Www.wbdi.com)

There is an additional work surface area for a mouse, which is not placed far away. The whole workstation is too crowded. All the hardware, peripherals are tried to be gathered in the same unit but this obstructs the child's mobility. The child working at this workstation will not have enough space for her feet. The chair is absolutely not a proper chair for CWS usage. The child in the picture sits in a risky posture.

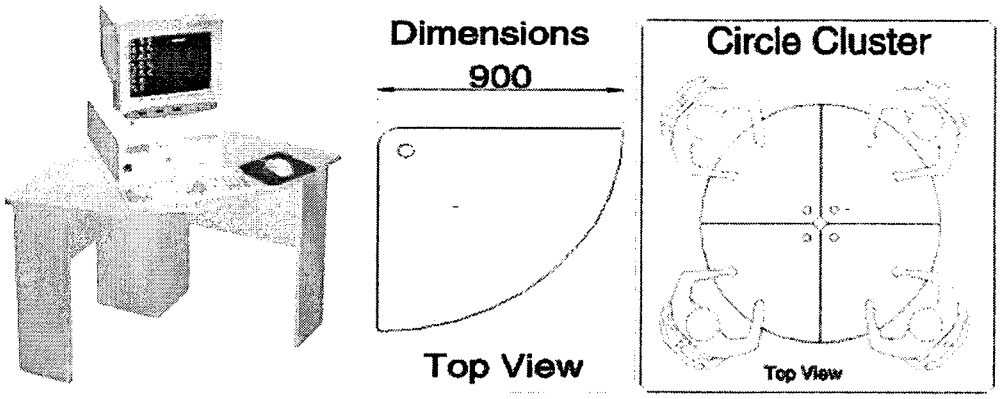


Figure 6.5 The pie module by Shawtec Company (www.shawtec.com.au)

The pie module forms either semi-circular clusters that can be positioned along a wall or groups of four that form circular workstation 'islands'. Each module incorporates cable entry ports. The desk is available in 5 desktop heights, 520 mm, 570mm, 620 mm, 670 mm, 720 mm. Screen to eye distance is 900 mm, which is nearly optimum. Footrest is not considered. It is difficult to get closer to a convex round working surface. It may make keyboarding difficult. The users cannot do adjustability of the desk height; it is done during the montage of the station.

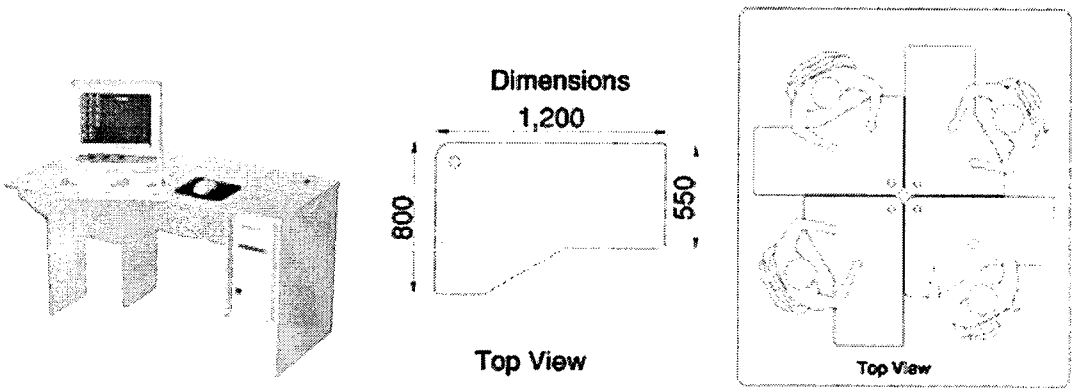


Figure 6.6 A CWS module by Shawtec Company (www.shawtec.com.au)

The module has 800 mm depth in the computer zone and this provides the optimum screen to eye distance. The design provides two distinct zones. Students can take notes on the desk area or turn to work with the computer at the same time. Tower

computer cases can be fitted on a shelf that mounts below the desk end. The under desk shelf has a removable back to conceal cables but also allowance for ventilation. The module can be adjusted in 5 different heights. Footrest is not considered. The users cannot do adjustability of the desk height; it is done during the montage of the station.

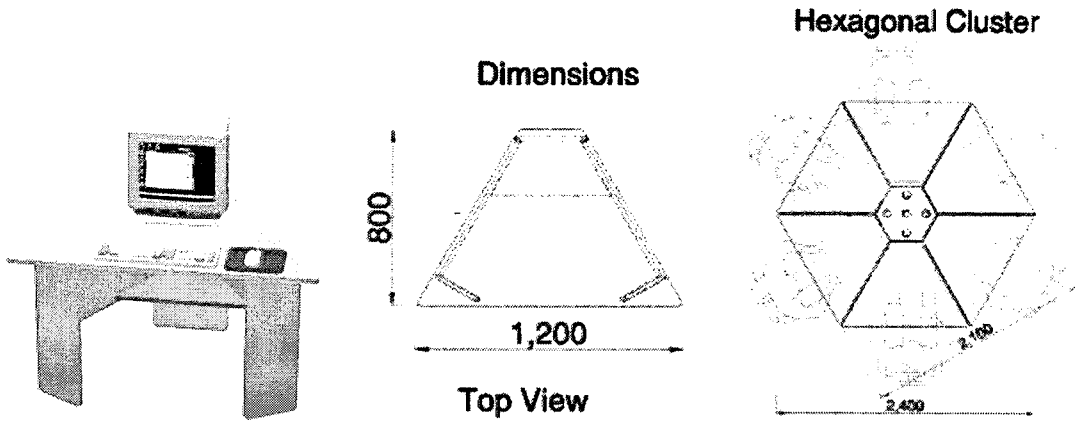


Figure 6.7 a hexagonal module by Shawtec Company (www.shawtec.com.au)

This hexagonal module is used in settings of three that can be positioned along a wall or in groups of six that from workstation "islands". The module has 800 mm depth that provides optimum screen to eye distance. At the front, the unit is wide and this may provide an area for notepaper and books. The modules have a storage shelf under the desk at rear. They are available in 5 desktop heights, 520 mm, 570mm, 620 mm, 670 mm, and 720 mm.Footrest is not considered. The users cannot do adjustability of the desk height; it is done during the montage of the station.

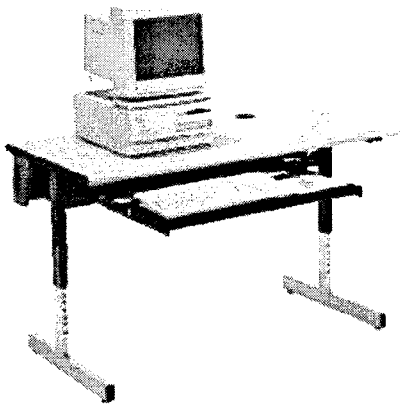


Figure 6.8 A CWS of Wood ware by design

Legs can be adjusted from 55 cm to 75 cm. Adjustment is easier than the previous examples. Wire management panel is included. There is a keyboard elevation. There is enough space for legroom but footrest might be considered.

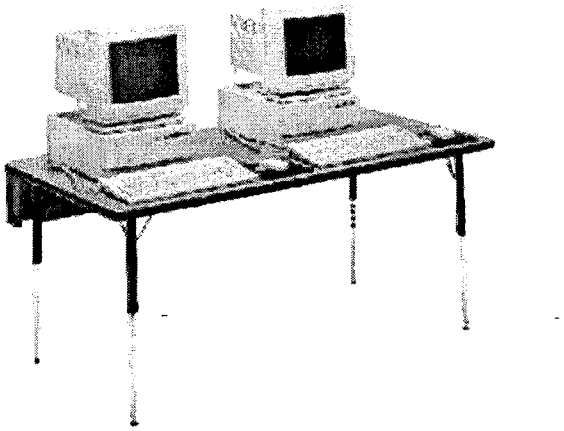


Figure 6.8 A CWS for two users by Wood ware

Legs can be adjusted from 55 cm to 75 cm. Adjustment is easier than the previous examples. Wire management panel is included. As cons we can say that there is no keyboard elevation. There is not very much place for mouse use and to put belongings. The place of CPU unit is questionable. There is enough space for legroom but footrest might be considered.

7. A CASE STUDY OF COMPUTER WORKSTATIONS AT 'ŞİŞLİ TERAKKİ' HIGH SCHOOL

While examining all the work done about school furniture, postural risks children face in school environments; a lack of such a study focusing on computer usage by students in Turkey is seen. It is decided to carry out a study on children's computer work settings at school. Since, private schools in Turkey, have vast amount of technological opportunities, it is thought that working with a private school will help more for such a study. Sisli Terakki is suited to this criterion. Sisli Terakki High School's education history goes back to 1873. In 1921, its name was changed into 'Sisli Terakki Mektebi'. From 1935 to 1975, the school had its campus at Nişantaşı. In 1975, it moved to the campus in Levent. Since 1994-1995 Education year it has been including nursery school, elementary school and high school. Sisli Terakki High School, which has a computer department including 8 laboratories in itself, is a very good example to find out how much computer is integrated to school life and results of this integration from postural risk assessment aspect. Besides, Sisli Terakki High School with its two different type of computer laboratories is also a good place to investigate the differences of these different computer workstation mediums and computer workstation used in these laboratories.

Subjects of the study are determined as 6th, 7th and 8th graders. Respectively these subjects are a group of children who are twelve, thirteen and fourteen years old. In each age segment there are twelve girls and twelve boys making a total of seventy-two. At Şişli Terakki High School, there are 288 students in the 6th grade, 320 students in the 7th grade and 448 students in the 8th grade in 2000-2001 Education year.

The main concern of the study as it is mentioned before, is to observe children's computer usage habits and computer and children interaction. The existence of this interaction in changing working mediums and at changing CWSs is also cross-examined. Further more, the existence of any physical discomfort due to the computer environment; children's probable adaptation to this situation is

investigated by the research methods as observation and questionnaire application. These methods will be told in the next section.

At the beginning of the study, a written permission for such a research is asked from school administration. A meeting is done with the head of computer department. He is been told about the reasons and the task of such a research. A written proposal is given to him. He and other administration members have a meeting and as a result of this meeting, give permission for this research but video shoot during lessons is not permitted since they think that it can be an attention-driving act that can affect the lessons in a negative way. The researcher makes her observations on Mondays and on Thursdays. The school administration is curious about the evaluation of their computer laboratories and wants to see the results as a report at the end of this study.

There are eight laboratories at Computer Department of Şişli Terakki High School based in a different unit from the other classes. Seven of these laboratories are called as Computer Laboratory (CL). The computer lessons take place there. The curriculum of computer lessons includes Word, Excel, PowerPoint, Access, Front Page and HTML. As the curriculum is examined, it is found out that the lesson topics include Internet, Word and PowerPoint for 6th graders, Internet, PowerPoint, Excel for 7th graders and HTML, FrontPage, Access and Excel for 8th graders.

Out of these eight laboratories there is another one called Computer Aided Education Laboratory (CAEL). The main idea to establish a different laboratory is driven from school's educational concept. This laboratory is aimed to be a helpful computer medium for Science and Mathematics lessons. According to the head of Computer Department, CWSs at CAEL are chosen in order to fulfill this aim. At the end of each Science or Mathematics lesson at CAEL, students answer an interactive test of the related subject on computer. During lessons at CAEL, students use special software called Elite Class.

Each week students spend two lessons (45 minutes per lesson) at CL and two lessons at CAEL. But due to their curriculum program, sometimes students might not come to CAEL in every week.

7.1. Computer Aided Education Laboratory (CAEL)

CAEL is a laboratory that consists of thirty-four lowered-monitor desks, a white board and a teacher unit. The desks are planned in horizontal rows. (Figure 7.1, Figure 7.2 and Figure 7.3)

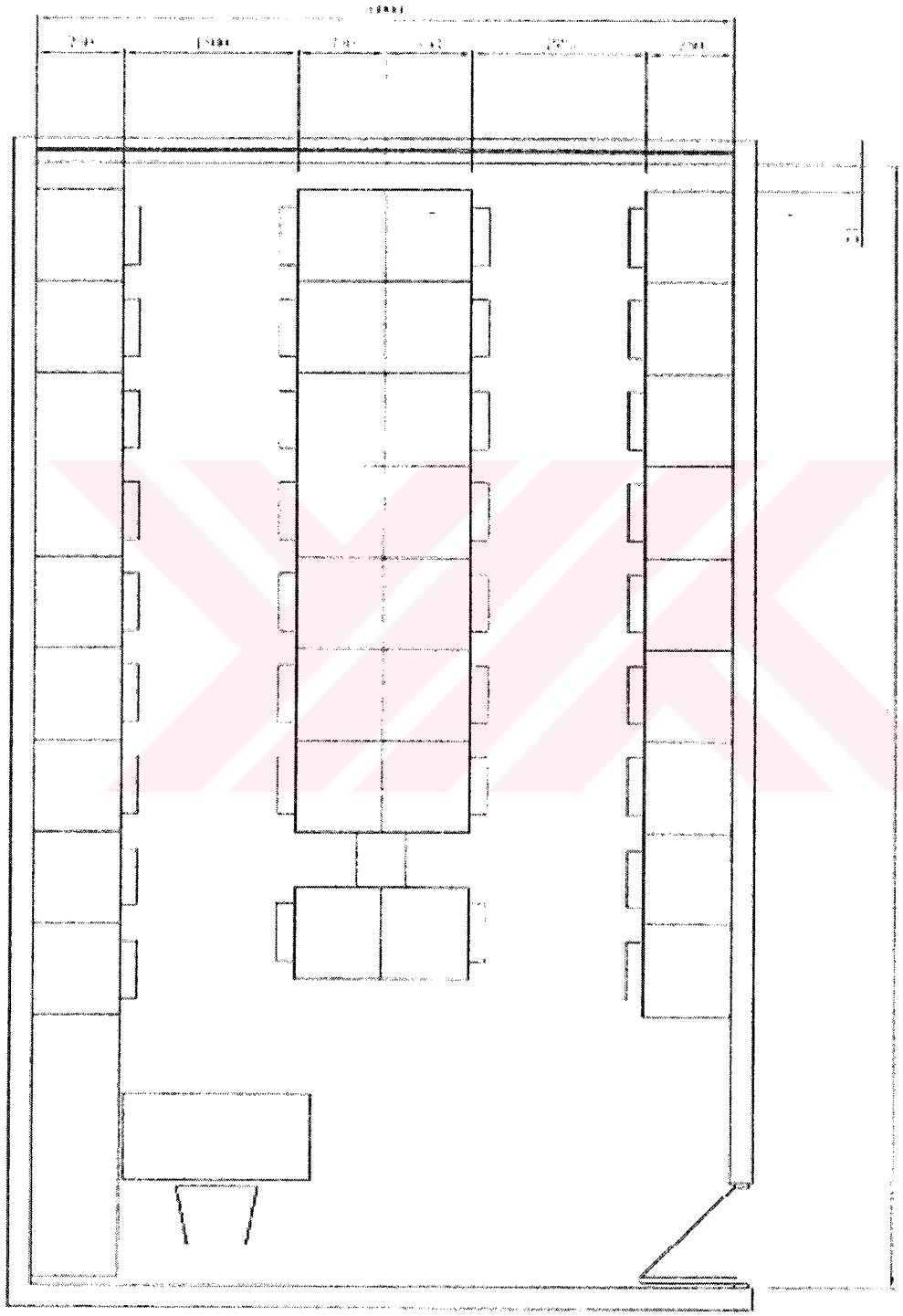


Figure 7.1 CAEL Plan Scale 1/50

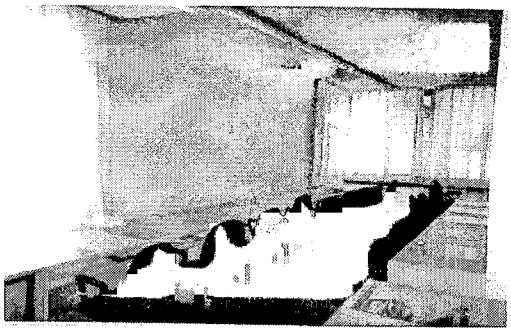
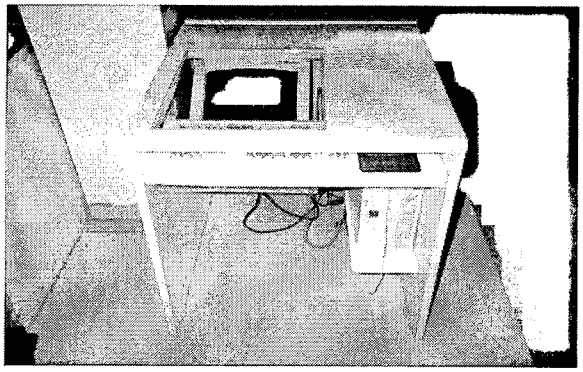


Figure 7.2 General view of CAEL without students

Figure 7.3 CAEL with students

In CAEL, lowered-monitor desks and office chairs were the main furniture. In the lowered-monitor desk, the monitor was placed below the desk surface and was viewed through a glass panel. The keyboard was placed on a retractable, flat keyboard tray. The mouse had to be used on a platform to the right of the keyboard. The teacher had his own desktop computer on a traditional white school desk. (Figure 7.4)



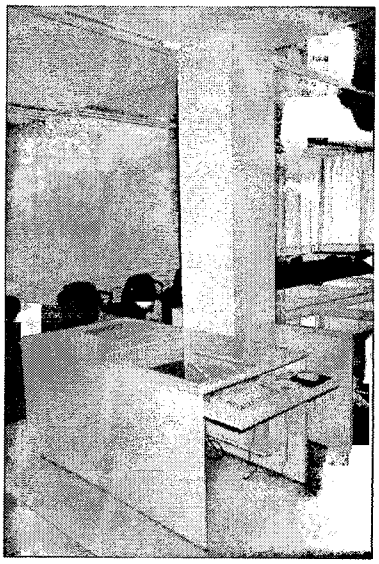


Figure 7.4 Lowered-monitor desks at CAEL

"The reason for choosing a lowered monitor desk (LMD), is the task requirement of science and math's lessons," says the head of computer department. During these lessons, the students may use both their computers and notebooks. As the teacher explains something, they can take notes. That is why, a desk where the computer is placed in it is chosen.

The following figure consists of the technical drawings of the LMD. (Figure 7.5)

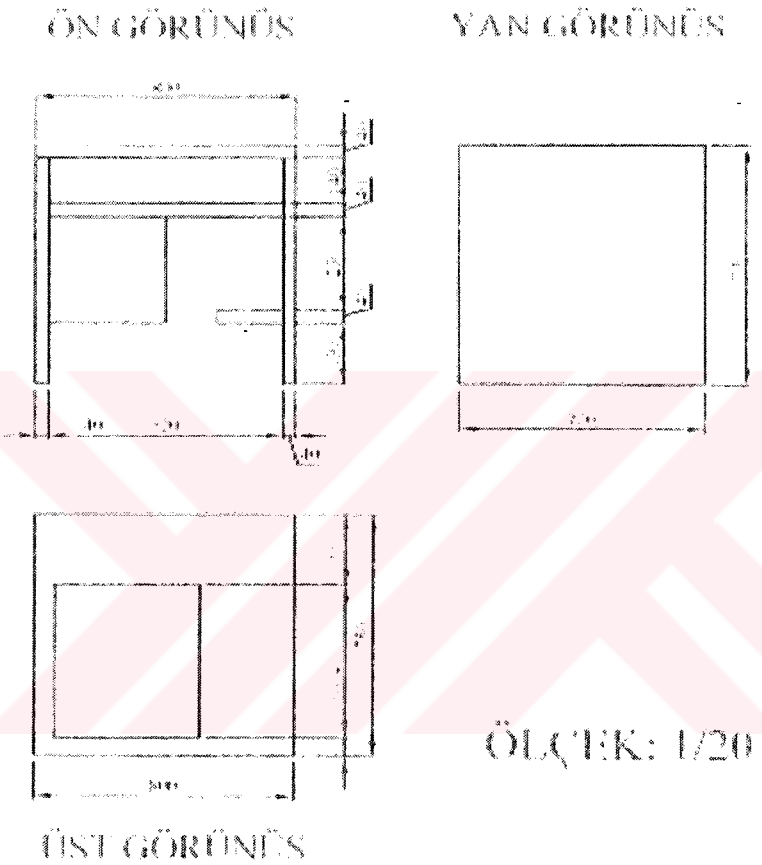


Figure 7.5 Technical Drawing of LMD

LMD's height from the floor is 74 cm and it does not have any adjustibility in height. This is a critical point when we consider the variety of users. The glass on the LMD surface reflects the overhead lights and cause glare problems. When the rectractable flat keyboard is pulled forward, the distance between the monitor and the student increases and as a result the student at this situation leans to the desk.
Being left-handed or right-handed is not considered for LMD. Left-handed students write on the glass surface and this obstructs their sight of the screen. There is no

footrest. Because of any cable management absence there is always a risk for children.

A standard office chair is used in CAEL. (Figure 7.6)

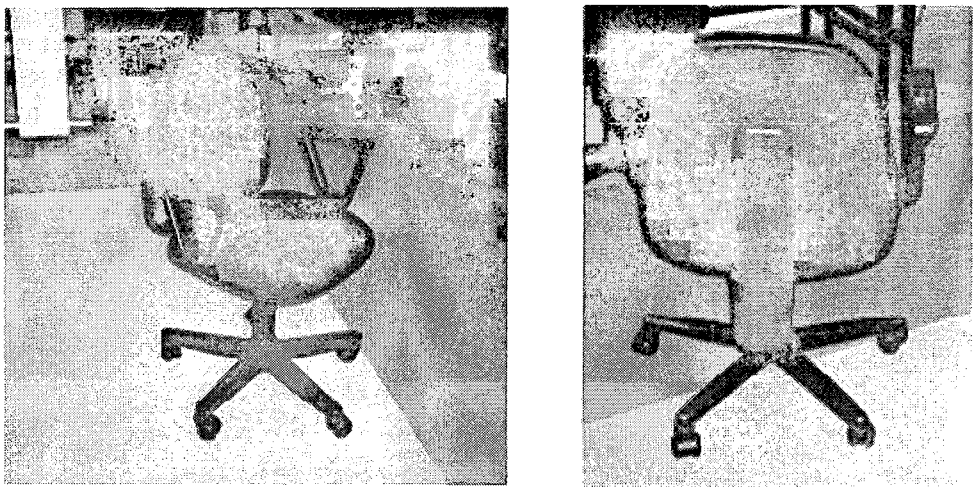


Figure 7.6 Chair at CAEL

Seat depth is 43 cmm. The backrest is 45 cm high (compatible with ANSI/HFS 100 minimums). It is only height adjudtible. The minimum height is 46 cm and the maximum one is 52 cm. The tension and tilt angle backrest is not adjustable. The armrests are not adjustable, thin and too far apart. It has five supporting legs, with roler castors and this is desirable for mobility.

7.2. Computer Laboratory

In CL, the computer, monitor and the keyboard were all placed on a typical white school desk. The desks were arranged in two rows and the same office chairs were used. Again the teacher had his own computer on the same type of desk. There was a printer and scanner used by all the students during the courses. (Figure 7.7, Figure7.8, Figure7.9, Figure7.10)

Figure 7.7 CL without students

Figure 7.8 CL with students inside

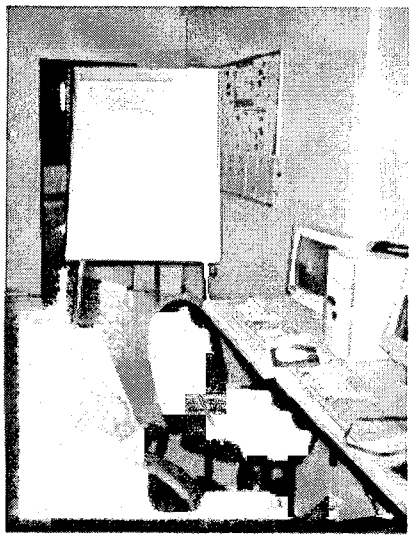


Figure 7.9 Whiteboard at CL

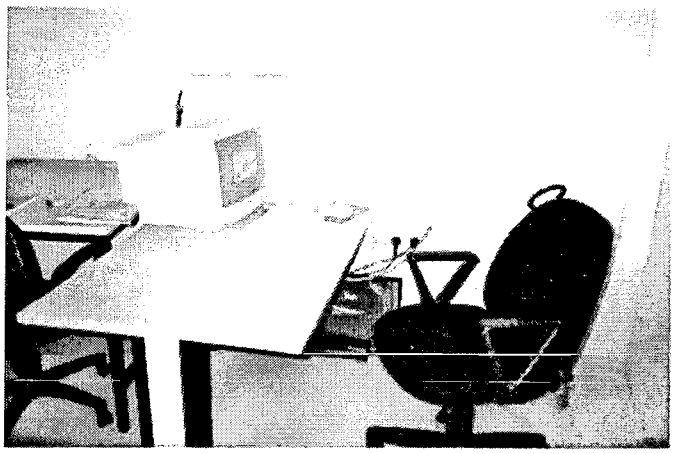


Figure 7.10 Teacher desk CL

Figure 7.11 The desk at CL

The height of the desk is 78 cm; it is more than the recommended level by ANSI/HFS. The depth of the desk is 75-cm. the working surface is not sufficient enough for comfortable movement. Monitor and keyboard are in the same plane and very close to teach other. There is not any sign of adjustability of the desk. The chair is the same with CAEL. There is not any sign of cable management as seen in Figure 7.11. In the general outlook, the classroom is too narrow and this prevents the teacher and students from moving freely in the classroom (Figure 7.12).

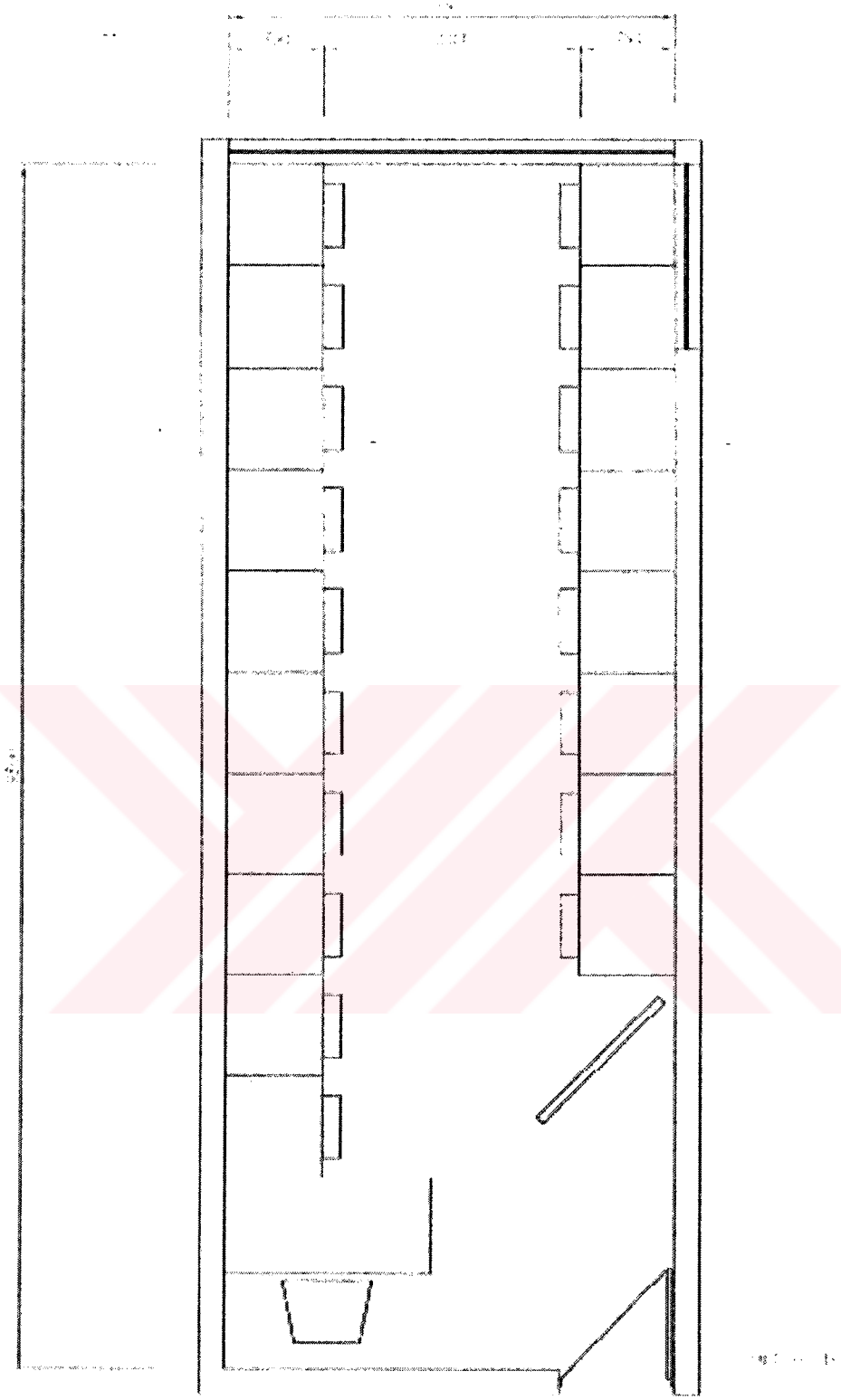


Figure 7.12 Plan of CL.

8. METHOD

As the hypothesis are determined, which are mentioned in the first section, a working model of the study is structured as in Figure 8.1.

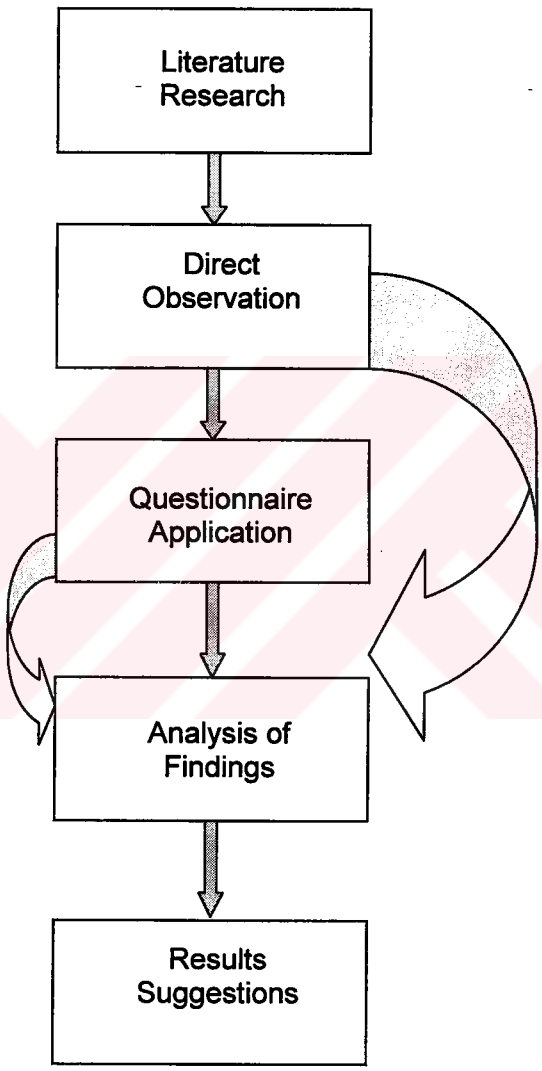


Figure 8.1 Working model of the study

In the beginning of the study, in the name of understanding the scope of this study, a literature research is done about CAE, physical development of 12-14 year old children, CWS definition, CWS components, and ergonomic considerations about CWS components and physical problems that occur due to CWS mediums. Since the core of the study is doing a research about computer using children and CWS 's

effects on them, literature research focusing on these subjects, are deepened. These literature researches establish the previous sections.

8.1. Observation

As literature research and 'state of art' work have come to an end, observation step takes place as the next step. Observation is one of the best ways to define the problems of the present situation at CAEL and CL mediums of Şişli Terakki High School. As the observation stage proceeds, the researcher has a chance of structuring new hypothesis in addition to evaluate the former ones.

There are many and varied observational techniques, which fall into three broad categories: direct, indirect and participant observations. However, the applications and limitations are similar in each of them. Each requires at least two people. (The observer and the participant). Although not essential, it is an advantage if the participant is an end-user of the system. A working example of the product needs to exist for observation to be viable.

Observations can be very useful for recording physical task sequences or interactions between participants. That is another reason for choosing such a method for the study. Video observation could be a valuable tool, but unfortunately video shoot is prohibited by the school administration in this study.

One of the main concerns with observation is the intrusiveness of the observational method; it is well known that the behavior of people can change purely as a result of being watched. People do get used to observers over time. During the observation stage at Sisli Terakki High School, surprisingly a stranger in the classroom is not an attention-driving situation. Since, the students are so much related with their computers, they only ask a few questions in the beginning of the first observed lesson. All the observations were based on students' computer usage habits and postures in two different types of classes including two different types of CWSs.

8.2. Questionnaire Application

After observation stage, due to the observational input two questionnaires are prepared to learn students' perceptions and thoughts about their computer

workstations. As mentioned above, observations do not reveal any cognitive information so a questionnaire is needed. They are inexpensive way to gather data from a potentially large number of respondents. Often they are the only feasible way to reach a number of reviewers large enough to allow statistically analysis of the results. Questionnaires are among the ubiquitous ergonomic methods. They are ideal for accessing quick opinions from target people about usability or other aspects of a product.

It is important to remember that a questionnaire should be viewed as a multi-stage process beginning with definition of the aspects to be examined and ending with interpretation of the results. Every step needs to be designed carefully because the final results are only as good as the weakest link in the questionnaire process. Although questionnaires may be cheap to administer compared to other data collection methods, they are every bit as expensive in terms of design time and interpretation.

The steps required to design and administer a questionnaire include:

1. Defining the Objectives of the Survey
2. Determining the Sampling Group
3. Writing the Questionnaire
4. Administering the Questionnaire
5. Interpretation of the Results

The importance of well-defined objectives cannot be over emphasized. A questionnaire that is written without a clear goal and purpose is inevitably going to overlook important issues and waste participants' time by asking useless questions. The questionnaire may lack a logical flow and thereby cause the participant to lose interest. This is one of the most attention paid parts while forming the questionnaire for the study. At this point, kind of data has already been decided and the objectives of the investigation have already been formulated and a participant group has already been decided on.

At this stage, a questionnaire scenario has already been prepared. A flow chart of such a scenario can be figured out as it is in Figure 8.2.

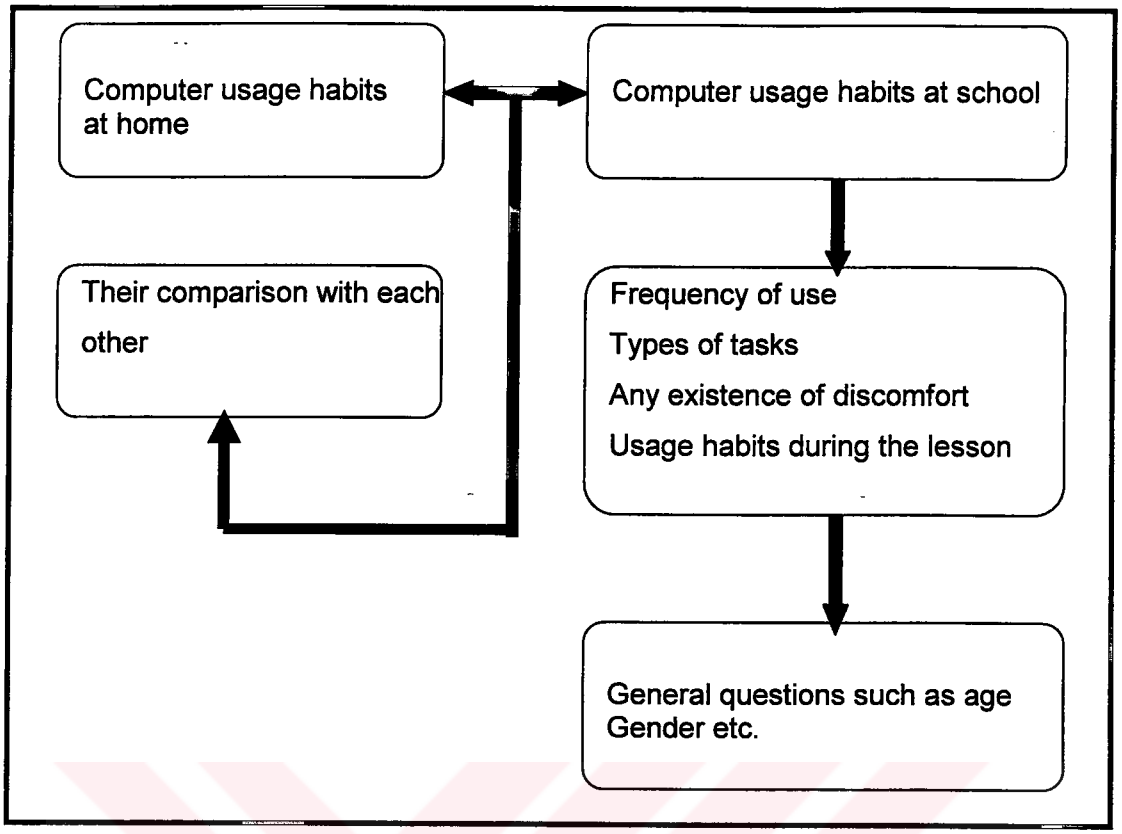


Figure 8.2 Questionnaire scenario

The questionaire is formed as a result of this thinking flow chart. (Appendix A)

There are several points that must be considered while writing or interpreting the questionnaire. The researcher during the whole process tries to bear the following in mind. Clarity, is probably the area that causes the greatest source of mistakes in questionnaires. Questions must be clear, succinct, and unambiguous. The goal is to eliminate the chance that the question will mean different things to different people. If the designers fail to do this, then essentially participants will be answering different questions. Since the participants are children, the questions must be very clear and straightforward. Any question that will cause a doubt for any of then will be a problem for questionnaire application and evaluation. Most adjectives, verbs, and nouns in English have either a positive or negative connotation. Two words may have equivalent meaning, yet one may be a compliment and the other an insult. Enough attention is tried to pay on phrasing of the questionnaire. The questions are asked in a clear way without affecting the participants. Embarrassing questions dealing with personal or private matters are avoided. It is known that the data is only as good as the trust and care that the respondents give. Hypothetical questions are based on conjecture not fantasy. This process is just like any scientific experiment.

Hypothesis is formed and the questionnaire helps to prove or disapprove this hypothesis (Appendix A).

8.3. Findings of the Questionnaire

For the data analysis of the questionnaire, SPSS software is used to evaluate the findings. Descriptive Statistics such as finding frequencies and cross tabulations is used for data evaluation. The whole questionnaire consists of 93 questions including demographic questions such as gender, age, weight etc. Some of the questions about students' attitudes in classroom at different times, software types they use are not included in the final matrix since they are only asked to have a general point of view about their computer skills.

During the analysis at first, demographic data such as gender, age etc. is evaluated within each other. Among female students (N=34) 23.5% of them weigh between 31 and 40 kg. Out of total they are 12.1%. 58.8% of the female students weigh between 41 and 50 kg. Out of total including the boys they are 30.3% of the population. 11.8 % of them weigh between 51 and 60 kg. Out of total they are 1.5% of the population. 5.9% of them weigh between 61 and 70 kg. Out of total they are 3%. Among male students (N=32), 3.1% of them weigh between 31 and 40 kg. Out of total this group is 1.5%. 53.1% of the male students weigh between 41 and 50 kg. Out of total including girls they are 25.8%. 37.5% of the male students weigh between 51 and 60 kg. Out of total this group has the percentage of 18.2. 6.3% of the male students weigh between 61 and 70 kg. They have the percentage of 3% out of whole population.

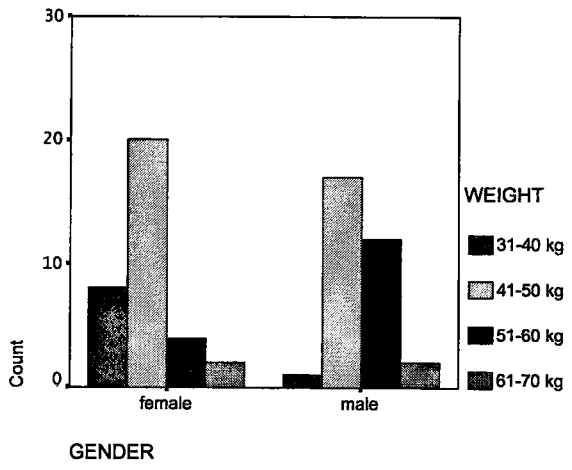


Chart 8.1 Gender weight cross tabulation

When weight evaluation is done regarding gender it is found out that 13.6% of the students weigh between 31-40 kg, 56.1% weigh between 41-50 kg. 24.2% weigh between 51-60 kg. 6.1 % weigh between 61-70 kg.

Among 34 female students, 2.9% (N=1) have the heights that vary between 1.31 and 1.40 cm. 5.9% (N=2) have the heights that vary between 1.41 and 1.50 cm. 61.8% (N=21) have the heights that vary between 1.51 and 1.60 cm. 23.5% (N=8) have the heights that vary between 1.61 and 1.70 cm. 5.9% (N=2) have the heights that vary between 1.71 and 1.80 cm. Out of total (N=66), girls whose heights are between 1.31-1.40 cm have the percentage of 1.5%, 1.41-1.50 cm have the percentage of 3%, 1.51-1.60 have the percentage of 31.8%, 1.61-1.70 cm have the percentage of 12.1%, 1.71-1.80 cm have the percentage of 3%.

Among 32 male students, none of them have the heights that vary between 1.31 and 1.40 cm. 6.3% (N=2) have the heights that vary between 1.41 and 1.50 cm. 34.4% (N=11) have the heights that vary between 1.51 and 1.60 cm. 53.1% (N=17) have the heights that vary between 1.61 and 1.70 cm. 5.9% (N=2) have the heights that vary between 1.71 and 1.80 cm. Out of total (N=66), boys whose heights are between 1.41-1.50 cm have the percentage of 3%, 1.51-1.60 have the percentage of 16.7%, 1.61-1.70 cm have the percentage of 37.9 %, 1.71-1.80 cm have the percentage of 3%.

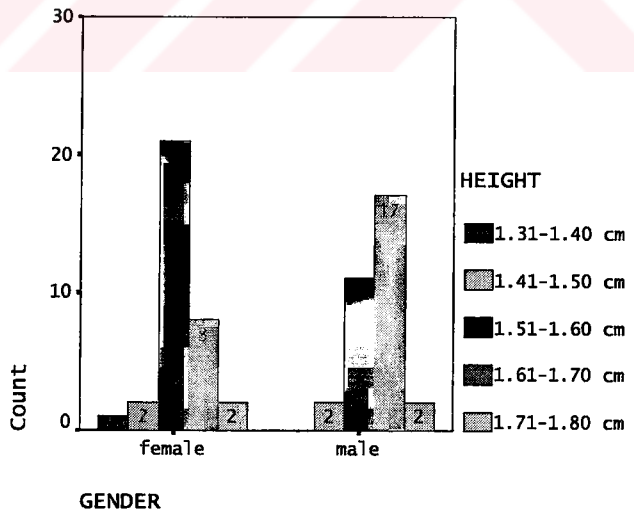


Table 8.2 Height gender cross tabulation

Totally without considering gender, 1.5% of the whole students that answer to this question (N=66), 3% of them have the heights that vary between 1.31-1.40. 6.1% of them have the heights that vary between 1.41-1.50. 48.5% of them have the heights

that vary between 1.51-1.60. 37.9% of them have the heights that vary between 1.61-1.70. 6.1% of them have the heights that vary between 1.71-1.80.

Out of 70 students (2 students do not answer), 79.2% (N=57) are right handed, 13.9% (N=10) are left-handed. 4.2% (N=3) use both of their hands while writing.

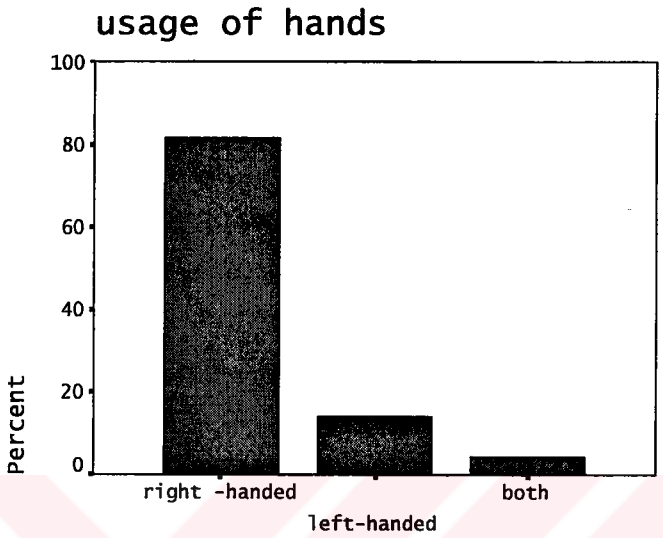


Table 8.3 usage of hands

Out of 71 students (1 answer to this question is missing), 26.4% (N=19) use spectacles, 8.3% (N=6) use contact lenses, 63% (N=46) use nothing as a visual aid.

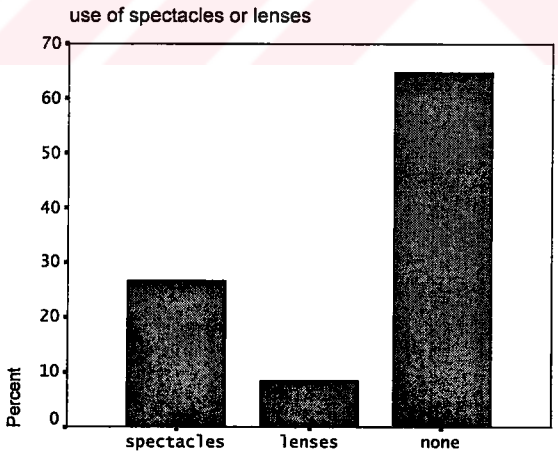


Table 8.4 usage of spectacles or lenses

Out of 72 students, 95.8% (N=69) use computer at home as well as school, 4.2%(N=3) do not use computer at home. Out of 71 students (1 student's answer is missing), 2.8% (N=2) use computer at home just for Internet. 1.4% (N=1) use computer at home just for studying. 4.2% (N=3) use computer at home just for doing homework. 2.8% (N=2) use computer at home just for play. 60.6% (N=43) use

computer at home for all the alternatives included such as Internet, play, chat, studying, doing homework. 7% (N=5) use computer at home for studying, Internet and chat. 16.9% (N=12) use computer at home for studying, Internet, doing homework and play. 1.4% (N=1) use computer at home for Internet, chat, doing homework and play.

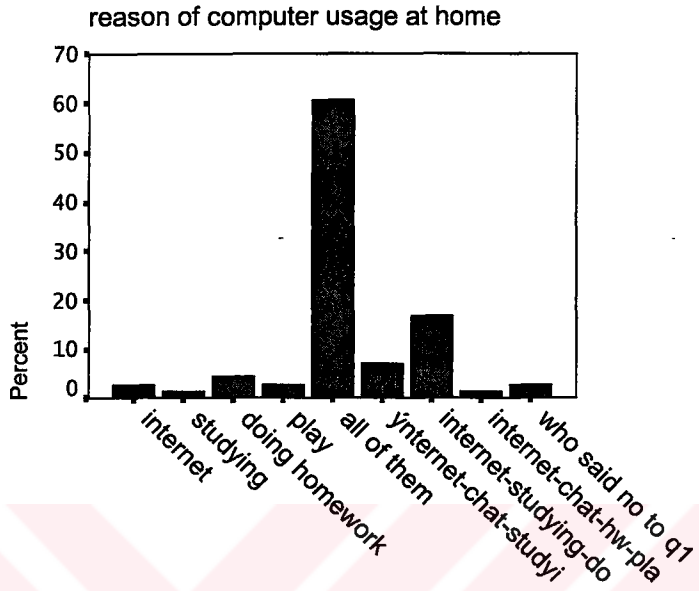


Table 8.5 reasons for using computer at home

Frequency of computer usage at home is tried to be investigated through the questionnaire. Out of 70 students, 42.9% (N=30) use computer everyday at home. 8.6% (N=6) of the students use computer at home every other day. 30% (N=21) of the students use computer at home only at weekends. 5.7% (N=4) of_the students use computer at home 3 or 4 days in a week. 10% (N=7) do not mention a definite period of time about their computer usage frequency at home.

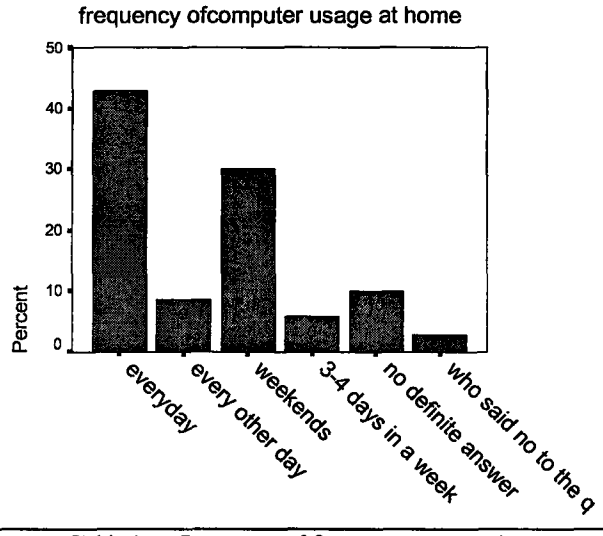


Table 8.6 Frequency of Computer usage at home

As the one session's duration of computer usage at home is investigated, it is found out that, 12.9% (N=9) of 70 students use computer for 30 minutes in each session. 30% (N=21) use computer for an hour. Another 30% (N=21) use computer for two hours. 10% (N=7) use computer for 3 hours. 8.6% (N=6) use computer more than 3 hours at one session at home. 5.7% (N=4) of the whole students do not give a definite period of time and answer as "it depends".

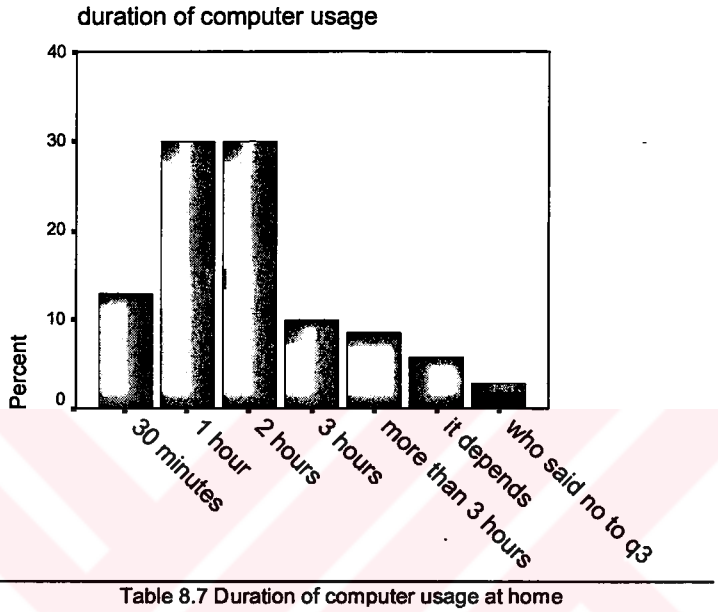


Table 8.7 Duration of computer usage at home

When the students are asked whether there is any kind of limitation for their computer usage time at home, 50% (N=35) say that they face with such a limitation. As they are asked, " Who/what limits their computer usage time at home?" out of 69 students who give answer to this question, 23.2% (N=16) say that other family members such as their mothers or fathers limit their computer usage at home. 24.6% (N=17) of the students say that their educational duties such as studying or doing homework limit their computer usage at home. 1.4% (N=1) of students say that any kind of physical discomfort limits their computer usage at home.

When it is tried to investigate whether there are any other family member-using computer at home, it is found out that 85.9% (N=61) of students' family members use computer at home. 14.1% (N=10) of students' family members do not use computer at home.

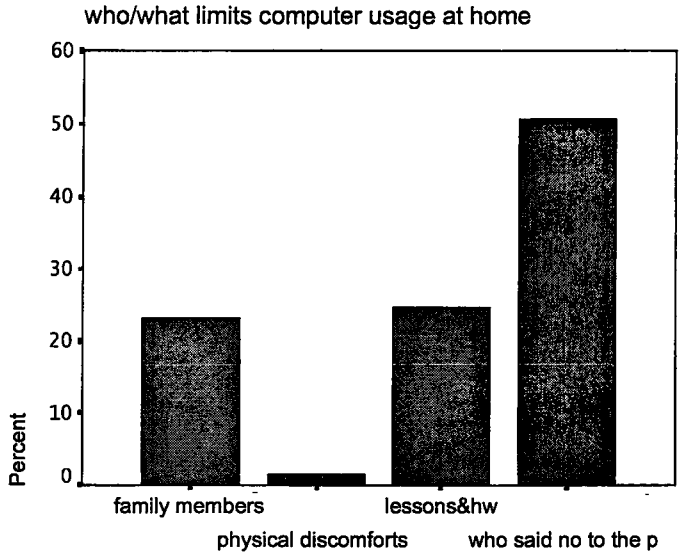


Table 8.8 who / what limits their computer usage time at home?

When the students are asked whether all the family members use the same computer at home, out of 61 students 65.7 % (N=46) say that they all use the same computer at home.

Until here, the questions asked and answered are about students' computer usage habits at home as well as school. By the help of these questions, it is tried to investigate whether these students regularly use computers other than school mediums.

The following questions and evaluations are about computer workstation mediums at CAEL and CL. Existence of pain or discomfort, types of pain or discomfort, reaction to these pain or discomfort situations, comfort and usability evaluation of CWS components at each laboratory from the students' point of views are main subjects that are focused on.

When the students are asked whether they work with the same computer in every lesson at CAEL, 94.4% (N=68) of them say that they do, 5.6% (N=4) say that they change their places due to computer defects. As the same question is asked for CL, 88.9% (N=64) say that they do, 11.1% (N=8) say that they change their places due to computer defects.

When the students are asked whether they feel any pain during CAEL lessons, out of total (N=71, one answer missing) 57.7% (N=41) admit that they feel some kind of

pain during CAEL lessons. As this percentage is distributed according to age, 18.3 % of 12- year- old students, 18.3% of 13- year- old students, 21.2% of 14- year- old students constitute this total amount of 57.7%. 42.3% (N=30) of the whole students tell that they do not feel any kind of pain while working at CAEL. As this percentage is distributed according to age, 15.5 % of 12- year- old students, 15.5% of 13- year- old students, 11.3% of 14- year- old students constitute this total amount of 42.3%.

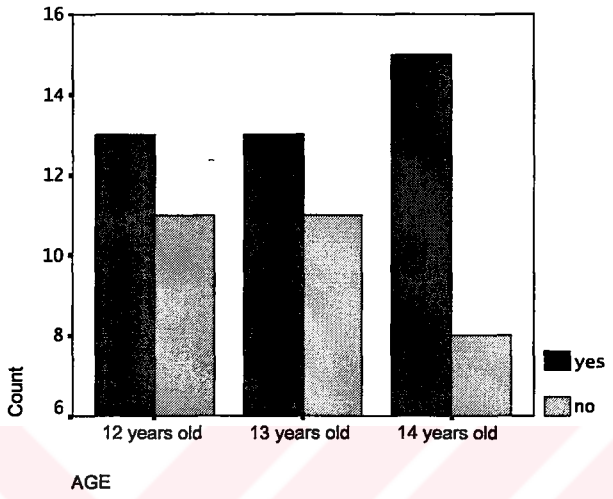


Table 8.9 existence of any kind of pain at CAEL

As it is obviously seen from the chart above, at the age of 14, students have the highest ratio of pain existence while working at CAEL.

As the same question about CL is asked to the students, out of total (N=71, one answer missing) 45.1% (N=32) admit that they feel some kind of pain during CL lessons. As this percentage is distributed according to age, 12.7 % of 12- year- old students, 14.1% of 13- year- old students, 18.3 % of 14- year- old students constitute this total amount of 45.1%. 54.9% (N=39) of the whole students tell that they do not feel any kind of pain while working at CL. As this percentage is distributed according to age, 21.1 % of 12- year- old students, 19.7% of 13- year- old students, 14.1% of 14- year- old students constitute this total amount of 54.9%. Again, at the age of 14 students have the highest ratio of pain existence. When the two outcomes are compared it is seen that the number of students who feel some kind of pain while working at CL is less than the number of students who feel some kind of pain while working at CAEL. This may be an outcome of working at different types of CWSs at these mediums.

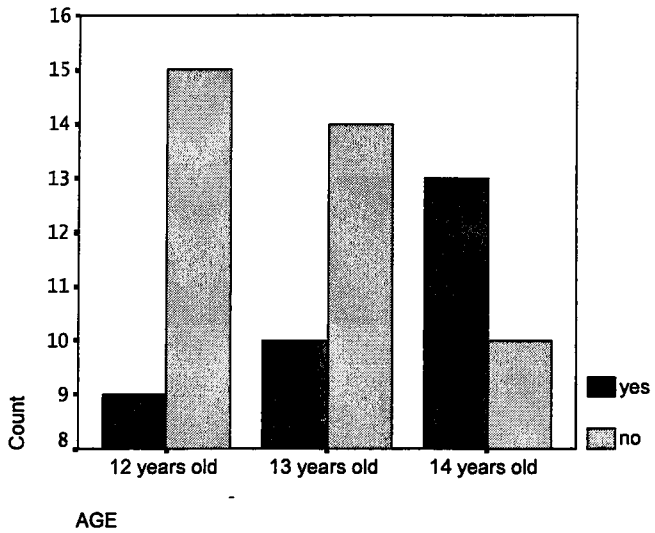


Table 8.10 existence of any kind of pain at CL

Some types of typical pain and discomfort types' existence are asked to the students. As the students (N=67, 5 answers are missing) are asked whether they feel any back pain at CAEL, out of total 34.4% (N=23) say "yes", 65.7% (N=44) say "no" as an answer. Out of this 34.3%, 11.9% is 12-year-old students, 14.9% is 13-year-old students, and 7.5% is 14-year-old students. Out of 65.7% students who do not feel any back pain at CAEL, 20.9% is 12-year-old students, 19.4% is 13-year-old students, and 25.4% is 14-year-old students.

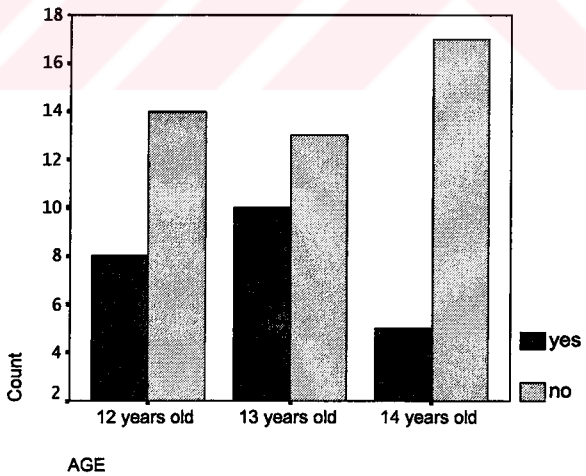


Table 8.11 any existence of back pain at CAEL

As the students (N=71, 1 answer is missing) are asked whether they feel any back pain at CL, out of total 32.4% (N=23) say "yes", 67.6% (N=48) say "no" as an answer. Out of this 32.4%, 9.9% is 12-year-old students, 12.7% is 13-year-old students, and 9.9% is 14-year-old students. Out of 67.6 % students who do not feel

any back pain at CL, 23.9% is 12-year-old students, 21.1% is 13-year-old students, and 22.5 % is 14-year-old students.

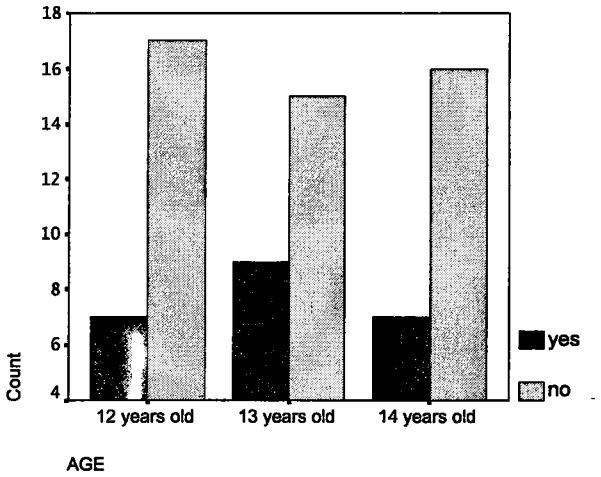


Table 8.12 any existence of back pain at CL

When their precautions for eliminating back pain are asked, 4.5% (N=3) of the students at CAEL, say that they stand up for overwhelming the pain. 6% (N= 4) move back and forth with the chair, 1.5% (N=1) get closer to the screen, 13.4% (N=9) of them lean backwards, 3% (N=2) of them do not give one significant answer but say that they stand up and move the chair backward and forward. 4.5% (N=3) sign as other but do not give a definite answer.

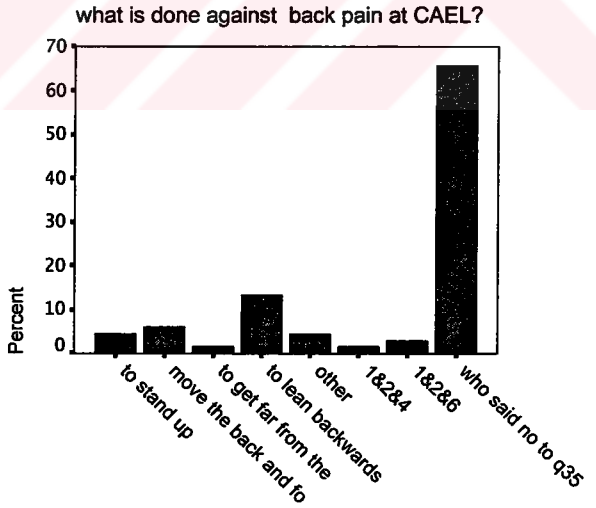


Table 8.13 what is done against backpain at CAEL?

When their precautions for eliminating back pain are asked, 4.2% (N=3) of the students at CL, say that they stand up for overwhelming the pain. 5.6% (N= 4) move back and forth with the chair, 1.4% (N=1) get closer to the screen, 14.1% (N=10) of them lean backwards, 4.2% (N=3) of them do not give one significant answer but

say that they stand up, get far from the screen and forwards and lean backwards. 1.4 % have more than one answer to this question such as moving the chair backwards and forwards and leaning backwards. 1.4% do not give a specific answer.

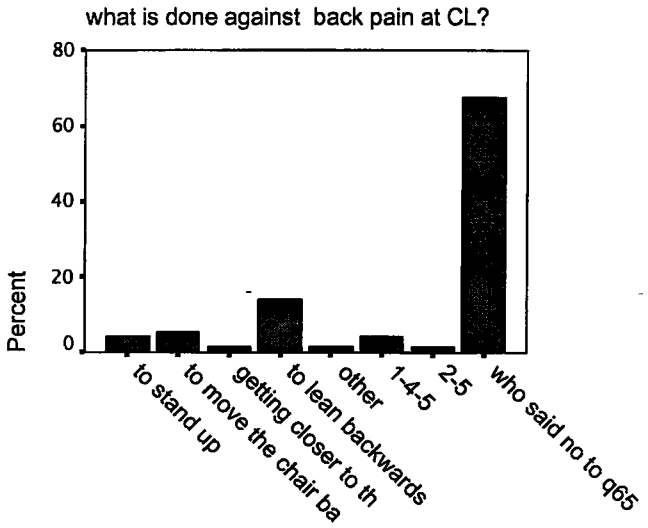


Table 8.14 what is done against back pain at CL?

As it can be easily seen from both of the graphs, in both laboratories the most common precaution taken by the students against backpain is to lean backward. At this point, a chair with a well designed and tiltable back support gains importance.

When the students are asked whether they feel any wrist pain while working at CAEL, a population of 22.5% out of total (N =70, 2 answers are missing) tell that they feel wrist pain during CAEL lessons. Out of this percentage of 22.5 %, 12 year old students are 8.5% (N=6), 13 year old students are 8.5%(N=6), 14 year old students are 5.6% (N=4).

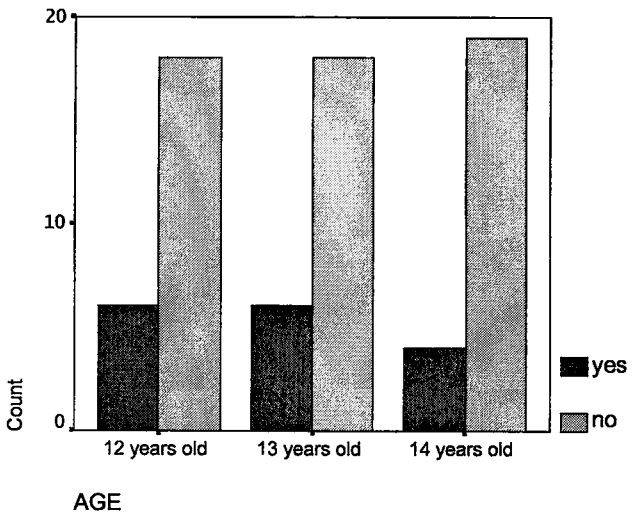


Table 8.15 existence of any wrist pain at CAEL

When the students are asked whether they feel any wrist pain while working at CL, a population of 22.5% out of total (N =71, 1 answers is missing) tell that they feel wrist pain during CL lessons. Out of this percentage of 22.5 %, 12 year old students are 8.5% (N=6), 13 year old students are 9.9%(N=7), 14 year old students are 4.2% (N=3).

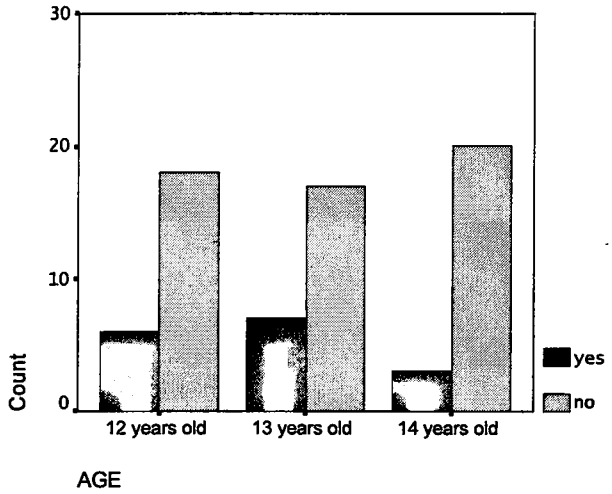


Table 8.16 existence of any wrist pain at CL

It is surprising that the ratio of students having wrist pains during CAEL and CL lessons are equal.

As the students' reactions against wrist pain are asked, it is found out that at CAEL, 1.4% (N=1) students out of total (N=71) pulls the keyboard toward himself, 1.4% (N=1) changes the direction of the keyboard, 4.2% (N=3) move their fingers, 7% (N=5) stop. 1.4% answers in a multiple way and say that he pulls the keyboard, turn and change its direction and stop. Again, another 1.4% answers in the same way and says that he moves the keyboard or stop. 5.6% (N=4) answer as "other" but do not give a definite answer.

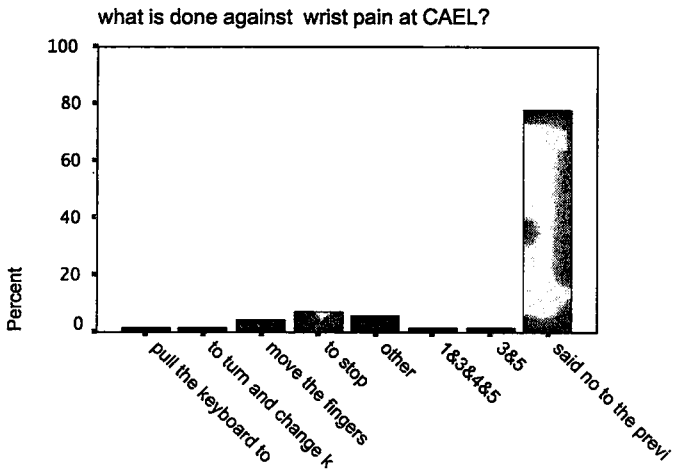


Table 8.17 what is done against wrist pain at CAEL?

As it is seen from the chart above, reaction with the highest ratio is to stop. In other words "to stop" may mean taking a break. Taking small breaks while working with computer is very helpful to overcome discomforts.

As the students' reactions against wrist pain are asked, it is found out that at CL, 1.4% (N=1) students out of total (N=71) pulls the keyboard toward himself, 1.4% (N=1) changes the direction of the keyboard, 6.9% (N=5) move their fingers, 4.2% (N=5) stop. 1.4% answers in a multiple way and say that he pulls the keyboard, turn and change its direction and stop. Again, another 1.4% answers in the same way and says that he moves the fingers or stop. 1.4% answer as "other" but do not give a definite answer.

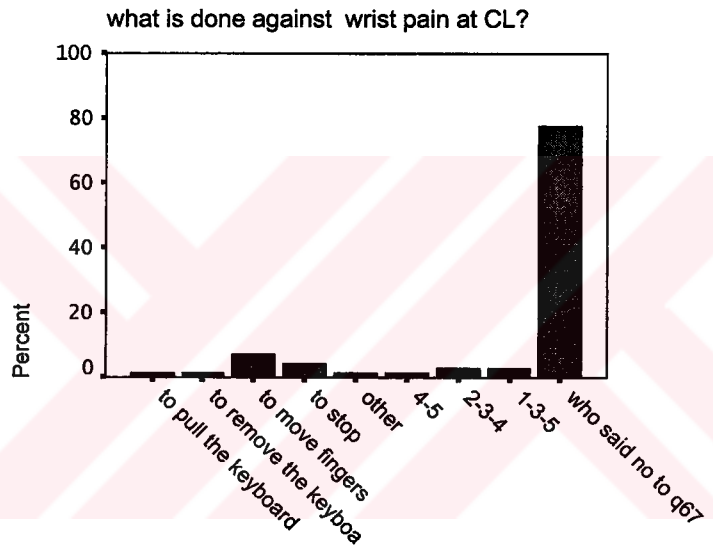


Table 8.18 what is done against wrist pain?

When the students are asked whether they feel any eyestrain while working at CAEL, 46.5% (N=33) of the students admit that they face with eyestrain while working at CAEL. 53.5% (N=38) of them tell that they do not feel any eye strain at CAEL. When this 46.5% population is examined, it is seen that 14.1% (N=10) of them are 12 year old, 15.5% (N=11) of them are 13 year olds, 16.9% (N=12) are 14 year olds.

When the students are asked whether they feel any eyestrain while working at CL, 49.3 % (N=35) of the students admit that they face with eyestrain while working at CAEL. 50.7% (N=36) of them tell that they do not feel any eyestrain at CAEL. When

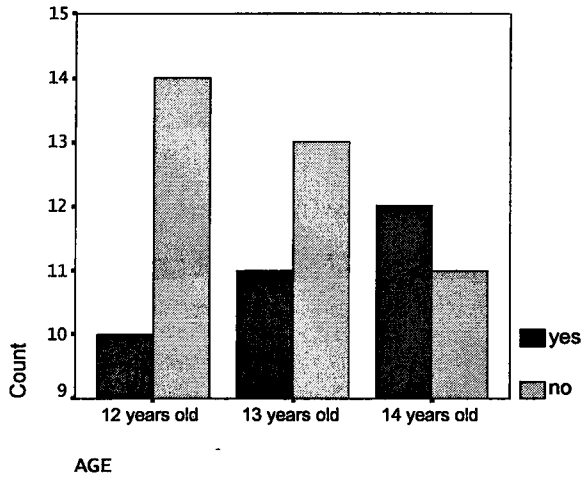


Table8.19 existence of eyestrain problem at CAEL

this 49.3 % population is examined, it is seen that 15.5% (N=11) of them are 12 year old, 16.9% (N=13) of them are 13 year olds and12.16 % (N=9) are 14 year olds.

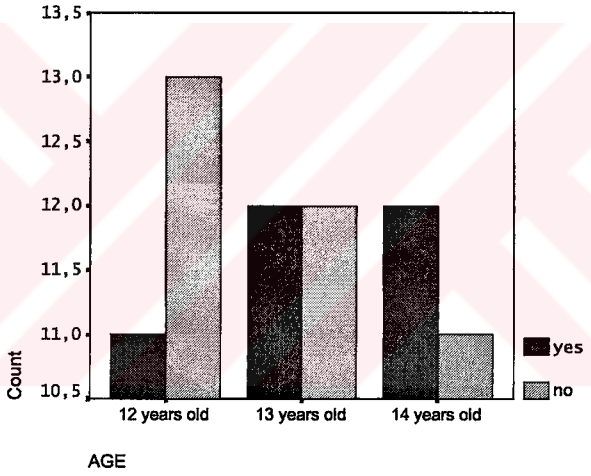


Chart 8.20 existence of eyestrain problem at CL

As these students who have eyestrain problems during CAEL and CL lessons are asked about their reactions to the existing situation. At CAEL, 2.8% (N=2) of them say that they lean over the screen. 32.4% (N=23) of them say that they get further from the screen. 11.3% (N=8) of them answer as "other" but do not explain these other things definitely. At CL 1.4% (N=1) of them says that he moves the monitor upwards and downwards against visual discomfort. 4.2% (N=3) say that they lean over the screen. 32.4% (N=23) find a solution by getting further from the screen, 4.2% say that they close their eyes, 1.4% say that he stops working, 1.4% say that he narrows his eyes. 2.8% (N=2) of them answer as "other" but do not explain these other things definitely.

When eyestrain and glare problem of CAEL are correlated, the significance is put at $p < 0.01$ level. (P=0.006). As the crosstabulation of these two variables are taken, it is seen that, 20.8% (N-15) out of total both say that they feel eyestrain and face glare problem at CAEL. We can make a conclusion that the reason for their eyestrain may have a relationship with the glare problem of the screens, which are positioned under glass surfaces.

When eyestrain and glare problem of CAEL are correlated, the significance is put at $p < 0.05$ level. (P=0.03). As the crosstabulation of these two variables are taken, it is seen that, 18.6% (N=13) out of total both say that they feel eyestrain and face glare problem at CL. Lighting problems also occur at CL, but at least students have the chance to rotate their monitors, so the decrease in ratio may outcome due to this reason.

When the students are asked about their reactions to glare problem at CAEL, 8.5% (N=6) find the solution as moving the monitor from one direction to another direction. 12.7% (N=9) say that they lean over the screen. 9.9% (N=7) try to solve the problem by getting further from the screen. The ones who lean over the screen have the highest score. One of the most attention driving points in observations is this leaning posture at CAEL. They will be demonstrated by pictures in the next pages, students often lean over the screen in order to see. The outcome of this act is inevitably hazardous from postural aspects.

When the students are asked whether they need a footrest at CAEL, 59.7% (N=43) say "yes" to this question. When they are asked about the places they use as footrests, 7.1% (N=5) answer as "wall", 40.0% (N=28) answer as "desk", 12.6% answer as "chair."

When the students are asked whether they need a footrest at CL, 55.7% (N=39) say "yes" to this question. When they are asked about the places they use as footrests, 7.1% (N=5) answer as "wall", 34.3 % (N=24) answer as "desk", 5.7 % answer as "chair, 11.4% answer as other but do not give a definite explanation.

It is obvious that these students try to find practical solution to footrest problem and use everything they find as footrests. The need of a properly designed footrest seems urgent for these students.

For the following questions, the students are asked to evaluate their CWS chairs and desks at CAEL and CL by the help of five degree Likert scale. When the

students do the comfort evaluation of the CWS chair at CAEL, it is found out that 17.1% (N=12) evaluate it as extremely comfortable, 40% (N=28) evaluate it as comfortable, 18.6% (N=13) are indecisive, 10% (N=7) evaluate it as uncomfortable, 14.3% (N=10) evaluate it as extremely uncomfortable.

As the same evaluation is done for the CWS chair at CL, it is found out that 13.9% (N=10) evaluate it as extremely comfortable, 41.7% (N=30) evaluate it as comfortable, 25% (N=18) are indecisive, 4.2% (N=3) evaluate it as uncomfortable, 15.3% (N=11) evaluate it as extremely uncomfortable.

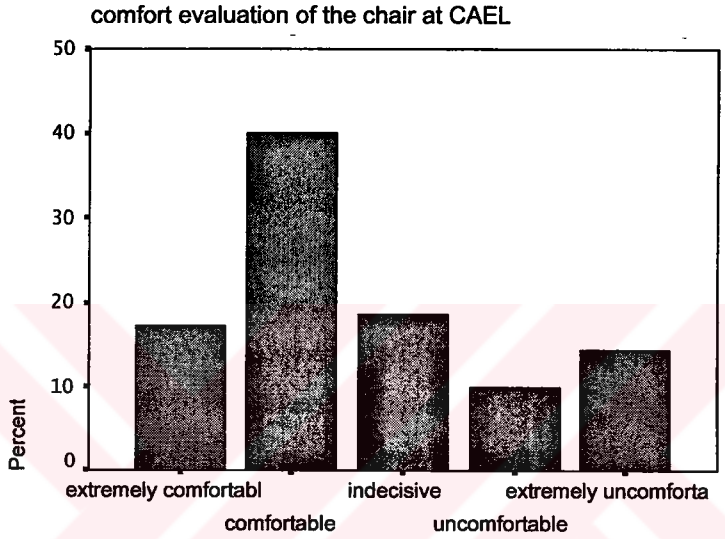


Table 8.21 Comfort evaluation of CWS chair at CAEL

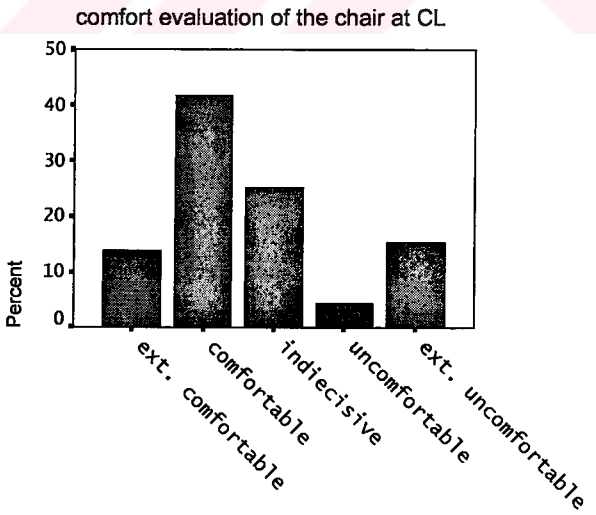


Table 8.22 Comfort evaluation of CWS chair at CL

As it can also be seen from the charts, the values of CAEL and CL for each degree are very similar. This is such a normal outcome since the types of chairs of both laboratories are typically the same.

When the students are asked to evaluate their CWS desks at CAEL and CL, the findings are as follows. 10% (N=7) of the students evaluate the desks at CAEL as extremely comfortable, 24.3% (N=17) evaluate the desks as comfortable. 40% (N=28) are indecisive. 8.6% (N=6) evaluate it as uncomfortable. 17.1% (N=12) evaluate it as extremely uncomfortable out of a total of N=70. For the CWS desk at CL, 8.5% (N=6) of the students evaluate the desks at CAEL as extremely comfortable, 39.4% (N=28) evaluate the desks as comfortable. 26.8% (N=19) are indecisive. 11.3% (N=6) evaluate it as uncomfortable. 14.1% (N=10) evaluate it as extremely uncomfortable out of a total of N=71.

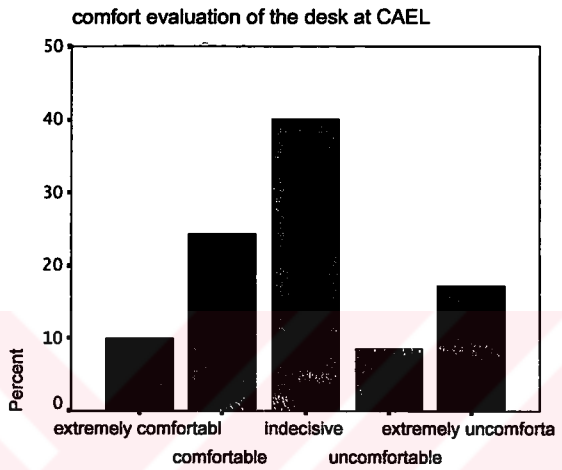


Table 8.23 Comfort evaluation of CWS desk at CAEL

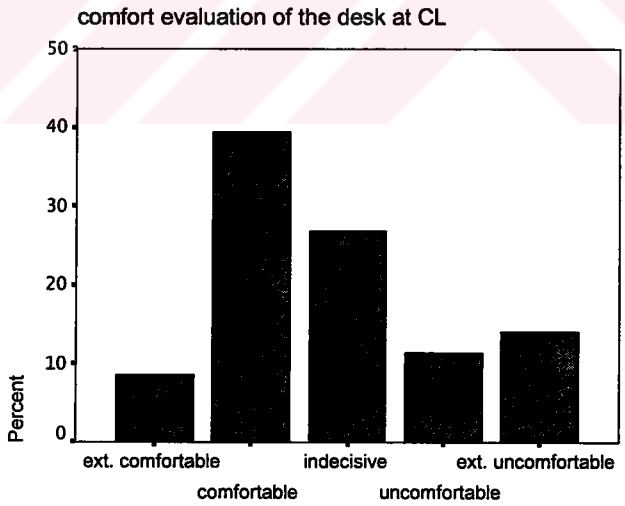


Table 8.24 Comfort evaluation of CWS desk at CL

When gender and comfort evaluation of the desk at CAEL are cross tabulated, the correlation is significant at the 0.05 level (p= 0.033). The ones who evaluate the CWS desk at CAEL as extremely comfortable are 7.2% (N=5) female, 2.9% (N=2) male. The ones who evaluate the CWS desk at CAEL as comfortable are 14.5%

(N=10) female, 10.1% (N=7) male. The indecisive ones are 21.7% (N=15) female, 18.8% (N=13) male. The ones who evaluate the CWS desk at CAEL as uncomfortable are 4.3% (N=3) female, 4.3% (N=3) male. The ones who evaluate the CWS desk at CAEL as extremely uncomfortable are 4.3% (N=3) female, 11.6% (N=8) male.

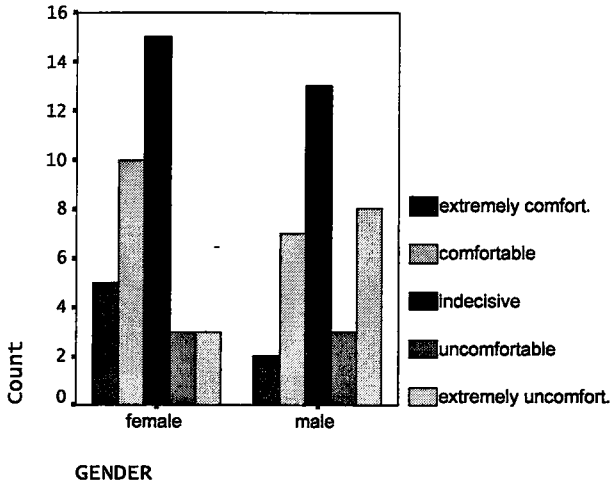


Table 8.25 GENDER * comfort evaluation of the desk at CAEL Crosstabulation

When gender and comfort evaluation of the desk at CL are cross tabulated, the correlation is significant at the 0.01 level (p=0.001). The ones who evaluate the CWS desk at CL as extremely comfortable are 5.8% (N=4) female, 1.4% (N=1) male. The ones who evaluate the CWS desk at CL as comfortable are 23.2% (N=16) female, 17.4 % (N=12) male. The indecisive ones are 18.8% (N=13) female, 8.7% (N=6) male. The ones who evaluate the CWS desk at CL as uncomfortable are 2.9% (N=2) female, 8.7% (N=6) male. The ones who evaluate the CWS desk at CL as extremely uncomfortable are 1.4% (N=1) female, 11.6% (N=8) male.

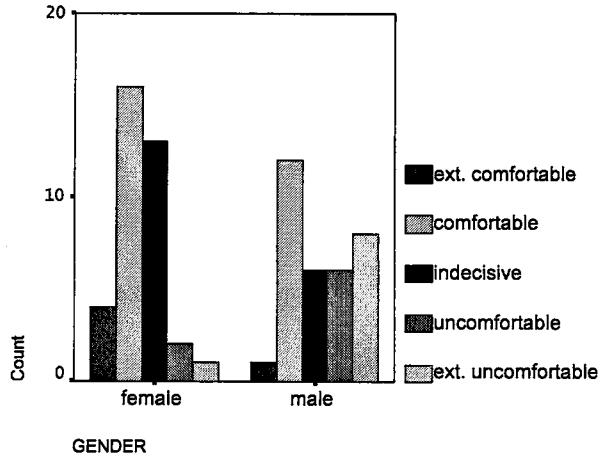


Table 8.26 GENDER * comfort evaluation of the desk at CL Crosstabulation

When gender and usability evaluation of the desk at CAEL are cross tabulated, the correlation is significant at the 0.05 level (p= 0.023). The ones who evaluate the

CWS desk at CAEL as extremely practical are 4.3 % (N=3) female, 2.9% (N=2) male. The ones who evaluate the CWS desk at CAEL as practical are 20% (N=14) female, 12.9 % (N=9) male. The indecisive ones are 20% (N=14) female, 12.9 % (N=9) male. The ones who evaluate the CWS desk at CAEL as unpractical are 7.1% (N=5) female, 10% (N=7) male. The ones who evaluate the CWS desk at CAEL as extremely unpractical are 1.4% (N=1) female, 7.1% (N=5) male.

When gender and usability evaluation of the desk at CL are cross tabulated, the correlation is significant at the 0.05 level The ones who evaluate the CWS desk at CAEL as extremely practical are 5.7 % (N=4) female, 1.4% (N=1) male. The ones who evaluate the CWS desk at CAEL as practical are 18.6% (N=13) female, 20 % (N=14) male. The indecisive ones are 17.1% (N=12) female, 12.9 % (N=9) male. The ones who evaluate the CWS desk at CAEL as unpractical are 8.6% (N=6) female, 4.3% (N=3) male. The ones who evaluate the CWS desk at CAEL as extremely unpractical are 2.9% (N=2) female, 8.6 % (N=6) male.

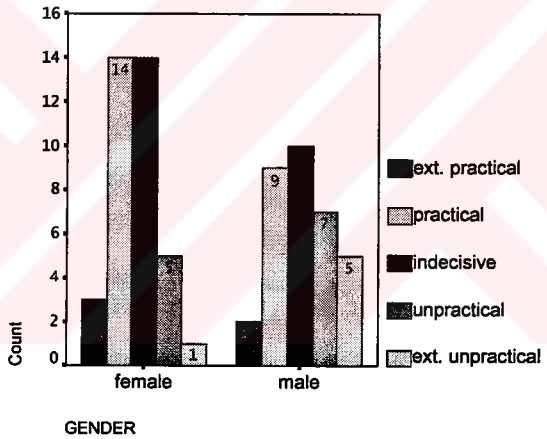


Table 8.27 GENDER * usability evaluation of the desk at CAEL Crosstabulation

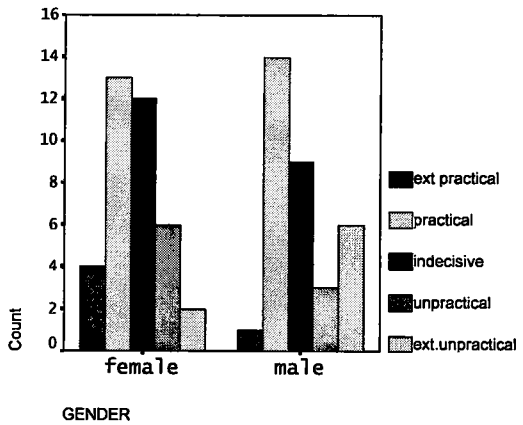


Table 8.28 GENDER * usability evaluation of the desk at CL Crosstabulation

At the end of the questionnaire, when the students are asked about their preference of both laboratories from comfort point of view, it is found out that 71.4 % (N=50) prefers CL to CAEL. 22.9% (N=16) prefers CAEL to CL. 5.7% (N=4) do not make any preference and evaluate them as equal. This may also be a sign for CL being more comfortable when compared to CAEL as it is also encountered during the observations.

9. RESULTS AND DISCUSSION

9.1. Results of the Observation Process

9.1.1. Observation in CAEL

Before talking about the questionnaire data, evaluation of observation results will be focused on and after that the relations between the observation results and questionnaire findings will be compared and evaluated. In this section the photos taken during the direct observation process will help to explain the researcher's evaluations about the situations at both of the CWS mediums.

Are they really comfortable? This is the first question that comes to one's mind during the observations. Unfortunately, during the observations it is seen that that they do not sit very comfortably at their CWSs as seen in the following figures. For example the boy, in the circle (Figure 9.1), tries to see the screen. He sits in an erect and trying position in order to fulfill his goal. This posture may cause back pain or other musculoskeletal problems.

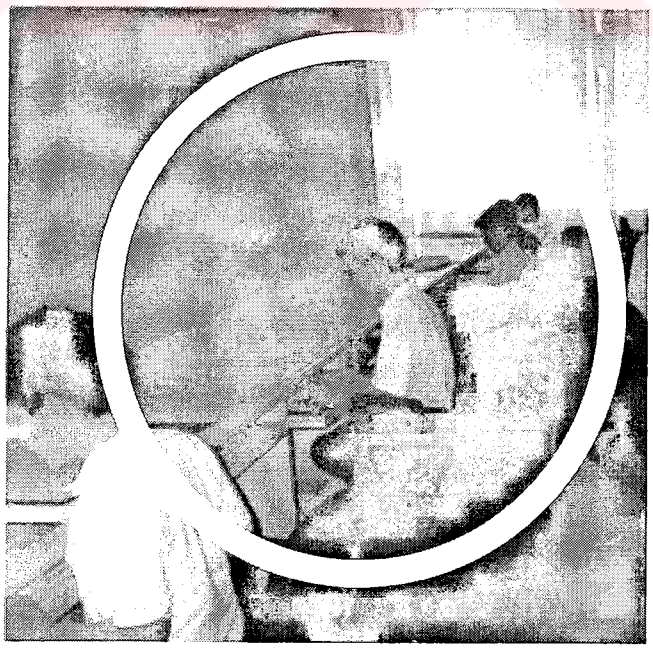


Figure 9.1 a the boy sitting at LWD

Figure 9.1 b the same boy after some time

After sometime he has still difficulty in seeing the screen and this makes things worse. If you look carefully to the picture you will see that there exists a hazardous way of keyboarding. The boy bends his wrists sideways, which may be an invitation to ulnar or radial deviation.

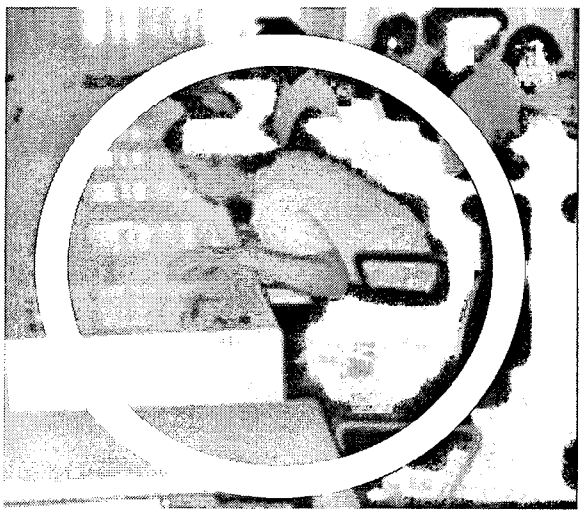


Figure 9.2 the girl lying over the LMD

This time there is a girl facing a postural problem. It is so obvious that this girl has a great problem in seeing the screen. She is lying over LMD more than sitting. The glass surface and curtains in light colors, direct light coming from the window causes the difficulty in seeing the screen. (Figure 9.2)

In section 5, with the figure 5.11, it is mentioned that head must be balanced on neck (not tilted back or too forward) upper arms close to body and relaxed (not abducted to the side or flexed forward), just the thing the boy in Figure 9.3 doing.

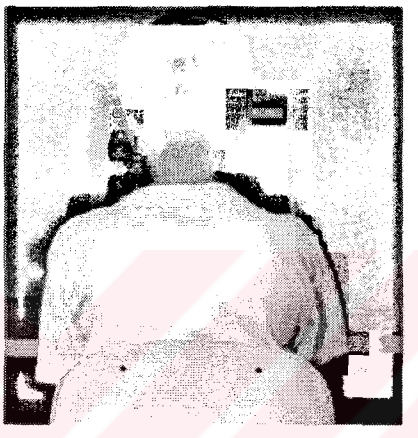


Figure 5.11 relaxed sitting position

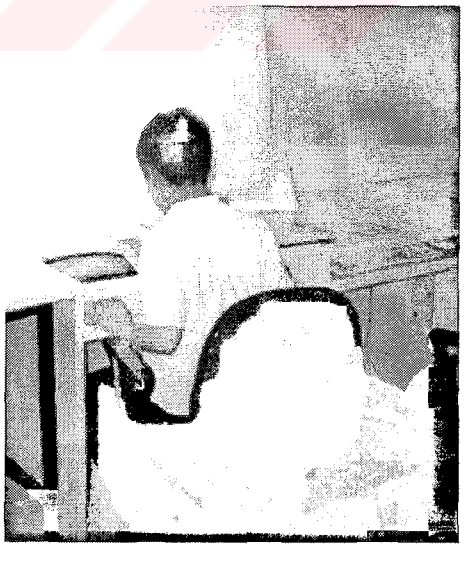


Figure 9.3 the boy sitting in an unrelaxed position

This problem is due to the glare problem of the monitor. He is sitting in front of a window and all the light is reflected by the glass surface of the LMD.

It is so obvious that these children consciously or unconsciously try to adapt themselves to their workstation medium even if they face with awkward postures. These postures can be very hazardous for them in the future. As the time passes chraned necks, hunched shoulders, awkwardly placed wrists and unhealthy posture are inevitable for these children. Such scenes of these awkward postures are seen more during the CAEL observations.

9.1.2. Observation in CL

When the lessons at CL are examined, it is seen that when keying data, the wrists of most of the students rest on the desk, this transfers additional "workload" to the fingers. (Figure 9.4)

Figure 9.4 students' wrists resting on the desk

A need for a proper footrest is essential, too. Instead of a properly designed footrest most of the children put their feet on the iron rods of the desk.

Figure 9.5 Alternative for a footrest

During a lesson period, it has been observed that children change their posture so often. This may be a sign of their discomfort and try to resist discomfort.

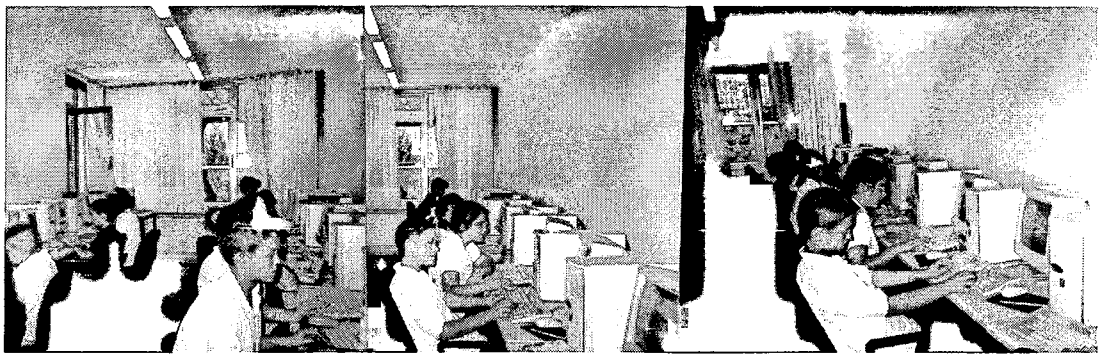


Figure 9.6 Change in posture during the time passes

9.1.3. Environmental problems in CL and CAEL

Other risky points are lighting and cable management at Şişli Terakki 's computer laboratories. As it is seen in the figures, for both of the CWSs at CL or CAEL, we cannot talk anything about cable management there. Lots of cables are mixed and a dangerous scene for children is viewed.

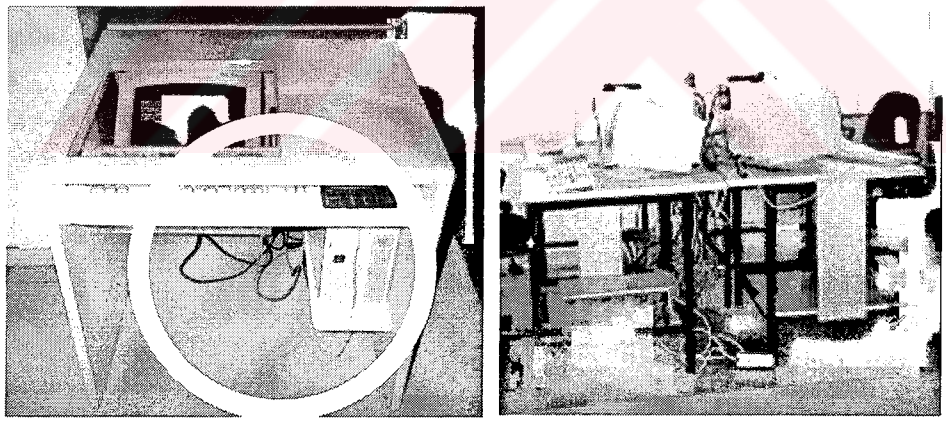


Figure 9.7 Poor cable management

A glare problem exists at both of the laboratories. The curtains are very light and they do not really avoid the sunlight to penetrate. Such situations can cause visual problems in addition too postural seen in the previous figures. (Figure 9.8)

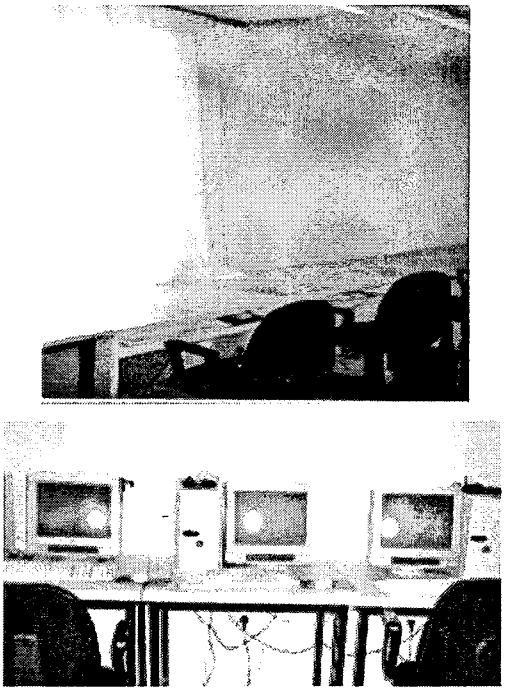


Figure 9.8 Lighting and glare Problems at CAEL and CL

bearing the points mentioned above in mind, it may be said that at CL and CAEL there are serious ergonomical problems due to the classroom settings and CWS used.

9.2. Results of the Questionnaire Analysis

In the questionnaire, there are some questions trying to find students' computer usage habits in their lives. Frequecy of computer usage at home, reasons for computer usage at home, limitations of computer usage at home are some of these questions.

A great number of students (95.8%) use comuter at home in addition to school. This prroves the thought that children are becoming computer literate. Becoming more computer literate brings more time of computer usage .

When the duration of computer usage is evaluatd it is found out that, equally (29.2% for both) most of the students spend for 1 or 2 hours when they begin to work at computers at home. Thi time is enough to affect children's postural habits while using computers.

As the duration of computer usage is evaluated, it can be said that the working period can affect the students' physical status. Effects of wrong postures can be felt during this time.

Most of the students(59.7%) use computers for internet using, studying, playing, doing homework at the same time. This means that they spend a lot more time in front of the computers.

As the data is evaluated, the students use computer very frequently, 41.7% use it everyday and 29.2% use it at weekends, in other words meaning gaining wrong and risky postural habits in front of computers may affect them a lot.

When the students are asked whether there is a limitation for their computer usage period 51.4% of them said no. The ones who said "yes" stated that ,these limitations are due to family members (22.2%), lessons and homeworks (23.6%) and any phyisical comforts (1.4%). Although the ratio of physical discomfort reason is low, it has to be kept in mind that these children have started using computers at a verly early age and as the time passes they mave have some disorders since it takes time to have disorders.

63.9% of students' family members use the same computer with the student. In such a situation, as mentioned before adjustibility of the CWS may be the keyword for healthy computer usage both for children and the other family members.

When the two outcomes are compared it is seen that the number of students who feel some kind of pain while working at CL is less than the number of students who feel some kind of pain while working at CAEL. This may be an outcome of working at different types of CWSs at these mediums.

In both laboratories the most common precaution taken by the students against backpain is to lean backward. At this point, a chair with a well designed and tiltable back support gains importance.

20.8% (N-15) out of total both say that they feel eyestrain and face glare problem at CAEL. We can make a conclusion that the reason for their eyestrain may have a

relationship with the glare problem of the screens, which are positioned under glass surfaces.

When eyestrain and glare problem of CAEL are correlated, the significance is put at $p < 0.05$ level. (P=0.03). As the crosstabulation of these two variables are taken, it is seen that, 18.6% (N=13) out of total both say that they feel eyestrain and face glare problem at CL. Lighting problems also occur at CL, but at least students have the chance to rotate their monitors, so the decrease in ratio may outcome due to this reason.

It is obvious from the findings that these students try to find practical solution to footrest problem and use everything they find as footrests. The need of a properly designed footrest seems urgent for these students.

Most of the students both in CAEL and in CL use the same CWS all the time, if any student face with any kind of discomfort due to the working environment it will continue and harm the child's health.

In the evaluations comfort ratio of CL is higher than CAEL. Also, when the students are asked about their preference of both laboratories from comfort point of view, it is found out that 71.4 % (N=50) prefers CL to CAEL. 22.9% (N=16) prefers CAEL to CL. 5.7% (N=4) do not make any preference and evaluate them as equal. This may also be a sign for CL being more comfortable when compared to CAEL as it is also encountered during the observations.

9.3. Discussion

The purpose of this study is to provide a preliminary assessment of ergonomic conditions and potential musculoskeletal risk for computer work settings in a primary school in Istanbul. Although utilization of computers in the primary school classroom in the Western world is becoming ever-present, clearly equal attention, at least in Turkey, has not been granted to the conditions under which children are working on computers. The data in total reveal a rather marked lack of attention and commitment to the provision of ergonomically suitable facilities for children to use computers in Turkish education system. A particular challenge posed by children as users of computers is the need to quickly accommodate multiple users, varying widely in stature. This situation can be contrasted with the more familiar office

workstation where there is more of a one to one relationship between furniture and user.

An obvious and important question emanating from the present data is, what are the potential health implications of these findings? Presently, most children are working for short periods of time on keyboards that are too high or low, incorrectly angled, looking sharply at the monitors, with legs unsupported on the floor. Seating support appears marginally adequate, although back support adjustability is lacking. Computer workstation dimensions are not that much adequate to accommodate the anthropometric diversity of the examined children.

Although children do not currently spend prolonged periods of time keyboarding at school, developing musculoskeletal structures could be especially vulnerable to trauma. Moreover, trends suggest that children are using computers at increasingly earlier ages and for longer durations of time. Findings of the questionnaire application also supports this thought. It is found out that most of the students with the percentage of %60 (N=72) spend at least 1 or 2 hours when they use computers at home. As it can easily be seen, computer usage is not limited with school hours. These children are severe computer users and use computers very frequently whether at home or at school.

One limitation of the present study is that a limited types of computer work settings, which are sampled. This raises a question about the generalisability of the findings. A definitive answer to this question requires a substantially large sample. Although the three classes of children at the age of twelve, thirteen and fourteen may seem small to statistically compare, some obvious differences are seen in the data. For example, when students are asked whether they feel any kind of pain or discomfort during their lessons at CAEL and CL, the answers differ according to their ages. As they get older, the percentage of discomfort and pain existence increase and 14 year old students have the highest rank (42.3% N=72) where 12 year old ones have the least.

A child may not be very aware of the position of his/her extremities in space (notice that occasionally young children draw distorted pictures of people). As it has been observed during observation process, the students especially while working at CAEL take awkward and hazardous body postures. That is, it is very unlikely that a child will keep track of whether his/her wrists are positioned at less than 15° deviation.

Therefore, it is especially important for the adult to notice and try to correct the child's posture. Children may respond more to images than to writing when it comes to learning about the ideal workstation posture. "Before" and "after" pictures of workstations can be shown in order to train them in proper posture when using computers. Every semester, as the computer lessons begin, these pictures can be shown to the students including important information of do's and don'ts while working at CWSs. Maybe this study can be a reference for school administration especially Şişli Terakki High School administration since they are the examined case.

Also according to the questionnaire data it is seen that children spend a lot of time in front of computer both at home and at school. They may find it more difficult than adults to know when to take breaks from typing or surfing the web. Thus, monitoring the child would be helpful, and they may respond well to monitoring software such as Ergo Pal and Ergo Fun. Students should be trained in proper posture when using computers. School should purchase appropriate CWS to accommodate students. For healthy and successful CWS mediums, especially in schools, adjustability is the key point since schools have a wide range of students from different ages meaning students with different physical requirements. Unfortunately, in this study it is seen that there is no sign of adjustability in CWSs of Şişli Terakki High School except the standard office chair used in laboratories.

In addition to having adjustable CWSs, being able to adjust chairs, monitors, desks, etc., is very important for children to know how to do in order to be comfortable. Educators and parents make sure that they understand and are physically strong enough to do so (some mechanisms are even difficult for adults). Prioritizing in terms of what workstation features need to function best for student's needs and those of others who will be using the workstation. For example, if you know that your computer will primarily be used for word processing, make sure that you have a good keyboard setup. If it will be used primarily for web surfing, make sure that you have a good mouse/pointing device configuration. Training should be made available to teachers, parents, administrators and other decision makers to be able to identify improper posture when children use computers.

With this caveat in mind, the data indicate cause for concern with existing CWS design in primary schools. The aspects, which have been told at the beginning of this study, must be concerned seriously when designing educational mediums. At a

minimum, school personnel and researchers need to pay more attention to potential health effects of computer usage among young school children. At the end of this study bearing all the literature research and findings of the case study in mind, a checklist has been prepared in order to be a reference for school personnel and researchers (Appendix C).

Finally we can say that, we do not know, nor have we thought much about the potential long-term health implications of children working with computers through 15 years of school before they even begin their careers. But as IT penetrates to our lives rapidly it is essential to think about all the things mentioned before and take the necessary precautions especially for children.

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APPENDIX A

QUESTIONNAIRE

Bu ankette amaçlanan sizlerin bilgisayar kullanım alışkanlıklarınızı ve bilgisayar laboratuvarlarında bulunan bilgisayar masaları ve sandalyeleri konusunda düşüncelerinizi öğrenmektir. Ayrıca sizin katılımlarınızla laboratuvarlarda karşılaşılan olumlu ve olumsuz noktalar da öğrenilmek istenmektedir. Burada yanıtladığınız sorular konusunda öğretmenlere ve başkalarına açıklama yapılmayacaktır. Yanıtlarınız ve de isimleriniz gizli kalacaktır. Bu çalışma üniversitede hazırlanan bir yüksek lisans çalışmasının parçasıdır.

1.Evde bilgisayar kullanıyor musunuz?
Evet
Hayır

2. Evde hangi amaçla bilgisayar kullanıyorsunuz?
Internet
Chat
Ders çalışma
Ödev hazırlama
Oyun
Hepsi
Diğer

3. Bir hafta içerisinde evdeki bilgisayarı hangi sıklıkta kullanıyorsunuz?
Hergün
Günaşırı
Haftasonları
Diğer.....
(EĞER CEVABINIZ "**DİĞER**" İSE "**DİĞER**" İ AÇIKLAR MISINIZ?)

4. Evde bilgisayar başına oturunca ne kadar süre kullanıyorsunuz?
15 dakika
yarım saat
bir saat
iki saat
üç saat
Diğer.....

5. Evde bilgisayar kullanım sürenizi kısıtlayan birşey var mı?
Evet
Hayır

6. Cevabınız evet ise nedir?
.....

7. Evinizde sizden başka bilgisayar kullanan var mı?
Evet
Hayır

8. Evinizde sizden başka kimler bilgisayar kullanıyor?
Annem
Babam
Kardeşim
Hepsi
Hiçbiri
Diğer

9. Evinizde hepiniz aynı bilgisayarı mı kullanıyorsunuz?
Evet
Hayır

10. Cevabınız HAYIR ise , evde başka bilgisayar var mı?
Evet
Hayır

11. Evet ise kaç adet ? .....

12. Evde kullandığınız bilgisayar kime ait? .....

13. Okulda hangi derslerde bilgisayar kullanıyorsunuz?
.....
.....
.....

14. Bu dersler kapsamında kullandığınız programların adları nelerdir?
.....
.....
.....

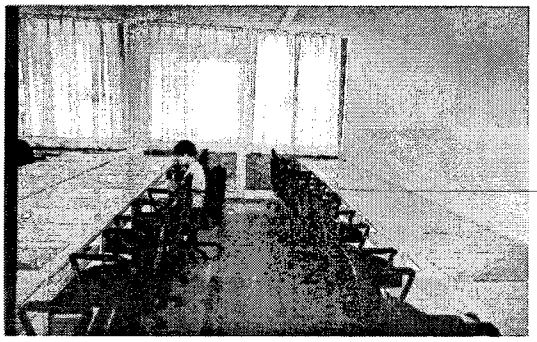
15. Bu programları size kim öğretti?
.....
.....
.....

16. Ders sırasında arkadaşlarınıza kullandığınız program konusunda soru sorar mısınız?
.....
.....
.....

17. Bilgisayar laboratuvarında sıkıldığınız oluyor mu?
Evet
Hayır

18. Bir önceki soruya cevabınız "evet" ise nedenini söyler misiniz?
.....
.....
.....

AŞAĞIDAKİ SORULARI **MATEMATİK VE FEN** DERSLERİNDE GITTİĞİNİZ **BİLGİSAYAR DESTEKLİ EĞİTİM LABORATUVARI** İÇİN YANITLAYINIZ.



19. Bir haftada ne kadar süre bilgisayar destekli eğitim laboratuvarında çalışıyorsunuz?
.....
.....
.....

20. Bilgisayar destekli eğitim laboratuvarında ne tür çalışmalar yapıyorsunuz?
.....
.....
.....

21. Bilgisayar destekli eğitim laboratuvarında öğretmenin söylediklerini nasıl takip ediyorsunuz?
Beyaz tahta
Bilgisayardan
Edemiyorum
Diğer.....

22. Ders dışında da bilgisayar destekli eğitim laboratuvarına geliyor musunuz?
Evet
Hayır

23. Ders dışında da bilgisayar destekli eğitim laboratuvarına geliyorsanız ne amaçla geliyorsunuz?
.....
.....
.....

24. Bilgisayar destekli eğitim laboratuvarında öğretmen olmadığı zaman oluyor mu?
Evet
Hayır

25. Laboratuvarda öğretmen yokken herkes ne yapıyor?
.....
.....
.....

26. Öğretmen yokken siz ne yapıyorsunuz?
.....
.....
.....

27. Öğretmen bütün laboratuvar dersleri boyunca sınıfta kalıyor mu?
Evet
Hayır

28. Bilgisayar destekli eğitim laboratuvarında hep aynı bilgisayar ile mi çalışıyorsunuz?
Evet
Hayır

29. Eğer cevabınız hayır ise nedenini söyler misiniz?
.....
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.....

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30. **Bilgisayar destekli Matematik/Fen derslerinde** sınıfta ayağa kalkıyor musunuz?
Evet
Hayır

31.Eğer ayağa kalkıyorsan ne amaçla kalkıyorsunuz?
Scanner/ Printer kullanmak
Arkadaşıma soru sormak
Öğretmenime soru sormak
Diğer.....
(EĞER CEVABIN "**DİĞER**" İSE "**DİĞER**" İ AÇIKLAR MISINIZ?)

32. **Bilgisayar Destekli Eğitim Laboratuvarında** bilgisayarı uzun süre kullandığında herhangi biryeriniz ağrıyor mu?
Evet
Hayır

33. Cevabınız EVET ise nereniz ağrıyor?
.....

34. **Bilgisayar Destekli Eğitim Laboratuvarında** bilgisayar kullanırken herhangi biryeriniz ağrıdığı zaman ne yapıyorsun?
Ayağa kalkıyorum.
Sandalyemi ileri-geri hareket ettiriyorum..
Klavyemi kendime doğru çekiyorum.
Ekrana yaklaşıyorum
Ekrandan uzaklaşıyorum.
Boynumu sağa sola döndürerek hareket ettiriyorum.
Diğer.....

35. **Bilgisayar Destekli Eğitim Laboratuvarında** bilgisayarı uzun süre kullandığında sırtınız ağrıyor mu?
Evet
Hayır

36. Cevabınız EVET ise ne yapıyorsunuz?
Ayağa kalkıyorum.
Sandalyemi ileri-geri hareket ettiriyorum..
Ekrana yaklaşıyorum
Ekrandan uzaklaşıyorum.
Arkama yaslanıyorum.
Sınıf içerisinde dolaşıyorum.
Diğer.....

37. **Bilgisayar Destekli Eğitim Laboratuvarında** bilgisayarı uzun süre kullandığınızda bileğinizin yorulup ağrıdığı oluyor mu?
Evet
Hayır

38. Cevabınız EVET ise ne yapıyorsunuz?
Klavyemi kendime doğru çekiyorum.
Klavyemi çeviriyor ve yönünü değiştiriyorum.
Klavyemi kendimden uzaklaştırıyorum.
Parmaklarımı hareket ettiriyorum.
Duruyorum.
Diğer.....

39. **Bilgisayar Destekli Eğitim Laboratuvarında** bilgisayarı uzun süre kullandığında gözlerinizde herhangi bir rahatsızlık hissediyor musunuz?
Evet
Hayır

40. Cevabınız EVET ise ne yapıyorsunuz?
Ekranı yukarı-aşağı, sağa-sola hareket ettiriyorum.
Ekrana eğiliyorum..
Ekrandan uzaklaşıyorum.
Diğer.....

41. **Bilgisayar Destekli Eğitim Laboratuvarında** bilgisayar kullanırken ekranın parladığı oluyor mu?
Evet
Hayır

42. Cevabınız EVET ise ne yapıyorsunuz?
Ekranı yukarı-aşağı, sağa-sola hareket ettiriyorum.
Ekrana eğiliyorum..
Ekrandan uzaklaşıyorum.
Diğer.....

43. **Bilgisayar Destekli Eğitim Laboratuvarında** çalışırken ayaklarınızı herhangi bir yere yaslamanız gerekiyor mu?
Evet
Hayır

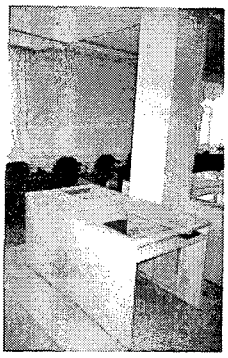
44. Cevabınız EVET ise nereye yaslıyorsunuz?
duvara yaslıyorum.
masaya yaslıyorum.
Sandalyeme yaslıyorum.
Diğer.....

45. **Bilgisayar Destekli Eğitim Laboratuvarında** bilgisayar ile çalışırken kitaplarınızı nereye koyuyorsunuz?
Masanın üstüne
Bilgisayar kasasının üstüne
Monitorun üstüne
Diğer

46. **Bilgisayar Destekli Eğitim Laboratuvarında** oturduğunuz sandalye için rahatlık bakımından bir derecelendirme yaparsanız ,sandalyeniz aşağıdaki hangi gruba girer?
Çok rahat
Rahat
Kararsız
Rahatsız
Çok Rahatsız

47. Eğer Bilgisayar Destekli Eğitim Laboratuvarında kullandığınız masa için rahatlık bakımından bir derecelendirme yaparsanız ,masanız aşağıdaki hangi gruba girer?

Çok rahat
Rahat
Kararsız
Rahatsız
Çok Rahatsız



48. Eğer Bilgisayar Destekli Eğitim Laboratuvarında kullandığınız masa için kullanışlılık bakımından bir derecelendirme yaparsanız ,masan aşağıdaki hangi gruba girer?

Çok kullanışlı
kullanışlı
Kararsız
Kullanışsız
Çok kullanışsız

AŞAĞIDAKİ SORULARI BİLGİSAYAR DERSLERİ İÇİN GİTTİĞİNİZ BİLGİSAYAR LABORATUVARI İÇİN YANITLAYIN.

49. Bir haftada ne kadar süre bilgisayar laboratuvarında çalışıyorsunuz?
.....
.....
.....

50. Bilgisayar laboratuvarında ne tür çalışmalar yapıyorsunuz?
.....
.....
.....

51. Bilgisayar laboratuvarında öğretmenin söylediklerini nasıl takip ediyorsunuz?
Beyaz tahta
Bilgisayardan
Edemiyorum
Diğer.....

52. Ders dışında da bilgisayar laboratuvarına geliyor musunuz?
Evet
Hayır

53. Ders dışında da bilgisayar laboratuvarına geliyorsanız ne amaçla geliyorsunuz?
.....
.....
.....

54. Bilgisayar laboratuvarında öğretmen olmadığı zaman oluyor mu?
Evet
Hayır

55. Laboratuvarda öğretmen yokken herkes ne yapıyor?
.....
.....
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56. Öğretmen yokken siz ne yapıyorsunuz?
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.....

57. Öğretmen bütün laboratuvar dersleri boyunca sınıfta kalıyor mu?
Evet
Hayır

58. Bilgisayar laboratuvarında hep aynı bilgisayar ile mi çalışıyorsunuz?
Evet
Hayır

59. Eğer cevabınız hayır ise nedenini söyler misiniz?
.....
.....
.....

60. Bilgisayar derslerinde sınıfta ayağa kalkıyor musunuz?
Evet
Hayır

61. Eğer ayağa kalkıyorsanız ne amaçla kalkıyorsunuz?
Scanner/ Printer kullanmak
Arkadaşıma soru sormak
Öğretmenime soru sormak
Diğer.....
(EĞER CEVABINIZ "**DİĞER**" İSE "**DİĞER**" İ AÇIKLAR MISINIZ?)

62. **Bilgisayar Laboratuvarında** bilgisayarı uzun süre kullandığında biryeriniz ağrıyor mu?
Evet
Hayır

63. Cevabınız EVET ise nereniz ağrıyor?
.....

64. **Bilgisayar Laboratuvarında** bilgisayar kullanırken biryeriniz ağrıdığı zaman ne yapıyorsun?
Ayağa kalkıyorum.
Sandalyemi ileri-geri hareket ettiriyorum..
Klavyemi kendime doğru çekiyorum.
Ekrana yaklaşıyorum
Ekrandan uzaklaşıyorum.
Boynumu sağa sola döndürerek hareket ettiriyorum.
Diğer.....

65. **Bilgisayar Laboratuvarında** bilgisayarı uzun süre kullandığında sırtınız ağrıyor mu?
Evet
Hayır

66. Cevabınız EVET ise ne yapıyorsunuz?
Ayağa kalkıyorum.
Sandalyemi ileri-geri hareket ettiriyorum..
Ekrana yaklaşıyorum
Ekrandan uzaklaşıyorum.
Arkama yaslanıyorum.
Sınıf içerisinde dolaşıyorum.
Diğer.....

67. **Bilgisayar Laboratuvarında** bilgisayarı uzun süre kullandığınızda bileğinizin yorulup ağrıdığı oluyor mu?
Evet
Hayır

68. Cevabınız EVET ise ne yapıyorsunuz?
Klavyemi kendime doğru çekiyorum.
Klavyemi çeviriyor ve yönünü değiştiriyorum.
Klavyemi kendimden uzaklaştırıyorum.
Parmaklarımı hareket ettiriyorum.
Duruyorum.
Diğer.....

69. **Bilgisayar Laboratuvarında** bilgisayarı uzun süre kullandığında gözlerinizde herhangi bir rahatsızlık hissediyor musunuz?
Evet
Hayır

70. Cevabınız EVET ise ne yapıyorsunuz?
Ekranı yukarı-aşağı, sağa-sola hareket ettiriyorum.
Ekrana eğiliyorum..
Ekrandan uzaklaşıyorum.
Diğer.....

71. **Bilgisayar Laboratuvarında** bilgisayar kullanırken ekranın parladığı oluyor mu?
Evet
Hayır

72. Cevabınız EVET ise ne yapıyorsunuz?
Ekranı yukarı-aşağı, sağa-sola hareket ettiriyorum.
Ekrana eğiliyorum..
Ekrandan uzaklaşıyorum.
Diğer.....

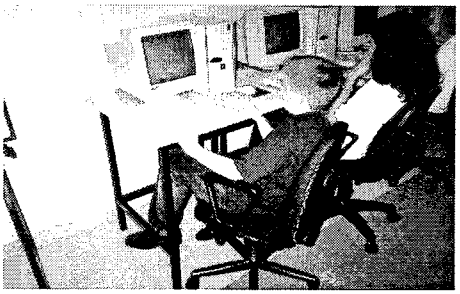
73. **Bilgisayar Laboratuvarında** çalışırken ayaklarınızı herhangi bir yere yaslamanız gerekiyor mu?
Evet
Hayır

74. Cevabınız EVET ise nereye yaslıyorsunuz?
Duvara yaslıyorum.
Masaya yaslıyorum.
Sandalyeme yaslıyorum.
Diğer.....

75. **Bilgisayar Laboratuvarında** bilgisayar ile çalışırken kitaplarınızı nereye koyuyorsunuz?
Masanın üstüne
Bilgisayar kasasının üstüne
Monitorun üstüne
Diğer

76. Bilgisayar Laboratuvarında oturduğunuz sandalye için rahatlık bakımından bir derecelendirme yaparsanız ,sandalyen aşağıdaki hangi gruba girer?
Çok rahat
Rahat
Kararsız
Rahatsız
Çok Rahatsız

77. Bilgisayar Laboratuvarında kullandığınız masa için rahatlık bakımından bir derecelendirme yaparsan ,masanız aşağıdaki hangi gruba girer?



Çok rahat
Rahat
Kararsız
Rahatsız
Çok Rahatsız

78. Bilgisayar Laboratuvarında kullandığın masa için kullanışlılık bakımından bir derecelendirme yaparsan ,masan aşağıdaki hangi gruba girer?
Çok kullanışlı
kullanışlı
Kararsız
kullanışsız
Çok kullanışsız

79. Okuldaki iki tip bilgisayar laboratuvarından siz hangisinde çalışmayı daha çok seviyorsunuz?
Bilgisayar Laboratuvarı
Bilgisayar Destekli Eğitim Laboratuvarı

80. Nedenini açıklar mısınız?
.....
.....
.....

81. Size göre "iyi" olan laboratuvar niçin iyi?
.....
.....
.....

82. Size göre "iyi" olmayan laboratuvar niçin iyi değil?
.....
.....
.....

83. Evde mi daha rahat bilgisayar ile çalışıyorsunuz yoksa okulda mı?
Evde
Okulda
Her ikiside rahat
Her ikisi de rahatsız

84. Herhangi bir yeriniz ağrıdığı için ilaç aldığınız oldu mu?
Evet
Hayır

85. Evet ise nereniz ağrıdığı için ilaç aldınız?
.....
.....
.....

Adınız-Soyadınız:..... .....
Doğum Tarihiniz:.....
Cinsiyetiniz:.....
Gözlük veya lens kullanıyor musunuz? .....
Yazı yazarken sol elini mi yoksa sağ elini mi kullanıyorsunuz? .....
Boyunuz:.....
Kilonuz:.....
Soruları cevapladığınız için teşekkürler

Anketi Hazırlayan: F. Pınar YALÇIN ÇELİK
İ.T.Ü. Endüstri Ürünleri
Tasarımı Bölümü

APPENDIX B

TABLES OF SPSS USED FOR QUESTIONNAIRE DATA EVALUATION

Table B.1

			WEIGHT				Total
			31-40 kg	41-50 kg	51-60 kg	61-70 kg	
GENDER	female	Count	8	20	4	2	34
		% within GENDER	23,5%	58,8%	11,8%	5,9%	100,0%
		% within WEIGHT	88,9%	54,1%	25,0%	50,0%	51,5%
		% of Total	12,1%	30,3%	6,1%	3,0%	51,5%
	male	Count	1	17	12	2	32
		% within GENDER	3,1%	53,1%	37,5%	6,3%	100,0%
		% within WEIGHT	11,1%	45,9%	75,0%	50,0%	48,5%
		% of Total	1,5%	25,8%	18,2%	3,0%	48,5%
Total		Count	9	37	16	4	66
		% within GENDER	13,6%	56,1%	24,2%	6,1%	100,0%
		% within WEIGHT	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	13,6%	56,1%	24,2%	6,1%	100,0%

Table B.2

GENDER * HEIGHT Crosstabulation

			HEIGHT					Total
			1.31-1.40 cm	1.41-1.50 cm	1.51-1.60 cm	1.61-1.70 cm	1.71-1.80 cm	
GENDER	female	Count	1	2	21	8	2	34
		% within GENDER	2,9%	5,9%	61,8%	23,5%	5,9%	100,0%
		% within HEIGHT	100,0%	50,0%	65,6%	32,0%	50,0%	51,5%
		% of Total	1,5%	3,0%	31,8%	12,1%	3,0%	51,5%
	male	Count		2	11	17	2	32
		% within GENDER		6,3%	34,4%	53,1%	6,3%	100,0%
		% within HEIGHT		50,0%	34,4%	68,0%	50,0%	48,5%
		% of Total		3,0%	16,7%	25,8%	3,0%	48,5%
Total		Count	1	4	32	25	4	66
		% within GENDER	1,5%	6,1%	48,5%	37,9%	6,1%	100,0%
		% within HEIGHT	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	1,5%	6,1%	48,5%	37,9%	6,1%	100,0%

Table B.3

reason of computer usage at home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	internet	2	2,8	2,8	2,8
	studying	1	1,4	1,4	4,2
	doing homework	3	4,2	4,2	8,5
	play	2	2,8	2,8	11,3
	all of them	43	59,7	60,6	71,8
	internet-chat-studying	5	6,9	7,0	78,9
	internet-studying-doing hw-play	12	16,7	16,9	95,8
	internet-chat-hw-play	1	1,4	1,4	97,2
	who said no to q1	2	2,8	2,8	100,0
	Total	71	98,6	100,0	
Missing	System	1	1,4		
Total		72	100,0		

Table B.4

frequency ofcomputer usage at home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	everyday	30	41,7	42,9	42,9
	every other day	6	8,3	8,6	51,4
	weekends	21	29,2	30,0	81,4
	3-4 days in a week	4	5,6	5,7	87,1
	no definite answer	7	9,7	10,0	97,1
	who said no to the question 2	2	2,8	2,9	100,0
	Total	70	97,2	100,0	
Missing	System	2	2,8		
Total		72	100,0		

Table B.5

duration of computer usage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30 minutes	9	12,5	12,9	12,9
	1 hour	21	29,2	30,0	42,9
	2 hours	21	29,2	30,0	72,9
	3 hours	7	9,7	10,0	82,9
	more than 3 hours	6	8,3	8,6	91,4
	it depends	4	5,6	5,7	97,1
	who said no to q3	2	2,8	2,9	100,0
	Total	70	97,2	100,0	
Missing	System	2	2,8		
Total		72	100,0		

Table B.6

who/what limits computer usage at home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	family members	16	22,2	23,2	23,2
	physical discomforts	1	1,4	1,4	24,6
	lessons&hw	17	23,6	24,6	49,3
	who said no to the previous question	35	48,6	50,7	100,0
	Total	69	95,8	100,0	
Missing	System	3	4,2		
Total		72	100,0		

Table B.7

AGE * any pain at CAEL? Crosstabulation

			any pain at CAEL?		
			yes	no	Total
AGE	12 years old	Count	13	11	24
		% within AGE	54,2%	45,8%	100,0%
		% within any pain at CAEL?	31,7%	36,7%	33,8%
		% of Total	18,3%	15,5%	33,8%
	13 years old	Count	13	11	24
		% within AGE	54,2%	45,8%	100,0%
		% within any pain at CAEL?	31,7%	36,7%	33,8%
		% of Total	18,3%	15,5%	33,8%
	14 years old	Count	15	8	23
		% within AGE	65,2%	34,8%	100,0%
		% within any pain at CAEL?	36,6%	26,7%	32,4%
		% of Total	21,1%	11,3%	32,4%
Total		Count	41	30	71
		% within AGE	57,7%	42,3%	100,0%
		% within any pain at CAEL?	100,0%	100,0%	100,0%
		% of Total	57,7%	42,3%	100,0%

Table B.8

AGE * any pain at CL? Crosstabulation

			any pain at CL?		
			yes	no	Total
AGE	12 years old	Count	9	15	24
		% within AGE	37,5%	62,5%	100,0%
		% within any pain at CL?	28,1%	38,5%	33,8%
		% of Total	12,7%	21,1%	33,8%
	13 years old	Count	10	14	24
		% within AGE	41,7%	58,3%	100,0%
		% within any pain at CL?	31,3%	35,9%	33,8%
		% of Total	14,1%	19,7%	33,8%
	14 years old	Count	13	10	23
		% within AGE	56,5%	43,5%	100,0%
		% within any pain at CL?	40,6%	25,6%	32,4%
		% of Total	18,3%	14,1%	32,4%
Total		Count	32	39	71
		% within AGE	45,1%	54,9%	100,0%
		% within any pain at CL?	100,0%	100,0%	100,0%
		% of Total	45,1%	54,9%	100,0%

Table B.9

AGE * any back pain at CAEL? Crosstabulation

			any back pain at CAEL?		
			yes	no	Total
AGE	12 years old	Count	8	14	22
		% within AGE	36,4%	63,6%	100,0%
		% within any back pain at CAEL?	34,8%	31,8%	32,8%
		% of Total	11,9%	20,9%	32,8%
	13 years old	Count	10	13	23
		% within AGE	43,5%	56,5%	100,0%
		% within any back pain at CAEL?	43,5%	29,5%	34,3%
		% of Total	14,9%	19,4%	34,3%
	14 years old	Count	5	17	22
		% within AGE	22,7%	77,3%	100,0%
		% within any back pain at CAEL?	21,7%	38,6%	32,8%
		% of Total	7,5%	25,4%	32,8%
Total		Count	23	44	67
		% within AGE	34,3%	65,7%	100,0%
		% within any back pain at CAEL?	100,0%	100,0%	100,0%
		% of Total	34,3%	65,7%	100,0%

Table B.10

AGE * any back pain at CL? Crosstabulation

			any back pain at CL?		
			yes	no	Total
AGE	12 years old	Count	7	17	24
		% within AGE	29,2%	70,8%	100,0%
		% within any back pain at CL?	30,4%	35,4%	33,8%
		% of Total	9,9%	23,9%	33,8%
	13 years old	Count	9	15	24
		% within AGE	37,5%	62,5%	100,0%
		% within any back pain at CL?	39,1%	31,3%	33,8%
		% of Total	12,7%	21,1%	33,8%
	14 years old	Count	7	16	23
		% within AGE	30,4%	69,6%	100,0%
		% within any back pain at CL?	30,4%	33,3%	32,4%
		% of Total	9,9%	22,5%	32,4%
Total		Count	23	48	71
		% within AGE	32,4%	67,6%	100,0%
		% within any back pain at CL?	100,0%	100,0%	100,0%
		% of Total	32,4%	67,6%	100,0%

Table B.11

what is done against back pain at CAEL?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	to stand up	3	4,2	4,5	4,5
	move the back and forth	4	5,6	6,0	10,4
	to get far from the screen	1	1,4	1,5	11,9
	to lean backwards	9	12,5	13,4	25,4
	other	3	4,2	4,5	29,9
	1&2&4	1	1,4	1,5	31,3
	1&2&6	2	2,8	3,0	34,3
	who said no to q35	44	61,1	65,7	100,0
	Total	67	93,1	100,0	
Missing	System	5	6,9		
Total		72	100,0		

Table B.12

what is done against back pain at CL?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	to stand up	3	4,2	4,2	4,2
	to move the chair back and forth	4	5,6	5,6	9,9
	getting closer to the screen	1	1,4	1,4	11,3
	to lean backwards	10	13,9	14,1	25,4
	other	1	1,4	1,4	26,8
	1-4-5	3	4,2	4,2	31,0
	2-5	1	1,4	1,4	32,4
	who said no to q65	48	66,7	67,6	100,0
	Total	71	98,6	100,0	
Missing	System	1	1,4		
Total		72	100,0		

Table B.13

AGE * any wrist pain at CAEL? Crosstabulation

			any wrist pain at CAEL?		
			yes	no	Total
AGE	12 years old	Count	6	18	24
		% within AGE	25,0%	75,0%	100,0%
		% within any wrist pain at CAEL?	37,5%	32,7%	33,8%
		% of Total	8,5%	25,4%	33,8%
	13 years old	Count	6	18	24
		% within AGE	25,0%	75,0%	100,0%
		% within any wrist pain at CAEL?	37,5%	32,7%	33,8%
		% of Total	8,5%	25,4%	33,8%
	14 years old	Count	4	19	23
		% within AGE	17,4%	82,6%	100,0%
		% within any wrist pain at CAEL?	25,0%	34,5%	32,4%
		% of Total	5,6%	26,8%	32,4%
Total		Count	16	55	71
		% within AGE	22,5%	77,5%	100,0%
		% within any wrist pain at CAEL?	100,0%	100,0%	100,0%
		% of Total	22,5%	77,5%	100,0%

Table B.14

AGE * any wrist pain at CL? Crosstabulation

			any wrist pain at CL?		
			yes	no	Total
AGE	12 years old	Count	6	18	24
		% within AGE	25,0%	75,0%	100,0%
		% within any wrist pain at CL?	37,5%	32,7%	33,8%
		% of Total	8,5%	25,4%	33,8%
	13 years old	Count	7	17	24
		% within AGE	29,2%	70,8%	100,0%
		% within any wrist pain at CL?	43,8%	30,9%	33,8%
		% of Total	9,9%	23,9%	33,8%
	14 years old	Count	3	20	23
		% within AGE	13,0%	87,0%	100,0%
		% within any wrist pain at CL?	18,8%	36,4%	32,4%
		% of Total	4,2%	28,2%	32,4%
Total		Count	16	55	71
		% within AGE	22,5%	77,5%	100,0%
		% within any wrist pain at CL?	100,0%	100,0%	100,0%
		% of Total	22,5%	77,5%	100,0%

Table B.15

what is done against wrist pain at CAEL?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	pull the keyboard towards oneself	1	1,4	1,4	1,4
	to turn and change keyboard's directior	1	1,4	1,4	2,8
	move the fingers	3	4,2	4,2	7,0
	to stop	5	6,9	7,0	14,1
	other	4	5,6	5,6	19,7
	1&3&4&5	1	1,4	1,4	21,1
	3&5	1	1,4	1,4	22,5
	said no to the previous question	55	76,4	77,5	100,0
	Total	71	98,6	100,0	
Missing	System	1	1,4		
Total		72	100,0		

Table B.16

what is done against wrist pain at CL?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	to pull the keyboard towards oneself	1	1,4	1,4	1,4
	to remove the keyboard far from oneself	1	1,4	1,4	2,8
	to move fingers	5	6,9	7,0	9,9
	to stop	3	4,2	4,2	14,1
	other	1	1,4	1,4	15,5
	4-5	1	1,4	1,4	16,9
	2-3-4	2	2,8	2,8	19,7
	1-3-5	2	2,8	2,8	22,5
	who said no to q67	55	76,4	77,5	100,0
	Total	71	98,6	100,0	
Missing	System	1	1,4		
Total		72	100,0		

Table B.17

GENDER * comfort evaluation of the desk at CAEL Crosstabulation

			comfort evaluation of the desk at CAEL					
			extremely comfortable	comfortable	indecisive	uncomfo rtable	extremely uncomfort able	Total
GENDER	female	Count	5	10	15	3	3	36
		% within GENDER	13,9%	27,8%	41,7%	8,3%	8,3%	100,0%
		% within comfor evaluation of the desk at CAE	71,4%	58,8%	53,6%	50,0%	27,3%	52,2%
		% of Total	7,2%	14,5%	21,7%	4,3%	4,3%	52,2%
	male	Count	2	7	13	3	8	33
		% within GENDER	6,1%	21,2%	39,4%	9,1%	24,2%	100,0%
		% within comfor evaluation of the desk at CAE	28,6%	41,2%	46,4%	50,0%	72,7%	47,8%
		% of Total	2,9%	10,1%	18,8%	4,3%	11,6%	47,8%
Total		Count	7	17	28	6	11	69
		% within GENDER	10,1%	24,6%	40,6%	8,7%	15,9%	100,0%
		% within comfor evaluation of the desk at CAE	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	10,1%	24,6%	40,6%	8,7%	15,9%	100,0%

Table B.18

GENDER * comfort evaluation of the desk at CL Crosstabulation

			comfort evaluation of the desk at CL					Total
			ext. comfortable	comfortable	indecisive	uncomfortable	ext. uncomfortable	
GENDER	female	Count	4	16	13	2	1	36
		% within GENDER	11,1%	44,4%	36,1%	5,6%	2,8%	100,0%
		% within comfort evaluation of the desk at CL	80,0%	57,1%	68,4%	25,0%	11,1%	52,2%
		% of Total	5,8%	23,2%	18,8%	2,9%	1,4%	52,2%
	male	Count	1	12	6	6	8	33
		% within GENDER	3,0%	36,4%	18,2%	18,2%	24,2%	100,0%
		% within comfort evaluation of the desk at CL	20,0%	42,9%	31,6%	75,0%	88,9%	47,8%
		% of Total	1,4%	17,4%	8,7%	8,7%	11,6%	47,8%
Total		Count	5	28	19	8	9	69
		% within GENDER	7,2%	40,6%	27,5%	11,6%	13,0%	100,0%
		% within comfort evaluation of the desk at CL	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	7,2%	40,6%	27,5%	11,6%	13,0%	100,0%

Table B.19

GENDER * usability evaluation of the desk at CL Crosstabulation

			usability evaluation of the desk at CL					Total
			ext practical	practical	indecisive	unpractical	ext.unpractical	
GENDER	female	Count	4	13	12	6	2	37
		% within GENDER	10,8%	35,1%	32,4%	16,2%	5,4%	100,0%
		% within usability evaluation of the desk at CL	80,0%	48,1%	57,1%	66,7%	25,0%	52,9%
		% of Total	5,7%	18,6%	17,1%	8,6%	2,9%	52,9%
	male	Count	1	14	9	3	6	33
		% within GENDER	3,0%	42,4%	27,3%	9,1%	18,2%	100,0%
		% within usability evaluation of the desk at CL	20,0%	51,9%	42,9%	33,3%	75,0%	47,1%
		% of Total	1,4%	20,0%	12,9%	4,3%	8,6%	47,1%
Total		Count	5	27	21	9	8	70
		% within GENDER	7,1%	38,6%	30,0%	12,9%	11,4%	100,0%
		% within usability evaluation of the desk at CL	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	7,1%	38,6%	30,0%	12,9%	11,4%	100,0%

Table B.20

GENDER * usability evaluation of the desk at CAEL Crosstabulation

			usability evaluation of the desk at CAEL					Total
			ext. practical	practical	indecisive	unpractical	ext. unpractical	
GENDER	female	Count	3	14	14	5	1	37
		% within GENDER	8,1%	37,8%	37,8%	13,5%	2,7%	100,0%
		% within usability evaluation of the desk at CAEL	60,0%	60,9%	58,3%	41,7%	16,7%	52,9%
		% of Total	4,3%	20,0%	20,0%	7,1%	1,4%	52,9%
	male	Count	2	9	10	7	5	33
		% within GENDER	6,1%	27,3%	30,3%	21,2%	15,2%	100,0%
		% within usability evaluation of the desk at CAEL	40,0%	39,1%	41,7%	58,3%	83,3%	47,1%
		% of Total	2,9%	12,9%	14,3%	10,0%	7,1%	47,1%
Total		Count	5	23	24	12	6	70
		% within GENDER	7,1%	32,9%	34,3%	17,1%	8,6%	100,0%
		% within usability evaluation of the desk at CAEL	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	7,1%	32,9%	34,3%	17,1%	8,6%	100,0%

APPENDIX C

A CHECKLIST FOR PREVENTING POSTURAL RISKS AT CWS MEDIUMS

Things to look for:	Possible solutions:
Elbows splayed out (shoulder abduction)	Lower work surface Lower chair armrests Bring chair armrests in closer Awareness and habit training
Raised or tensed shoulders	Habit or tension training Lower work surface or keyboard Lower chair armrests Raise chair, if foot contact with the floor can be maintained
Twisting the head to the side	Bring viewed item closer to mid line of view
Wrists bent to the sides when using side keys	Habit training Keyboard with more accessible keys
Wrists bent back (extended) or forward (flexed) for prolonged periods	Habit training Wrist rest Lower, raise, or change slope of the keyboard
Wrists or palms resting for long periods on hard or sharp keyboard or work surfaces	Habit training Wrist rest Padded or rounded surfaces, corners
Rapid, sustained, or prolonged keying	Greater work variety Aggressive break schedule
Prolonged mouse use	Greater work variety Aggressive break schedule Alternate hands Alternative pointer devices Arm support, including small table Mouse close to body (extended keyboard tray) Learn keystroke substitutes for menus

Prolonged sitting, especially in only one posture	Greater work variety Aggressive break schedule Chair that supports posture change, through movement, size, or easy adjustability Habit training Check chair fit Monitor in-out mechanism Sit-stand work surface
Lumbar back area not supported	Lumbar cushion Backrest height and tilt Check chair fit, especially backrest/lumbar height
Feet dangling, not well supported, or a posture which seems to put pressure on the backs of the thighs	Lower chair Lower work surface Habit training Foot rest (last resort)
Chair backrest not used for long periods	Check chair fit, especially seat pan depth and height Check leg room Check monitor distance Habit training
Twisted torso	Rearrange work Provide more knee space U-shaped work surface layout Swivel chair
Frequent or prolonged leaning or reaching	Rearrange work Mouse pad wrist or forearm rest Bring mouse and keyboard closer to body
Working with one or both arms "reaching" toward a mouse or keyboard	Bring keyboard closer to body Mouse pad wrist or forearm rest Bring mouse closer to keyboard
Light sources that are in the line of sight	Cover or shield light sources Rearrange work arena Lower other viewed objects to lower field of view
Reflected glare on the screen	Shield light sources Shade screen Glare screen Move monitor so light enter from side angle, not back Lower light levels Move light sources

Too much contrast between screen and surroundings or document; user feels relief when bright areas are shielded	Lower ambient light levels Turn off or dim task lights Change screen polarity to black on white
Monitor closer than approximately 40 cm	Push monitor back Habit training for reclining Bring keyboard forward, possibly with a slide out keyboard tray
Different viewed objects (screen, documents) at different distances from the eyes	Use document stand or otherwise equalize distances to within about 10 cm
Screen or documents not oriented perpendicular to the line of sight	Change monitor, document stand angle
Prolonged near focusing throughout the day with few far-focusing opportunities	Habit training Rearrange space to provide view
Monitor image dim, fuzzy, small, or otherwise difficult to read	Upgrade monitor Use software to enlarge image
Forward position of the head (peering) or squinting	Check for monitor image quality problems or monitor distance Suggest the student gets their eyes checked.
Eyestrain complaints	Check all aspects of visual environment Suggest consultation with vision specialist
Neck extended backwards, head tilted back, even slightly	Remove CPU from under monitor Remove tilt-swivel base from monitor (leave ventilation space)
Neck flexed (downward)	Raise document or monitor to a comfortable height Adjust posture Habit retraining

CURRICULUM VITAE

Fatma Pınar Yalçın, was born in 1975. In 1993, She graduated from Kadıköy Anatolian High School. In 1997, she had her under graduate degree from Istanbul University, Landscape Architecture Department. In 1997, she began her MSc. Degree at ITU Industrial Product Design Department. In 1998 she began to work as a research assistant at the same department. She is still a research assistant at this department.