Ergonomics in the Office Environment: A Review

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***Abstract*—**The evolution of "office ergonomics" has been largely due to rapid growth of information technology. Nowadays most of the offices are based on the concept of non-territorial or free address offices in which a given desk, office or workstation is intended to be used by different people at different times. Ergonomics in the office environment ranges from business process analysis to workplace design including furniture, equipment, computer systems and environmental factors. Recently in the office, there has been a significant increase in the number of injuries due to over-exertion and repetitive strain. In this paper an attempt has been made to give deep insight of office environment ergonomics and workstation design issues applicable to flexible office work. With the passage of time flexible office design, has improved to eliminate as far as possible the undesirable effects without compromising the benefits and furthermore, to extend the range of potential benefits afforded by the presence of flexibility in the office. The paper gives the readers a broad overview of the different aspects of ergonomic issues applicable to office work and discuses worker health and safety relating to work performed using a computer as a workstation. However, most requirements are applicable to any office environment, which is considered prudent practice for the avoidance of ergonomic related injuries and losses. These advances will create a new era of office ergonomics that will provide considerable health and cost benefits to computer users. Ergonomics work design is best done by assisting users in making informed decisions to enhance efficiency at work, safety, health, physical and psychological well being of people at work or using facilities or equipment. Intensive use of computer and information technology for long periods of time in the office workplace calls for an examination of employee performance and possible work-related health and stress problems. It also provides an overview of a systems analysis tool using a macro-ergonomic approach to understand and identify problems and probable casual factors related to such office environments. Flexible office also provides a process for developing strategic and systematic solutions for solving problems arising in a computer intensive office environment. Reductions in weight and size of computer display equipment, along with advances in lift technology will allow creation of optimized office computer work environments that are substantially lower in cost and easier to set up in the future. The paper contains useful information for workplace practices and may be referred to by inspectors with the Ministry of Labor in performing their duties in enforcing the Occupational Health and Safety Act.*

***Keywords*—**Computer vision, human computer interaction, human factors, posture, user interface.

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I. Introduction

ERGONOMICS can be defined as the application of knowledge of human's characteristics to the design of systems. Many companies have contested the established view of office design and office work since the beginning of the 1990's. Most of the offices nowadays are based on the concept of non-territorial or free address offices in which a given desk, office or workstation is intended to be used by different people at different times. It is important that the management has a clear understanding that when transforming the office to support flexible work practices the primary focus must be on people's needs and behavior rather than on actual interior design. Based on experience from research performed in the United States [1] and Sweden [2], some critical factors for success of the office design process have been identified. These include: A clear identification of the project owner, projects that are productivity driven and not cost driven, identification and realization of benefits for the office staff, staff involvement in the process, all aspects of the project considered as a whole including the available space, interior design, information technology, organization, and working practices, good interior design and openness and flexibility to meet future requirements.

To succeed with an office design concept based on flexibility and openness requires a new and different way of looking at offices. The office must be regarded more as a tool, like any computer or telephone system, with the main purpose of supporting the business tasks. The organization of computer-based tasks has proven to have an essential impact on the comfort of the user. The environmental factors in the office environment also play an important role in ensuring comfort and efficiency in task performance. Reflections in video display terminal (VDT) screens, high indoor temperature, and disturbing noise levels are factors that could occur in cases of bad office planning. The negative impact of those factors must not be overlooked. Even though the computer hardware is designed according to the latest ergonomic findings, extensive keyboard input work could still cause muscular problem such as repetitive strain injury (RSI). Flexibility in work practices and work positions is essential to minimize health and safety risks. This paper presents a review of the effects of business process analysis approach to office design ergonomic aspects of the organization of office work, office environmental ergonomics, and workstation design tools. Extended work with computers can lead to muscular fatigue and discomfort, usually in the back, arms, shoulders and neck. As well, if the computer is used for prolonged periods in awkward postures, there is a risk of musculoskeletal

injury (MSI). This risk increases as the intensity of computer work increases. Frequently, the source of muscular fatigue and discomfort is the operator's posture while working at the terminal, and this posture is due in turn to the layout of the computer workstation and the furniture provided. The specific tasks and the intensity of the work are also factors. Computer operators may experience visual as well as muscular fatigue and discomfort. Symptoms include eyestrain, burning eyes, blurred vision and headaches. The layout of the computer workstation can increase the visual demands on operators, as can lighting levels and glare.

II. Flexible Office And Work Practices

One of the most important factors when carrying out a flexible office designs or redesign project is the awareness that it is a project of changes that primarily affects staff and organization and only secondarily a building project. One cannot easily transfer an existing office design from one organization to another. Instead every office must be created by and for its own staff organization. The business process analysis is therefore a fundamental element in the design of the flexible office. This emphasizes the need for a master plan – an office design process (ODP). This process could be described in several steps [3]. The staff members working in flexible and traditional office designs were asked to report the sensation of body strain. The "standard" report for people working in an office environment concerning the presence of body strain in neck and shoulders between 30 to 35 percent. In this case, the reported level in the traditional office design meets the expected value. The reported value from the flexible office design is much lower. There are no reports concerning strain in elbow, forearms, wrist, hands, or fingers from the personnel working in the flexible office design. One explanation is the increased flexibility in working positions that the furniture and work organization offer in this type of office.

A flexible office design offers more than just a nice interior. The changes in work organization/work behavior made possible by portable phones, client server computing, open plan office design, group work and telecommuting have made higher efficiency and better quality in office work possible [4]. Companies that have adopted this working style can present figures and facts that clearly demonstrate the advantages [5]. These include: More satisfied employees, decrease in sick leave time, decrease in staff turnover, up to 47 percent increase in working time availability, increase of net income (33 percent) and less costs for office space (50 percent). Five major activities, mainly standout for bringing out the significant organization changes that result in such numbers: A strong management encouraged staff involvement in the change process, a clear setting of objectives, a business idea in line with the change process, taking advantage of the organizational force that comes with the enthusiastic people, a change in management style from control to support and coaching. There are some prerequisites for this transformation, with modern information technology playing a vital part. Central storage of all common information, digital communication between staff members, strict routines for computer usage and ways of cooperation is factors that must be considered.

III. Office Environment Ergonomics

There is a continuous and dynamic interaction between people and their surroundings that produces physiological and psychological strain on the person. This can lead to discomfort, annoyance, subtle and direct affects on performance and productivity, affects on health and safety, and death. Discomfort in offices can be due to glare, noisy equipment, draughts, or smells. In the cold people experience frostbite and die from hypothermia. In the heat they collapse or die from heat stroke. People exposed to vibrating tools encompass damage to their hands. Performance can be dramatically affected by the loss of manual dexterity in the cold, noise interfering with speech communication or work time lost because the environment is unacceptable or distracting. Accidents can occur due to glare on displays, missed signals in a warm environment or disorientation due to exposure to extreme environment [6].

A. Office Lighting

Office lighting should meet a number of requirements to provide high-quality illumination. Low-quality lighting is tiring both physically and mentally. Even though inadequate lighting in most cases does not make vision impossible, the signals from the eyes to the brain can result in interpretation problems. Unsuitable lighting can lead to difficulty in concentration as well as in poor working performance. In addition it can also cause muscular strain as a result of the worker being forced to sit or stand in awkward positions. Lighting in offices must ensure sufficient high levels of illumination in requested areas, such as reading areas and computer operation areas. There must be no distracting reflections within the normal field of view, and specific requirements in respect to luminance levels should be met. Beside visual conditions, energy efficiency and environmental implications must be considered [7]. Visual conditions to be considered are- Illumination, placement of accessories in relation to workstation, glare luminance and luminance distribution, contrast reduction, color rendering and color temperature, reflecting factors, flickering, installation and electric and magnetic fields. For energy efficiency, special high-frequency operation lights, installed wattage and the total use of energy are of interest. Research work has shown that an installed wattage level of as low as < 10 W/m^2 still can maintain good ergonomics light quality.

Glare is caused by large differences in light levels within the visual field. The eyes try to adapt to these large differences and visual fatigue and discomfort may result. In addition, the computer operator may adopt a poor posture while trying to reduce the glare by changing his or her orientation to the screen. This may result in neck and back pain. There are three types of glare: direct, indirect and masking. Direct glare occurs when there are bright light sources directly in the operator's field of view. Windows are often a source of direct glare. Indirect glare occurs when light from windows or overhead lighting is reflected off shiny surfaces in the field of view, such as terminal screens, desks and other office equipment. Light from sources directly overhead causes masking glare on the screen, partly obscuring what the operator is trying to focus on. Ways of reducing both direct and indirect glare include the use of light-absorbing blinds or

curtains. Every workstation should have a task light. Because harsh light spots increase eye strain and fatigue, the lamp needs to have an antiglare screen that does not impede the lamp's ability to deliver a broad area of uniform low glare light across the immediate work surface. The lamp should have an adjustable arm that permits both height and angle adjustments. The lamp base needs to be weighted to maintain stability when the lamp is positioned at its extremes. Lamps can be purchased using halogen, fluorescent, or incandescent bulbs. Lamps are available that utilize a combination of fluorescent and incandescent. In general, the halogen lamps allow the user to better focus the light's energy on the work, but the light is harsh and generates more heat. The fluorescent lamp offers the greatest potential for providing the necessary light. Special considerations for the workstations in a new office are that the workstations (desks with monitors) can be pointed in different directions within the same area, and that they can also be placed at different heights. This influences the choice of light fixtures. It can often be difficult to shade ordinary fluorescent lights with lighting turned down to avoid direct glare from occurring at any angle. In this environment it is therefore appropriate to have well-shaped fittings, either turned down with a deep-lying light source or a fitting with 100 percent upturned light. In a good light environment, a combination of these fitting types is recommended. It is also appropriate to use fixtures capable of high-frequency operation, so that light flickers do not arise. Local lighting should be designed so that the local lighting that a nearby standing person has at his or her workstation will not blind a person sitting down at workstation. Anti-glare screens should be used only after other methods have proved unsuccessful. Although these reduce indirect glare from the screen, the mesh types also tend to attract dust, and some glass models create more reflections. This may increase visual demands on the operator.

B. Sound Level

Ambient sound levels should not be higher than 55 decibels (dBA). Sounds from conversation between colleagues and telephone conversations are the largest cause of disturbances in this type of environment, it is important in both the cases to apply a certain amount of telephone discipline. Simultaneously, great efforts are made to create an interior design equipped with the prerequisites for a good sound environment. The recommended reverberation time for office space is 0.4 to 0.6 seconds, and one method to manage this is to create many surfaces using sound absorbent material [8]. Examples of this are textiles on the walls and the ceiling, perforated slabs as an esthetic element in the office environment, plant arrangements, and so forth. It is especially important to have curtains in front of glass walls, since glass surfaces have low sound absorbency. The sound of steps is another source of disturbance, and one should consider using floor material with a muffling effect in the passage areas. Another method that has been tried is to use "white noise", that is, barely detectable music that reduces the worker's comprehension of what others on the premises are discussing.

C. Climate

Temperature and humidity should be within comfortable ranges. A relative humidity level between 40% and 60% is generally desirable for most workers in office environments. Under no circumstances should the temperature and humidity be allowed to vary by an amount greater than 20% over a one hour time period. A positive aspect that has emerged is that large air volumes in these types of premises create the environment for a good indoor climate. A necessity, however, is that all heat-producing devices such as printers and copying machines are placed in their own location, which should be well ventilated so that the heat from these does not have a negative effect on the overall climate. This is also advantageous in noise suppression, since these devices are often very loud.

D. Office Layout

The premises that make up the flexible office environment should not be planned so that they become too large when connected. Experience points to a group size of 15 to 18 employees per workstation, area of approximately 200 to 250 m^2 (2.150 to 2.700 ft^2) as being appropriate [5]. Within an area of this size one can still feel certain closeness and have a good general overview. It must be emphasized that several factors affect floor space accessibility per workstation or individual. Different businesses have different requirements, and the occurrence of tele-working and other out-of-office activities affects this. An analysis of business processes should be the basis for the planning of floor space utilization, and therefore one generally cannot determine a specific number of square meters (feet) per person. The design of the workstation is especially vital in a flexible office, where the adjustment of furniture to suit multiple users must be accomplished in a simple way. For instance, adjusting table heights must be extremely easy to accomplish.

E. Telephone Work

Increasingly, workers are required to use a keyboard while on the telephone. This often results in awkward head, neck and back postures with the receiver cradled between the shoulder and head to leave both hands free. Workers required to use a computer while on the telephone for long periods tend to experience discomfort, particularly in the head and back. In such cases, headsets should be used. Hands-free phones are also an option, where the office space and task are appropriate. A spacer or cradle that mounts to the handset is not a preferred option. Although it improves the head position, a static effort is still needed to hold the handset in place.

F. Personal

The office environment should be comfortable to the person utilizing the office. By comfortable, we mean mentally as well as physically. Pictures, plants, knick-knacks, etc., all have an important role to play in a proper work environment. An office worker's potential to obtain an ergonomic injury IS affected by their attitude toward their job and their surroundings [9]. While this is very important, it is also important to understand that many of these personal "touches" bring on their own set of problems. Pictures reflect light. Watering plants near electrical outlets or devices is unsafe. Knick-knacks attract dust. Encouraging the office worker to bring a little of their home to the work place is a good thing. However, it is a good thing that needs to be managed with

both individual and group safety as the ultimate arbitrator. Office workers should be encouraged to take rest / exercise / change of task breaks. A common recommendation is 2 to 3 minutes off every 30 minutes. Keep in mind that sitting in a chair is a repetitive task.

IV. Workstation Design

There is no such thing as an "ergonomic working position". Workplaces and work organizations that support flexibility also support good ergonomics. The ability to alter one's position by sitting, standing, walking, and even lying down in a working situation is healthier than sitting continuously with 90 degree angles in knees and hips. Tables that are adjustable to meet working height of both sitting and standing positions; telephone and computer systems accessible all over the office; and comfortable, lie-down chairs in quiet areas are examples of designs that support good ergonomics [10], [11]. Instead of referring to measurements regarding width and depth of tables and other office furniture, the basis for furniture requirements in this paper is the user and the user's task to perform.

A. Working Surface

Working surface will then be defined as the width a user needs to accomplish a certain task. The width requirement is based on working on the task working with VDT (Visual Display Terminals) using a keyboard and an input mouse. It is important to have space available for the mouse/input device on both sides of the keyboard. The depth of the work surface will then be based on the required viewing distance in relation to the screen size. For displays based on the CRT technique there is a relationship between screen size and the depth of the housing. There is also a relationship between character size and the size of the screen. In both cases this means that for a bigger screen a greater depth is required. Experience from flexible office environments shows that some types of furniture is more suited types than others to encourage and facilitate flexible work practices [12]. Examples of such furniture follow-

B. Balanced Tables

The balanced table is very appropriate for use as a worktable, since it can easily be adjusted to different heights. To work well, balanced tables must be able to be adjusted; so that they balance the load placed on them. The desk surface can be designed so that size and shape will specially accommodated the equipment and tasks to be performed.

C. Chairs

To meet the requirements of flexibility, one chair per person is not enough even though certain chair is fully adjustable regarding sitting height, width and so forth experience shows that people very seldom change the initial settings [13]. To offer each employee a set of different chairs that support differences in sitting style will contribute to increased health and safety.

Chairs should have the following features –

- *Seat height*: Must adjust to allow the user to place the feet firmly on the floor or a supportive footrest; assuming an adjustable work surface height, an adjustment range of 380-520 mm (15 - 20.5") will allow 90% of potential users to find a comfortable sitting height while wearing shoes.
- *Seat pan depth*: Must be such that the user can maintain contact with the backrest in the lumbar area and avoid increased pressure on the back of legs and behind the knees; seat pan depth should be less than 430 mm (17") and there should be space, about the width of a clenched fist, between the front of the seat pan and the back of the knees horizontal adjustment of the backrest is an excellent feature to permit changing the effective seat pan depth - a good range of seat pan depth is 380-430 mm (15 - 17") - a backrest like this will permit all but the shortest 5% of users to have adequate back support while seated.
- *Seat pan*: should have a "waterfall" or rounded front edge to minimize pressure on the back of the legs.
- *Backrest*: Should provide good contact and support for the lumbar region of the user's back; the backrest should be vertically adjustable the backrest should have a height of 380-540 mm (15-21") and a width of 350-480 mm (14-19") the backrest tilt angle may be fixed, adjustable or spring-tensioned; if fixed, an angle of 103 +/-1 degrees is suitable; if adjustable, a range of 95-110 degrees is usually sufficient; the force of a spring-tensioned reclining backrest should be adjustable to suit the user's needs.
- *Adjustable armrests*: Adjustable in both the horizontal and vertical planes which can provide light arm support are recommended for moderate and intensive computer users - armrests should not impede access to the work station or arm movement.
- *Five-pronged chair base with casters*: For stability and easier mobility; the ability to swivel 360 degrees and move the chair around improves access to work materials, eases sitting down and standing up and reduces twisting stresses on the spine; appropriate casters for the surface (hard casters for soft floors or soft casters for hard floors).
- *Seat cushion*: should have minimal contouring to allow easy shifting of position and there should not be any local pressure points such as buttons or prominent seams.

V. ADDITIONAL OFFICE FURNITURE

The rolling cabinet is appropriate to use when the work is characterized by flexibility and when the staff person does not have a fixed workstation. The surface area of the rolling cabinet is often used as an extension of existing table surfaces, which means that the "desk" height is controlled by the work height. This is naturally not good from an ergonomic point of view, and therefore the table surface of the cabinet should be introduced as an unloading area.

A. Displays

The evolution of "office ergonomic" has been due largely to the rapid growth of information technology [14]. Factors concerning display ergonomics are related to the physical design of (VDT's) as well as user interface design aspects of the software. The software should be based upon usability factor. One of the main factors that affect performance and comfort is the image quality of monochrome as well as multicolor displays. Good image quality is a multi-factorial issue, dependent on character design, phosphorus quality (for

CRT-based displays), and overall technical quality of the display.

Flat panel technology will enhance the possibilities to arrange work places using proper ergonomics. The easier positioning of the flat display gives more flexibility both regarding the use of the furniture and for the user.

The guidelines for use display unit in office environment:

- The work surface should be chosen to complement the task being performed and be able to accommodate the tools and space required.
- Moderate and intensive computer users should sit directly in front of the monitor and keyboard/mouse.
- Lateral viewing boundaries should not exceed 30 degrees either side of the body centre-line.
- The mouse or pointing device should be located next to the keyboard (as close as possible and at the same height) to minimize reach.
- The keyboard and mouse (or other pointing device) should be located at a height that allows the user's forearms, wrists and hands to be parallel to the floor (the surface of the keyboard should generally be lower than a typical writing surface in order to permit the best posture).
- Under desk adjustable height keyboard/mouse arms should be used to accommodate this need when the work surface height cannot be altered to accommodate this posture.
- An adjustment range of 600-730 mm (24-29") will allow most people to adopt a suitable arm posture for repetitive keying; if a single fixed surface is used, a work surface height of 720 mm (~28") is commonly recommended.
- Work surface height should provide adequate clearance for the operator's legs when seated in his or her most comfortable sitting position.
- Monitor viewing distance should be about arm's length away when seated comfortably in front of the keyboard.
- The computer screen should be positioned such that the top of the screen is about eye level or slightly lower (0 to 60 degrees below eye level is usually suggested).
- Individuals who wear bifocals and trifocals may need to place the monitor lower than this to maintain comfortable (neutral) neck posture.
- Frequently used items should be stored close to the user but should only be on the work surface if they are in constant use.
- Store heavy items close to minimize lifting, reaching, twisting or carrying.
- The screen height should be easily adjustable to accommodate gender height differences and the operator's personal preferences throughout the day. Further, the viewing height should allow the operator to view the monitor screen within an orthopedically correct "viewing cone" to minimize musculoskeletal stress disorders (MSD's).

B. Keyboard

Keyboard layout, key functionality, and design are all essential factors that contribute to user productivity and comfort. Other factors such as thickness of the work surface supporting keyboard and overall layout of the workstations have implications on the comfort of the users. Low-profile keyboards with a proper tactile feedback are suitable for most users. However extensive keyboard work, (i.e. several hours per day) is not recommended due to the fact that even limited muscular stress could cause muscular problems if exaggerated. Keyboards should be placed at a height that allows the operator to operate the keyboard with the forearms level and hands sloping slightly downward. A negatively tilting keyboard, allowing the operator to "keep the wrinkles out of the top of the wrists" is ideal. Fore and aft positioning of the keyboard should be consistent with allowing the hands to move easily over the keyboard with forearms level and elbows at the sides, maintaining a 90° - 120° angle between upper and lower arms.

C. Portable Computers

Since the keyboard and screen on a portable computer (also called a laptop computer) are attached, it is often difficult to position the computer to get a comfortable posture for both keyboarding and viewing. Either the keyboard is too high or the screen is too low. The importance of optimum posture increases as the duration and frequency of computer use increases. Awkward postures can be tolerated for short periods of time. Laptops are not ideal for extended periods of use; however, they are increasingly used in this manner. Laptop computers have several advantages for users in terms of being lightweight and highly portable, but these desirable design features present inherent ergonomic problems when moderate and intensive computer users use these devices extensively. Because the keyboard/pointer and the screen are attached, postural compromises are unavoidable. Short-term, infrequent use of laptops is not problematic but if a laptop is being used in one location for extended periods of time, then it is not the right tool for the job. If a laptop needs to be used in one location regularly for any length of time, a separate monitor or keyboard and mouse should be provided at that location**.** In addition, moderate and intensive laptop computer users need to be very aware of their keyboarding posture (avoid bending and resting wrists on the edge of the laptop, for example). Below are some good practices. For general use, place the laptop on a flat surface with the screen tilted back 110-150°. If desk use is extended some additional equipment should be used. As the keyboard and screen are attached it makes it difficult to optimally position the computer for suitable typing and viewing conditions. Ideally, a docking station or port replicator with a separate monitor, keyboard and mouse should be used. However, another option is to use a separate keyboard and mouse, then raise the laptop such that the screen is in an optimal position for viewing to avoid excessive neck bend (viewing angle of not more than 15° down). Bifocal users should take extra care to position the screen to allow viewing without awkward head positions. Take short "micro-breaks" frequently. Focus on a distant object for a few seconds. Avoid prolonged periods of use. Optimize viewing conditions. Maintain a comfortable viewing distance (in the range of 40-74 cm). Font size can be adjusted to allow the laptop to be placed for both good viewing and a comfortable body position. Place laptop to minimize glare from lights and windows Adjust brightness and contrast to suit

lighting conditions. Keep screen clean. Have regular eye examinations and inform your eye care provider of your computer use. The Health and Safety Guide provided with the computer should be referenced.

D. Mouse and Other Input Devices

The WIMP-concept (Windows, Icon, Menus, and Pointing Device) is commonly used today. It is easier task to choose an object than to remember a certain action command- especially human computer communication tends to become more intense and time consuming. Ergonomic aspects of pointing devices (mouse, trackball, joystick, tablets) have been well studied. The most common input device, the mouse, could, in a bad workplace design, give the user muscular stress problems. This problem has been addressed in a number of technical studies as a substitute to using shortcut commands on the keyboard. Different input devices present different characteristics regarding speed, accuracy, and preference. The right approach is not to attempt to identify the best input device in general, but to classify input devices based on the task to be performed. Common activities are "choose objects, drag objects, change orientation of objects – rotate and data input." Classification can also based on "learn-ability, effectiveness, speed, accuracy, attitude, benefits versus cost (in terms of fatigue, stress, frustration, discomfort and flexibility)."The usage of input devices can cause muscular stress in the hand/arm/shoulder regions. These effects are the combined results of the design of the input device, workstation layout task, and individual applications. Input devices such as computer mouse, trackballs and digitizing tablets are used to perform a variety of types of computer work ranging from word processing to computer aided design (CAD). There are a number of types and styles of devices. For example, some mouse now has scroll buttons. Mouse settings can also be adjusted for left handed users and to change the speed and distance of mouse travel and clicking actions required. It is important that users and purchasers of computers are aware of the range of devices and settings available, to determine which are most appropriate for their application and use. Even with the appropriate device, poor positioning can lead to problems. Users may hold the arm they use to control the device in a fixed, raised or outstretched position. This results in static loading of the shoulder and in bent wrist postures that contribute to discomfort and risk of injury. A mouse or a tablet should be placed as close to the worker's side as possible at a height that allows the upper arm to hang relaxed from the shoulder with a "neutral" wrist position, with the hand in line with forearm. This position causes the least physical stress. The mouse should be also placed so the cord and items on the desk do not limit movement. If a keyboard/mouse platform is used, take care that it allows the mouse to be placed as close to the keyboard as possible (at the same height and in the same plane), and that it provides a stable surface of sufficient size. At CAD and other workstations where work is done with one arm for long periods, the forearm should be supported by a desk surface to the side of the operator or by adjustable armrests on the desk or the chair. This support is necessary to reduce static loading. The mouse or other hand-held input device should not contribute to cramped hand postures. This may require consideration of different-sized devices for different hand sizes. The device should be shaped so as to minimize bent wrist postures, or, failing that, the forearm should be supported on a raised smooth surface to allow a comfortable wrist posture. The mouse buttons should be located so as to avoid awkward finger and hand postures. The activation force (the force needed to make a button click) should not be so great as to cause fatigue. But it should not be so little that buttons can be clicked inadvertently since users will then tend to hold their fingers up away from the buttons, causing static loading of the muscles. Users should be encouraged to hold the mouse in a relaxed way, not to grip it tightly, and to move it from the shoulder rather than just the wrist. This better distributes muscular demands and reduces wrist movements and static loading. Ergonomics studies [15] have also shown that anthropometric difference related to gender are factors relating to muscular stress. The conclusion is that it is not possible to choose "the right input device" without taking the context of use into consideration [16], [17].

VI. Standards And Guidelines In The Office Ergonomics Domain

Standardization plays an important role in the field of ergonomics, as it is an important channel to bring knowledge of ergonomics and human factors to industry. There is a difference between technical standards that must deal with a dynamic technical development and ergonomic standards that are based on human abilities and limitations, factors that are more constant over time. Among standards regarding the aspects of ergonomics in an office environment, ISO 9241 and ANSI/HFS 100-1988 could be referred. Standards and guidelines are useful, but there are limitations. They are helpful in making designers and technicians aware of the ergonomic and human factors aspects of product design and in providing support in solving ergonomic requirements established in the process. While the workstations described above the recommended adjustable mounting hardware are designed to address the average range of workers, with some modification the suggested workstation designs can provide a satisfactory workspace environment for the 5% female to 95% male range of seated office workers. Addressing the average male to 95% male range of office workers who are typically 68.3" (173cm) to 72.8" (185cm) tall and who have 48.6" (123cm) to 52.1" (132cm) sitting eye heights [18]. Addressing the average Range of operator's workstation design provides an optimum ergonomic computer work environment for a minimum of 50% and perhaps up to 60% of all workers in a typical office at an extremely low cost [19]. Design a sit/stand workstation for employees who require this type of work environment. Anthropometric Data can be used; to design a sit/stand workstation to address the average range of female to male operators requires a vertical adjustment range of 20" (508mm). To address the 5% female to 95% range of operators requires a vertical adjustment rage of 27.8" (706mm). However, standards and guidelines are by nature relatively limited and general. This gives a wide range for interpretation, and designers must use their own judgment, based on previous experience, when addressing ergonomic principles in a given design task [20].

VII. Conclusion

Flexible office (i.e. offices where people, employees, and consultants work sporadically) will increase in number from the year 2020 onwards. Mobility of the labor market less rigid terms of employment, and work carried away from the office in different forms will create such demands for changed office design and changed working methods that the traditional office structure of today will no longer be able to compete. From an ergonomic point of view, this puts demands on development of new furnishing systems. The furniture produced in recent years and used in flexible office today is not sufficiently well developed for future needs, either in terms of function or quality. Future Systems illustrates a sit/stand workstation that can be designed as a free standing system or integrated into an office cubicle or other office or call center work environment. This system features a 20" (508mm) vertical lift system which has the capacity to lift a work surface, monitor mount and keyboard mount designed as an integrated unit and can be dynamically adjusted to address the entire range of average sit/stand workers. Reductions in weight and size of computer display equipment, along with advances in lift technology will allow creation of optimized office computer work environments that are substantially lower in cost and easier to set up in the future. These advances will create a new era of office ergonomics that will provide significant health and cost benefits to computer users who work anywhere from homes, schools, and clinics to the largest of corporations (offices). The development of the flexible office and flexible work will be accentuated during the coming years and it is therefore of great importance that this line of development is allowed to take place based on ergonomic knowledge and principles.

Appendix

For detail ergonomic design of workstation, refer Appendix-I.

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Appendix I