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To the Graduate Council:

I am submitting herewith a thesis written by Sandra Louise Rudd entitled "A comparison of actual ergonomic usage using a statistical survey to prescribed ergonomic usage by experts." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

Robert E. Ford, Major Professor

We have read this thesis and recommend its acceptance:

John C. Hungerford, W. Wayne Claycombe

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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W. Wayne Claycombe

Accepted for the Council:

Interim Vice Provost and
Dean of The Graduate School

# A Comparison of Actual Ergonomic Usage Using A Statistical Survey to Prescribed Ergonomic Usage by Experts

A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

Sandra Louise Rudd
May 2001

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I would also like to thank the hundreds of individuals that completed the survey for me to be able to attain the needed data to complete this thesis. Without their support, this thesis could not have been finished.

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# Abstract

The purpose of this research is to show how factual data can be combined with statistical evidence to make people more aware of the fact that having knowledge of ergonomic workstation design is not necessarily the same as putting that knowledge to work and then to further show that continuous use of bad computer workstation habits can lead to permanent disability. A survey model is presented and used to validate the previous hypothesis of permanent disability occurring. There are 250 individual, anonymous surveys used in the data collection for the validation. The statistical evidence is then compared to the factual evidence presented in the literature review to show any differences or similarities.

This research represents an array of medical and professional people that have worked with or are currently working in the field of computer workstation ergonomics. The technique of statistical analysis was a major factor in determining the outcome of whether the computer workstation population is using the information supplied to them regarding the correct usage of computer ergonomics. The survey used to obtain the data for the analysis can be adjusted to fit any ergonomic professionals quest for data input. The outcomes will be dependent on how the input is arranged and the amounts of participants.

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# Chapter 1: Introduction

The computer workstation is a wonderful asset to any office environment. The office environment, however, is not the only place a computer workstation may be present. The most common environment is in the office, but there are many people that use a computer at home or various other places. Some of these people set up makeshift workstations in the home that consist of a kitchen table, a cart or just an old bench that has been lying around the house. Industry is also a culprit that makes use of tables, desks and other areas that are not specifically designed for computer users. On the other side of the computer workstation spectrum, there are a multitude of ergonomically designed workstations and accessories that lay claim to accommodate the ever-increasing ergonomic demand of the increasing hourly use of the computer user.

The posture of the computer user, at the workstation, is of extreme importance in maintaining a healthy body. There are several accessories that many computer users take for granted. Some of those would include a chair, a keyboard, and a mouse. Not only do the accessories play a large role in keeping the computer user healthy, but the lighting of the room and the surrounding color scheme may do so as well.

The computer workstation is not the only piece of equipment that may cause harm to the computer user. The human eyes can be injured in a variety of ways. One of those ways is through misuse of the workstation monitor. The computer monitor is usually not discussed at length when purchasing a new computer system, but there are items of interest to the user that should be noted. The main concern seems to be the size of the monitor, but this is hardly what should be given priority in the selection process. Some

of the factors that go into the choosing process would also include where the monitor will be placed when being used, the refresh rate, and the color quality. Injury to the eyes may cause other parts of the body to feel pain. This pain can confuse the user into thinking that their pain is being induced from an incorrect source. If the correct source of pain is not corrected, this can cause the user to try and correct the wrong injury, thereby letting the real culprit continue to cause harmful injury.

Headaches are a frequent complaint of computer workstation users that generally spend four plus hours per day at the computer. The main reason for the headache of a computer user is usually associated with some type of eye fatigue, but may be guilty of neck strain, as well. Hours of looking at a computer monitor with minimal breaks can cause muscles to tense and headaches to occur.

The FEB feels that electromagnetic rays are another cause for concern. [32] These invisible rays emanate from the computer monitor and form magnetic fields that can cause injury to humans. Unknown to most, the most harmful rays come through the sides and back of the monitor, instead of through the front. There are several symptoms that indicate overexposure to electromagnetic rays. They will be discussed in Chapter 2.

The most common type of injury by computer users is that of repetitive strain. Repetitive strain covers a large category and an even larger category when every ache and pain that is felt near the wrist is thought to be a repetitive strain injury. The fact is that many other parts of the upper extremities can cause pain that "feels like" a repetitive strain injury. The human body is a complex machine that involves many muscle groups, bone structures, tendons and nerves. A damaged nerve in the neck could have brought on

pain felt in the wrist. A shoulder with an overworked bursa can also transmit the feelings of pain down to the wrist.

The psyche of the computer user also plays a role in their health, not only while working at their computer workstation, but in all of their work time. Divorce, children, marriage and health related disabilities or problems could all factor into the ergonomic equation for maintaining a healthy body. Previous injuries and surgeries can affect a human working at a computer workstation as much as current injuries and surgeries can. The affect would be dependent on the specific injury or surgery.

The wonder of it all is that anyone can work at a computer workstation for hours upon hours a day, year after year, and not sustain some type of injury. Have no fear, it can be done, but it takes a certain degree of interest of the computer user to maintain a healthy work environment. When precaution is thrown to the wind, whether it is the fault of the user or the employer, serious repercussions can be expected.

**Objective**

The objective of this thesis is to show through research that although there is an abundance of suggestions, rules, ergonomic assessments and health and safety programs in use, that ultimately the computer workstation user will disregard this information and continue to sustain injuries. This will be compared with statistical evidence taken from a population of 250 adult volunteers that work at computer workstations.

**Scope of Thesis**

There are four major sections to this thesis:

Chapter 2: Review of literature on what experts and research are informing the computer workstation user to be the best possible ways to work for

extended hours at a computer workstation with minimal injuries. This includes detailed research information on specific parts of the human body in which injuries are most likely to occur for the computer operator.

Chapter 3: Presentation of the survey model that was designed for this thesis to show correlation between the expert research already done and statistical evidence showing how research and real-life practices do not always comply with one another.

Chapter 4: Discussion of various ways to put this statistical survey model to use in the ergonomic workplace. Discussions of further opportunities associated with research and improvements that can be done to better enhance the working situation of the computer workstation user and to have the computer workstation user become more involved in said improvements.

Chapter 5: Summaries and Conclusion

**Statement of Non-Disclosure**

The statistical survey model in this thesis was developed specifically for the research in this thesis. Due to the sensitivity of some of the material and/or questions asked in the survey, the surveys were completed anonymously. This study has been restricted by certain conditions that were beyond the researcher's control. The voluntary nature of the sampling has potentially limited the results of the study. It is possible that the attitudes of individuals not choosing to participate in the study differ significantly from those of subjects volunteering to participate. The sample might more appropriately be termed an incidental sample, in which subjects participate on the basis of availability

and willingness to cooperate. This factor may restrict the generalizability of the findings regarding subjects' attitudes

**Significance of Research**

The significance of using the statistical survey model specified in this thesis is that it can show the correlation between the prescribed uses of a computer workstation are not always used in actual practice. This non-use or misuse of ergonomic practical advice is resulting in the compounding amounts of computer users injuries. These injuries can become disabling. The statistical data retrieved from the survey used in this thesis serves as a tool that can be used to alert the world of computer workstation users that changes are to to be made to prevent further, permanent injuries.

# Chapter 2: Concepts and Literature Review

## Statistics of Computer and Related Injuries

More than 647,000 American workers in 1996 were exposed to serious injuries and illnesses. These injuries and illnesses were blamed on repetitive motion and overuse. They also accounted for 34 % of lost workday injuries with costs exceeding $50,000,000 in worker's compensation and indirect costs. [86] By the year 2000, it was estimated that 180 million computers would be in the office workplace and by the year 2005, no less than 50 percent of workers will be using computers. Over ten million Americans sought help for the eyes alone in 1991, blaming their computer related work. [12] The Bureau of Labor Statistics (BLS) reported that in 1998 there were 26,266 recorded incidences of carpal tunnel syndrome, 16,900 recorded cases of tendonitis, 42,353 recorded incidences of back pain and 101,599 recorded incidences of other related soreness and pain within the typing or key entry industry. These injuries had a median of 5 working days away from the job with one day being the least at 289,474 cases and the most being 3-5 days at 349,120 cases. [24] Sixty-five percent of those injured were women. Absenteeism is expected to run costs up to $450,000 annually in the white-collar work market with 500-750 man hours lost. Sixty-three percent of those absenteeism's are due to wrist, hand and shoulder injuries. Carpal tunnel syndrome, alone accounts for 36%of disabling injuries, with a cost of $15,000. [96] Disabling here refers to not being able to work.

The National Academy of Sciences (NAS) reported to Congress on scientific evidence showing that back injuries, carpel tunnel syndrome and other musculoskeletal

disorders (MSDs) can be caused from doing work. Of these disorders and injuries, about one-third can be blamed on overexertion or repetitive motion. The pain and disability caused from these injuries is costing the United States $20 billion in direct workers' compensation costs. This does not include indirect costs. Indirect costs were estimated to be as high as $45 to $60 billion each year. [84]

Arthritis and similar conditions affect an average of one in six Americans. Many people who have arthritis, also have upper extremity disorders. There are many cost effective ways to intervene and prevent further disability, but they are currently underused. [71]

Work related musculoskeletal disorders (WMSDs) might severely injure a worker. Depending upon the damage done, a person may never be able to return to their current job. Simple tasks such as combing hair could be extremely difficult. Most injuries arising from computer workstation use are either from repetitive strains, back injuries, neck injuries, wrist problems, tendonitis and/or vision problems. There are over a hundred different injuries that can result from repetitive motion injuries. In 1998, the National Institute for Occupational Safety and Health (NIOSH) conducted an in-depth analysis of 600 epidemiological studies and found "compelling scientific evidence of a consistent relationship between musculoskeletal disorders and certain work related physical factors." The panel of analysts included scientists and ergonomists from academia, government and private practice. [86]

Employee compensation for eye care can run up to $300,000. Computer Vision Consulting (CVC) states, "A 1% improvement in work efficiency is worth $300. Eye

care can be provided for considerably less than this – and will likely result in much more than a 1% increase in productivity." [13]

Most professionals that use a keyboard can type at least 40 words per minute. This equals to a maximum of 12,000 keystrokes per hour and 96,000 keys in an 8-hour day. Approximately 8 ounces of force is necessary to press one key down, and that would be equivalent to 16 tons of force being exerted by a computer operator each working day! Not only that, but strength loss in the hand occurs after only four hours of using a mouse. [88]

The number of people that are increasingly using computer workstations or some makeshift station is rising at an exponential rate. The use of computers has gone from a primarily business based usage to one of which one can almost find a computer on every desk in any office type environment. In fact, 90 percent of businesses in the United States use computers, with 40 percent of those businesses using a computer over four hours a day. Nineteen percent of these people will use a computer at home for either work or personal use. [89]

**The Computer Workstation and Ergonomics**

The same ergonomic principles apply whether working on the job or at home, and with more of the workforce being able to work from home, the safety of the computer user is quickly becoming a valid concern. If a business or a person owns a computer, they need to have somewhere to operate it. In most places, this is called a computer workstation, and this workstation has definite characteristics. These basic characteristics would include, but are not limited to: a desk, a chair, a central processing unit (CPU), a

monitor, a keyboard, and a mouse. These are not the only factors in equating the formula for a healthy work environment. There is also the lighting, the environment and the overall health of the computer operator.

It would be unnatural to think that with all these factors involved, no injuries would evolve, but with good ergonomics many injuries can be avoided. OSHA defines ergonomics as "the science of fitting the job to the worker". Ergonomic guidelines have been put into place to try to assure the safety of the computer operator while at their workstations. These are only guidelines though, and not specific rules or laws. One reason for this is that OSHA has presently decided not to use the "one size fits all" approach to mandate specifics of computer workstation use. Their reasoning for doing this is that they could not devise one formula that could definitely state that there will be Y number of injuries if doing X number of repetitions. Moreover, they could not say that not doing X number of repetitions would prevent anyone from having occupational injuries. [84] If the ergonomic guidelines were to be feasible, the anthropometrics of each computer operator would have to be known and the workstation designed specifically per operator. To determine the correct dimensions for only one part of the body could at the same time deter the correct use of another part of the body. Therefore, each part of the body would need to be assessed per individual user.

Many companies and individuals rely on The American National Standard for Human Factors Engineering of Visual Display Terminal Workstations (ANSI/HFES 100-1988) for ergonomic guidance. These guidelines were designed around the human body in an upright sitting position, often referred to as the 90-90-90 posture. What most people

do not realize is that these guidelines are not intended for a prolonged working posture. [31]

The design of the typical computer workstation takes into account various aspects of the human body. Several of these are shown in Figure 2-1

**Posture at the Computer Workstation**

The 90-90-90 degree posture is thought to have been brought into circulation during the 1880's, by a Prussian orthopedic surgeon by the name of Staffel. The posture was not induced by scientific methods, but rather by the militaristic culture during this time period. The military promoted stiff, erect bearings.

The 90-90-90 degree working posture is defined as having a right angle at each of

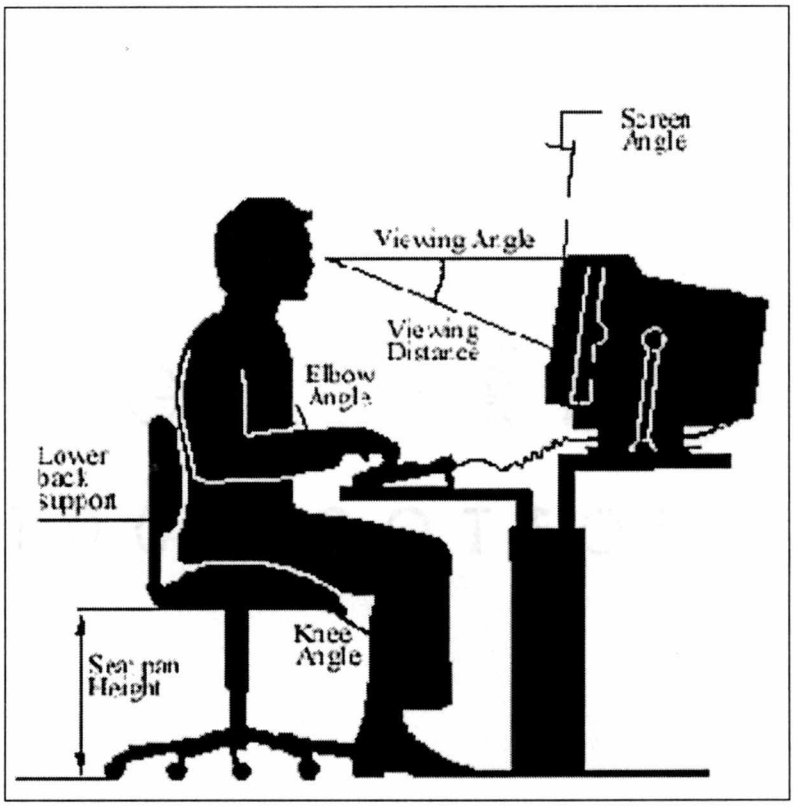



Figure 2-1 Computer Workstation [63]

the knees, hip joints and elbows. This means that while sitting at the computer workstation, the operator is to have the arms level with the keyboard with the elbows at 90 degrees, the body sitting in an upright position with the hips at 90 degrees, and to have the feet flat on the floor with the knees at 90 degrees. MacLeod believes that a better-suited posture would be where the angles at the hips and knees are 120 degrees, thus allowing less pressure on the discs in the lower back. In fact, the hip joint has been shown to accommodate better when at an angle of greater than 90 degrees. [67]

As one can imagine, most people deviate from the right angle positions quite often. This deviation allows the body to lubricate itself in the joints, thereby reducing the probability of stiffness occurring. Even so, the joints tend to not lubricate, as much after puberty and caution should still be heeded. [96]

**Furniture and Accessories of the Computer Workstation – How Safe are They?**

The workstation furniture should allow for adjustments. The American National Standards Institute (ANSI) [19] guidelines state that the desk, table or cart should allow enough room for the knees and the rest of the body to maneuver comfortably; this is usually a height of 26 to 28 inches from floor to desktop. The edge of the desk or table should also be taken into consideration. When an operator continually leans on the edge of the desk with their forearms, a contact trauma can be created. This traumatizes the nerves, blood vessels, and muscles, leading to pain in those respective areas. [85]

The keyboard should be within easy reach of the operator's hands without having to reach up to type and preferably include a wrist rest. [16]

The chair is also of importance to healthy posture. One of every four dollars is spent on computer workstation seating. After sitting at a computer workstation for eight hours, spinal compression has been demonstrated to be from a quarter to three-quarters of an inch. The chair must be adjustable in the height, pan and back and be adjustable to fit the 5th percentile woman and the 95th percentile man. [96] The distance from the top of the seat pan to the bottom of the desk surface should be 11 inches with 24-32 inches horizontally at each of the knees and ankles. The seat pan should be a minimum of 18.5 inches wide and padded. The backrest should provide support between the L3 and L5 vertebrae. The lordosis, also called swayback, is an exaggeration of the forward curve of the lower part of the back. [68] The lordosis of the spine is restored this way, and the backrest in this position will help to assist the weight of the upper body, providing relief to the upper back. [85] It is also a good idea to have wheels on the chair and five chair legs for better balance and support. If the feet still do not reach flat on the floor, then a footrest should be used. Footrests are not discussed in further detail in this study. Some operators lean forward or sit forward in their chairs to be able to have their feet reach the floor. A contact trauma can be caused from this to the musculoskeletal system in the back of the legs, as well as cutting circulation to the lower legs, which can cause swelling and pressure to the sciatic nerve. This position also removes the pressure needed on the lower lumbar region of the back that is attained from the back of the chair. This in turn can lead to poor posture causing lower back pain. [85]

There are different views on whether or not to have armrests, but it is in agreement that the armrests should not be full length. Full-length armrests get in the way

of the chair being able to fit under the desk. This can cause the operator to have to lean forward to view the screen, creating fatigue and pain in the back and neck. [16] Operators that do not have any armrests should have them made available. [85]

The Visual Display Terminal (VDT) should also have an adjustable height. The VDT should be placed accordingly, depending on the individual's eyesight. The viewing size of the VDT should also be taken into account. The operator should be able to sit where his line of sight is looking downward at a 10-20 degree angle to the center of the screen. If the center of the screen is higher or lower than this, it can lead to incorrect posture. Document holders should be as close to the VDT as possible. This gives less distance for the eyes to focus back and forth. [16] The visual horizontal distance should be from 24 to 37 inches. [6]

The risks increase for injury as posture remains in a static position for longer periods of time. The same risks apply to repetitious movements. [85] For the same reasons that OSHA does not have specific guidelines concerning the correct formulas to prevent ergonomic injuries, Macleod can also state that there is no correct posture that is appropriate for an eight-hour workday; the body needs to be able to change its position frequently. [67] An eye level monitor and an upright backrest can cause the computer operator to accommodate to a variety of postures. Sometimes the operator will develop thoracic kyphosis (rounding of the shoulders and upper back causing the body to slump forward) from sitting at a computer workstation for too many hours without a break. This would in turn cause neck extension when viewing the monitor. [5]

Another common problem associated with incorrect posture while working at a computer workstation is back pain, specifically low back pain. The American Academy of Orthopaedic Surgeons report that four out of five people will experience some type of low back pain at some point in their lives. It is also the second leading cause of missed workdays in adults under the age of 45, costing a total of 16 billion dollars annually. Poor posture is not the only cause of low back pain – poor working habits can contribute to this pain as well. For someone that does not maintain a healthy posture while sitting at a computer workstation for four or more hours a day, low back pain is almost eminent. Stress tensions or emotional problems, although not a direct cause of low back pain, can be a factor in aggravating it. These people are usually very tense and this tenseness can increase muscle spasms in the back, thereby leading to increased pain. [4]

The Chicago Legal Net states that while back pain is a problem for computer workstation users, the U.S. Department of Labor reported that Carpal Tunnel Syndrome (CST) was the "chief occupational hazard of the 90's – disabling workers in epidemic proportions." This fact is further enhanced when Chicago Legal Net reported that over 80% of their Workers Compensation claims are women in the workforce. [29]

David Rempel believes that long uninterrupted hours at the computer can be a cause of CST and repetitive strain injuries (RSI), and that improper work habits and improper postures while working at a computer can put stress on the wrists. He further states that age, physical conditioning, hobbies and even our relaxation techniques can add to the problems of CTS. [93]

But, is the worker alone all that causes all these CTS injuries? Of course not. The worker does not simply sit at the workstation and injuries appear out of nowhere. One accomplice is the computer keyboard. There are several styles of keyboards and all claim maximum efficiency, but none can claim that they take into consideration the human needs and physiology of the computer workstation user. Most operators will force their arms and wrists into unnatural positions while typing. This causes inflammation of the muscles pressing against the median nerve that passes through a narrow sheath called the carpal tunnel. If the position of the wrists is not changed and the injury continues to be pursued, the results could range from intense discomfort to loss of hand function altogether. [27]

Most believe that CTS is an injury, but not everyone believes it is permanent. Alan Hedge is one of those who do believe that CTS can be a permanent injury. For the past five years, Alan Hedge has researched ergonomics at Cornell University and found that "repeated extremes of vertical wrist extension could put excessive pressure on the median nerve as it passes through the carpal tunnel of the wrist, and it is thought that eventually this impairs nerve function and ultimately results in injury." [51]

Roxanne Nelson disagrees with Hedge. She believes that the symptoms can be treated, even though the cause may be work related. Nelson's belief is based on a study presented by the American Journal of Orthopedics that found 82% of patients could return to work full time after being treated for CTS, while 18% could still work with modifications made to their jobs. Even more so, Alon Gary, M.D. of the University of

California at San Diego found that those treated surgically had an even better outcome than those who were treated non-surgically. [72]

The incidence rate of CTS of the general population is greater than 1.5%. The frequency of reported cases in high-risk circumstances, such as the high tech field of computer operators, are in excess of 25%. The cost of one person getting hurt can range from $3,500 to $50,000, including direct costs of treatment and lost wages. This may or may not include indirect costs of lost production, retraining and personnel replacements. [20] The repetitive action of typing at a computer workstation may cause a mechanical alteration of the carpal tunnel that interferes with the soft tissue structures within, most notably the median nerve. [87] These changes in orientation of the wrists and arms may be due to direct trauma, fluid imbalance, and hypothyroidism or from hormonal conditions, such as pregnancy and diabetes. [64]

Carpal Tunnel Syndrome is most likely the best-known computer related injury. With incidences increasing and the costs of recovery and treatment soaring, it is no wonder that so much time and effort is put into correcting the issues and problems surrounding this crippling injury. One of the items that can also cause a great deal of pain and disdain, but is given much less attention to, is the eye. It is for this reason that the eye will be discussed in greater detail.

**The Eyes – The Windows to the Well-Being of the Body**

The human eye is an intricate part of our body. Although a person can survive without sight, to do so would be extremely difficult. The eyes attribute to over 80 percent of the learning process. Even though the human eye has been

unchanged for the past 40,000 years, the past few hundred years may be changing that, or at least to some variation. Work has become increasingly close in distance as the human race goes farther into the technology era. [17] The human eye has many different mechanisms and each can play a vital part in how well the eye can withstand constant close range viewing. A graphic anatomy is represented in Figure 2-2. While all human eyes have the same basic characteristics and features, they do not all operate the same for each individual computer operator.

There is an assortment of various causes of eye problems associated with using VDTs. Some of the symptoms include, but are not limited to, the eyes becoming red, watery or dry. Fatigue can make the eyes can feel tired or aching. Sometimes glasses are necessary, even for computer operators that do not normally wear glasses. [3]

**Visual Display Terminal's and the Eyes**

VDT users are making the high visual demands increasingly aware to the eye care field. Corporate Vision Consulting conducted studies and concluded that 75-90% of

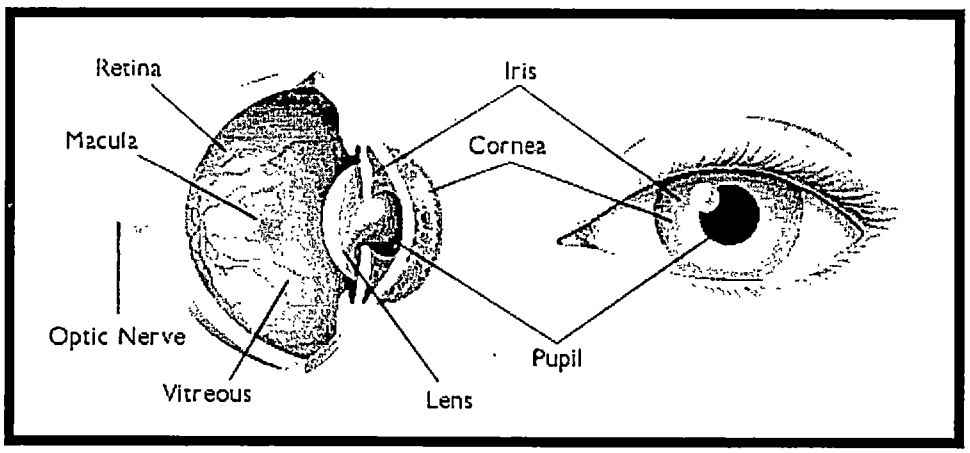



Figure 2-2 Anatomy of the Eye [2]

VDT workers complain of vision problems. The National Institute of Safety and Health (NIOSH) conducted similar studies and found that 22% of VDT workers also suffer from musculoskeletal disorders. Even though the number for musculoskeletal disorders is less, they are paid more attention to in the business world due to the much higher workers compensation cost associated with them over eye care. [13] A survey given by Corporate Vision Consulting specifically to optometrists indicates that 10 million eye exams are given in the United States due to VDT vision complaints. These complaints have been categorized and are known as Computer Vision Syndrome (CVS). The American Optometric Association states CVS to be a complexity of eye and vision problems connected with close work of computer operators. These symptoms are not always the same with each individual, but usually include: eyestrain, headaches, blurred vision, dry eyes, neck and shoulder problems, sensitivity to light and double vision. CVS is usually unnecessary and could have been avoided by the use of good visual hygiene. [9]

Dr. David Balfour, states that having 20/20 vision does not guarantee that CVS will not occur. He also says that poor workstation design is a cause for CVS. One reason for this is due to the peripheral vision. While the central vision is not very sensitive, the peripheral vision is. Therefore, as the electron beam scans back and forth across the screen creating an image, the central vision does not detect it, but the peripheral vision does. This shows up as a flicker. Flickering can make an operator grow tired, and even cause nervousness. It can even provoke a seizure in an epileptic operator. [22]

In the United States alone, over 600,000 patients per month complain to eye care professionals about computer related vision problems. The Computer Industry forecasted

that by 1997, over 70 million computers would be used in the workplace. And almost one-fourth of these patients would receive improper diagnosis and treatment. [97]

Eyestrain is a term that can mean different things to different people. The scientific term for eyestrain is asthenopia and is described to be the subjective complaint of uncomfortable, painful and irritable vision. There are 24 different variations of asthenopia, each one dependent on cause. Environmental and visual surroundings play a role for the VDT user in acquiring asthenopia. [9]

The term "eyestrain" is not necessarily a medical term used by the eye care professionals, but is most widely used by VDT users. While working at a computer workstation, there are several factors that can affect the eyes: lighting, fatigue, eyestrain, general overall health and the computer-viewing screen.

Reading from a VDT is not the same as reading from a piece of paper or a book. When one reads a book, the distance of reading is usually between fourteen and sixteen inches at an angle of close to 40 degrees. The eyes are accustomed to this style of reading. When trying to read from a VDT, the person must change his normal settings causing the muscles to struggle against one another to keep a good image. Computer Vision Consulting states that the center of the screen should be 7-10 inches below the horizontal sight line. [17] OSHA states that a good rule of thumb is to judge the viewing distance by the size of the text. "The size of the text needs to be three times the size of the smallest text you can read. This can be tested by viewing the screen from 3 times your usual working distance – you should still be able to read the text." [85]

The common trend in the workforce seems to be that there is no harm done to the human eye due to working at a computer workstation. Research at IBM concludes that VDTs cannot be connected to any type of eye disease. This is not to say that there is no discomfort associated with improper use of VDTs, just that it is not permanent. A National Institute for Occupational Safety and Health (NIOSHA) conducted studies as well and concluded the same outcome. Hours worked per week and years worked at a computer workstation were taken into account during NIOSHA's study. [61] IBM further states that there is no medical evidence proving that normal office environments can damage the eye. [60] Here, the term 'normal' is subjective to IBM and not described in detail. The American Academy of Ophthalmology has agreed that although there is no evidence to convince them of VDT being harmful to the eyes, the fact remains that discomforts such as fatigue, burning, and dry eyes are becoming more common. This is in itself a cause for concern. Even the concern of exposure to the levels of radiation produced by monitors has not shown to cause lifetime damage to the eyes. [3]

Because the eyes can affect so many parts of the body, a further discussion is required specifically for injuries associated to and with the eyes. And before going any further into the discussion of injuries to the eyes, some functions and aspects of the eyes themselves should be discussed. The eyes are equipped with muscles. There are both internal and external muscles. Focusing and pupil size are managed with the internal muscles and the external muscles are responsible

for directing the eyes to a point of interest while keeping the retinal image in constant motion. The external muscles must work together to maintain a clear focus. [59]

Two sets of muscles control pupil size. The sphincter pupillae muscles cause the iris to close as light is increased and makes the pupil smaller, while the dilator pupillae muscles cause the iris to open as light is decreased, making the pupil larger. Small movements of the eye are called saccades and movement from one point to another is called version. These two muscle groups operate at different speeds and are controlled separately.

The size of the pupil is also of importance. "Pupil size is a function of the weighted average of the luminance (popularly called brightness) within the field of view." [57] IBM found that viewing distances at computer workstations cause larger pupil sizes than do the luminance levels, as could be characterized by the logarithmic graph in Figure 2-3. A person can reach a point where increasing the level of light to the pupils does nothing to improve visual acuity. [92]

Working at a computer workstation and having a VDT that is constantly changing colors, may cause stress on the eyes. The pupil being forced to constantly change size causes this stress. Fry and King found that pain and discomfort caused by damping was a result when stimuli of about 3 Hz were introduced to the pupil. In essence, if fixations of more than 3 times per second between sources were required for the VDT worker, then it would be best to avoid bright task lighting. [43]

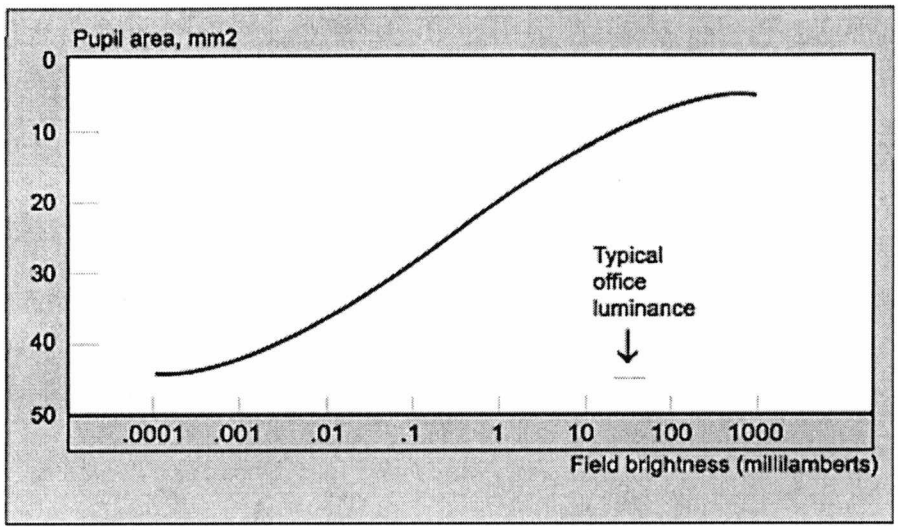


Figure 2-3 Logarithmic Graph of Pupil Size [57]

**The Near Triad**

The Near Triad is the term used when convergence, accommodation and depth of focus are being discussed. Vergence describes the movement distance between the eyes. It only takes approximately 40 milliseconds for an eye to move 10 degrees. For instance, when a person appears to be cross-eyed, then his line of vision is facing inwards and thereby not parallel. This happens when an object is too close. [57]

When working at a computer workstation, IBM recommends that a safe viewing distance would be 20-26 inches. This distance requires less convergence, thereby leading to less eye fatigue and pain. [62] When viewing a VDT, the correct convergence is achieved when the red, green and blue images are displayed correctly across the entire viewing area. Even a slight difference in colors will cause the viewer to have less of a contrast ratio. [91]

When a person views a monitor that is close, the eyes converge, leading to possible eyestrain. [41] Persons with far resting points of vergence complained of having more

eyestrain while working at a computer 20 inches away than those working with close resting points of vergence. [63]

When viewing a monitor, the eyes try to accommodate and converge into focus due to the closeness. In 1988, Jaschinski-Kruza found that convergence is a larger factor in computer eyestrain than accommodation. He tested subjects with far and near resting points of vergence with monitors positioned at 20 and 40 inches away. He found that eyestrain especially affects those with far resting points of vergence. [63] The resting point is on average, 45 inches. When viewing at an upward 30-degree gaze angle, the resting point of vergence can be extended to 53 inches. To the contrary, when viewing at a 30-degree downward gaze angle, the resting point of vergence will move in closer to approximately 35 inches. Since the gaze angle is smaller at a downward view, lowering the monitor would reduce the demand on the vergence system, thereby lessoning the stress on the vergence system. [65] Gaze angle also influences the resting point of vergence. [52]

There are two terms that should be known when discussing VDT's and how they affect the human eye. The first would be focal length and the second would be diopter. The focal length refers to the distance between the lenses of the eye to the point at which the light rays converge on the lens. The diopter, which is more commonly used and easier to measure in units of meters, is the reciprocal of the focal length. An example would be ¼ of a meter in focal length would be equal to 4 diopters. [60]

The zonula is an elastic ring of ligaments around the lens. When the eye is in a resting state, the zonula exhibits tension around the middle circumference of the eye.

This is what happens when viewing objects at a distance. To view objects in close proximity, the ciliary muscle contracts, thereby reducing the tension exerted on the lens by the zonula. The lenses also become more spherical in shape. The zonula is part of this process, which is called accommodation. In simple terms, accommodation is the ability of the eye to change focal power. For the lens to stay focused at a close range, a continuous force must be exerted by the ciliary's muscles. At approximately one meter from the eye, the lens may oscillate over a quarter of a diopter at a rate of three to four times per second. [26]

Excessive amounts of close or distant work for extended periods of time may cause problems when trying to refocus at an object opposite to what has been accustomed. The muscles in the eyes may spasm momentarily while refocusing. [14]

While working at a computer workstation and viewing a VDT for hours a day, the eyes will converge and accommodate quite frequently. This can cause eyestrain. [30] A VDT screen that is placed lower than the horizontal line of vision will reduce the need for accommodation. Ripple found that people over the age of 42 increased accommodation by an average of 25.5 percent. [94] Figure 2-4 shows the percent of

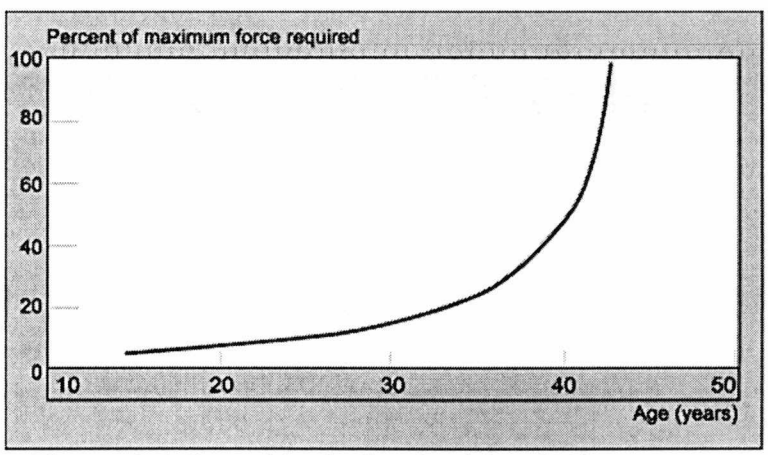



Figure 2-4 Logarithmic Graph of Age [55]

maximum force required at different ages to maintain a 3.5-diopter level of accommodation, a level appropriate for a reading distance of about 28 cm

There is a range of distance that does not require the eyes to refocus. This range is called the depth of focus. People over the age of 40 usually need a larger depth of focus since their ability to see at closer distances starts decreasing at this time. [23] A 15-year-old person should have about 10 diopters of accommodation, whereas a 40-year-old person might only have three to four diopters of accommodation when viewing close objects. This would make age a factor of accommodation. [7]

The eyes also have what is called a "dark focus." This is actually a point in space where the eyes are focusing, but cannot see. An example would be to imagine being in a completely dark room and have your eyes still viewing something in space. Even though the object could not be seen, the eyes would still be focusing. This focus point is called the "dark focus," and better known as the Resting Point of Accommodation (RPA). This point lies from three to four feet in front of your face and is not dependent on any other factors. The eyes are completely relaxed at the RPA and to move them causes fatigue. When the eyes do move to view an object, there is a lag time. This lag time, called the lag of accommodation, is the difference from a resting state to the state of focusing on another object. [70]

Resting state is the state of the eye under any lighting condition when the pupil of the eye has adapted to that particular lighting condition. Even though the name implies that the pupil is static, it is still in constant motion. [57] Being in constant motion for eight hours a day will cause fatigue and eyestrain if necessary precautions are not met.

Chromatic aberration is the process of different wavelengths coming into focus at different distances behind the eye. Chromatic aberration is usually measured in diopters. When the eye comes into focus the chromatic aberration exhibits an orderly color fringe on the retina. When the object becomes unfocused, the color will not change. The color will change however if the lens of the eyes become defocused. This change in chromatic aberration, whether increasing or decreasing, will signal a change in accommodation. [57]

**The Importance of Contrast to the Computer Workstation User**

Contrast is required to be able to view anything, but contrast can vary by individual. There are ways of determining it. One very well known way is by using the Webner-Feschner Law. This is a law governed by ratios. Another way to judge contrast is by using the Woodworth and Schlosberg method, which uses shades of gray. [106] The ratio to get a shade of gray in the latter method is about 1.05:7 and represents the contrast ratio of target to background. VDTs use shades of gray to contrast when visual images are being presented. Poorly illuminated VDTs can be a cause of concern since this will affect contrast. The formula for shades of gray is:

$$\text{Shades of Gray} = \log \Omega_{\delta\lambda}(L_{object}) - \log (L_{background})$$

Most office VDT's are capable of less than 8 shades of gray, and therefore if the object to be viewed is in the periphery, it must be large enough to make a good contrast with the background. [58]

The ratio of contrast would be defined as the intensity between the lightest

and darkest areas of the display screen. Black characters on a white background are typically the best contrast. When the contrast ratio is reduced, for example, gray lettering on a white background, eyestrain can occur. [91] If a color monitor is not required, the monochrome monitors are better suited for contrast. These monitors have a dark background with one color for character display, but black lettering on a white background would be the best choice. Other choices for background color may be used as long as the contrast ratio between background and lettering is kept high. [16] Research by CVC has also shown that productivity and performance are reduced when working from a monitor screen, compared to working from paper. [17]

**The Strains of Vision and their Affects to Computer Workstation Users**

People who are nearsighted are said to have myopia. Working at a computer workstation could cause eyestrain for these people more so than those with hyperopia (far sightedness). The reason for this would be due to the incoming light rays being bent too much causing the eyes to come into focus in front of the retina. The myopic person must move closer to an object to come into better focus. The closeness of this position could lead to discomfort while working due to more movements now being produced by the head. [1] Transient myopia has been found more often in computer users. Research by CVC found "...20 percent of VDT workers had a nearsighted tendency towards the end of a shift." [7] Hyperopic persons will focus images behind the retina. This usually causes them to sit further away from their workstation monitors, which could lead

to reach problems. Phoria is when both eyes are looking at the same image, but each eye sees the image differently. This is caused by an imbalance of the external eye muscles, which causes more stress when converging the eyes. Most people have phoria to some degree, but it does not usually cause problems. Presbyopia occurs when people age. The lenses lose elasticity, thereby preventing them to accommodate. This in turn limits the range at which objects are brought into focus. A workstation may be designed to cause the presbyopic person minimal problems. If accommodations are not made for the presbyopic person, there could be visual discomfort produced when working too close to the computer workstation monitor. [6]

**The Need for Corrective Vision**

Special glasses may be the best way of helping VDT users. The time spent in front of a VDT is a factor in determining whether special glasses are required. Special monofocal lens that have been refracted for the specific viewing distance of the person working could save a computer operator from eyestrain problems.

Some VDT users were already wearing glasses before working at a computer workstation. Those users with presbyopia may have a more difficult time. The majority of these users either has to switch between different pairs of eyeglasses or is constantly shifting their gaze between different parts of their bifocal lens. If a person wears bifocals and works at a computer workstation and does not take corrective measures where their eyewear is concerned, they could have problems with neck motion and muscle strain. Trifocals might be a better

choice for these users. Another option is special monofocal lenses specifically designed per individual to optimize focus. [46][56]

Nearly everyone beyond the age of 40 either wears bifocals or reading glasses. The prescriptions they have do not usually match their work using a VDT. The VDT is usually located higher and further away from the normal reading field of view. This positioning of the VDT can lead to awkward postures and eyestrain. [13] The American Academy of Ophthalmology states, "The additional visual demands of VDT use may mean that some individuals who normally do not need glasses should have corrective lenses for this activity." [3]

The part of the lenses used for reading in bifocal glasses is placed just below the horizontal viewing plane. This is done since there is less muscular effort, and balancing of the head becomes easier. The VDT should be placed where the top of the monitor is at eye level to the user, thereby giving the user a slightly downward gaze, as would be accustomed to reading from a book. [21]

It has been estimated that 65% of the population requires eyeglasses under some circumstances. [25] Age affects many activities, including working at a computer workstation. As a natural part of growing older, the lenses of the eyes begin to turn yellowish. This causes the lens to become less able to transmit blue light by about 30% from age 20 to 50. [58] This ranges from a 16 year old who can focus as close as 3 inches to a 60 year old with whom it may take nearly 40 inches to focus. At age 32, 44 and 50, the focal distances increase respectively to approximately 5, 10 and 20 inches. [44] Accommodation for a person over the age

of 40 could still be approximately 28 cm., but the effort required to do so over long periods may result in pain and discomfort to the eyes. Computer workstation users may need corrective glasses after the age of 30 due to the ciliary's muscles not being able to maintain a static force of more than 15% of their capacity for long periods of time. Since there are more people working for longer hours per day and simultaneously production is expected to increase, the aging factor cannot be ignored. [17]

**Monitor Nuisances that May cause Strain**

Flickering can be a cause of eyestrain for the computer workstation operator. Flickering of overhead lights or from the computer monitor can cause contrast sensitivity to be increased. Frequency is the dependent factor. A "just noticeable difference" would be between 1 and 5 flashes per second. [58] Having 2 adjacent monitors operating at different refresh rates can also induce flickering. This causes a magnetic interference called "beating." If beating appears from 10-20 times per second, a flicker will be noticeable. [91] The flickering of a VDT can cause headaches if sitting in front of it for long periods. [73] Flicker strains visual performance when using a 17-inch or larger monitor. [102]

Blinking is not usually done enough by VDT users. This staring effect can cause discomfort to the eyes. [56] Blinking maintains the tear level in the eyes. Tears evaporating too quickly can cause dry or burning eyes. [8] One of the fastest reflexes of the human body is blinking. Normal blinking occurs about 12-15 times per minute. The faster an activity, the faster the blink rate. Hence, the

slower or sedate activities, such as those of a computer workstation operator, the slower the blink rate, and the greater the chance of developing dry or burning eyes. The higher gaze angle of the VDT worker compared to the book reader makes VDT users more prone to tear evaporation. This is due to the eye opening being greater when working at a VDT. [11]

Diplopia, or double vision as it is more commonly called can be caused from too much close work for extended periods of time. The extended hours of close work causes the eyes to lose the ability to lock into one image. The eyes become misaligned and will view different images. One of the eyes will usually close so that the object can become focused. This can be corrected easily by focusing on a more distant object. [10]

The position of the monitor is of extreme importance, not only for posture, but for the eyes as well. Powell suggests placing the screen about 10-15 degrees below the VDT users horizontal line of vision. [90] When positioning the VDT for the computer workstation user, several considerations should be made. Measurements need to be made from the user's eyes to the top of the display screen, to the middle of the screen, and to the lower portion of the screen. The measurements could depend on what part of the screen will be used for viewing. Frequency of use and time spent away from the workstation could also be helpful information. All of these measures would aid in proper refraction for the user. [56]

Dr. Bailin suggests the screen should be 18-30 inches from the user's eyes,

and the eyes be level with the top of the monitor. This is because the eyes are most comfortable when looking straight ahead, but with a slight downward gaze angle. [21] CVC differs with Bailin in their conclusion that the straight-ahead position is unnatural. CVC believes while the eyes are in a straight-ahead position, the muscles of the eyes must continually fight one another to maintain a correct image. This can cause eyestrain and headaches. CVC also suggests the center of the screen be 7-10 inches (or 10-20 degrees) below the horizontal line of sight. [17] OSHA states that, "The VDT screen should be elevated to a height of about 36-46 inches such that the employee can view the screen and maintain their line of sight at about vertical or somewhere between 2 degrees above vertical to 26 degrees below vertical. The horizontal distance from the viewers eyes to the VDT screen should be about 24-37 inches." [83]

As with any other feature of the computer workstation, the monitor position must depend on several factors per individual. Whether the user is myopic, hyperbiopic or presbyopic would make a difference. The user may be right or left-handed or the monitor may need to be placed below the work surface instead of on top. Lighting is another commonly disregarded factor. [48]

**Effects of the Monitor to Computer Workstation User**

To better grasp an understanding of what the user's eyes are working with at a computer workstation, some details of the actual monitor need to be explained. One of the smallest parts of the display screen is called a pixel. A pixel is one dot on the screen. The higher a resolution is set, the smaller the pixels. The smaller pixels make up a more

concentrated image, but that image will be smaller. For instance, on a 17-inch monitor, a 1024 x 768 resolution would be able to display more images than an 800 x 600 resolution because the higher resolution contains more concentrated pixels, thereby making the image smaller. [73]

These images are of a certain type. They are called Gaussian images due to their Gaussian curve or distribution. This just means they are clearest at their centers and fade out around the edges. These are the types of images on your screen that actually force the eyes to the dark focus point. The eyes are constantly trying to pull back from the dark focus point to the plane of the screen. This can be a direct cause of eyestrain. When the eyes are attempting to focus on a continually changing VDT, they can become fatigued. The Gaussian curves that produce images that are seen on a VDT are made up of many pixels. Computer operators that work up to eight hours a day are constantly focusing and refocusing these pixels, sometimes up to 25,000 times per day. It is no wonder that headaches and eye fatigue occur to computer operators. [70]

Refresh rate is measured in Hertz (Hz), and measures how often the pixels on the monitor screen are updated. Refresh rates on modern monitors are normally 60 Hz. [16] The refresh rate decreases as resolution increases. The higher refresh rates (75-80 Hz) will help minimize flickering from the monitor. Flicker is more obvious in older monitors where the refresh rates are lower, especially noticeable when standing at a distance. [73] The part of the monitor being refreshed is a phosphor coating. This phosphor coating needs to be refreshed so the image does not fade. The 60 Hz means that

the phosphor coating is being refreshed 60 times per second. The slower rate causes flicker. [17]

Dot pitch is the distance between each pixel on the screen. It is measured in millimeters (mm). Naturally, if the dot pitch is high, the pixels will be further apart. The VDT user should want the pixels spaced closely together to form a clear, sharp image. The farther apart the pixels are, the fuzzier the image becomes, leading to eyestrain. [73]

A Direct Operating System (DOS) compatible VDT screen should have a pixel density of about 75 dots per inch (dpi). CVC has found that by increasing the pixel density from 75 dots-per-inch (dpi) to 115 dpi, reading can be done 17.4% faster. This was tested in 30-minute reading sessions. A gray-scale improvement in image quality further quickened reading. Quality improved from 4.1% to 19.9%, depending on the type of monitor. This could help improve the vision capabilities of the computer workstation worker. [13]

There are a couple of other things that are of importance to a computer workstation operator. A VDT screen should also be degaussed to help prevent eyestrain. Degaussing will demagnetize the area near the front of the display screen. This will cause any colors that have shifted during magnetization of the steel parts of a monitor to correct themselves. [91] Most monitors have a button for degaussing.

A document holder should be placed as close to the monitor screen as possible, and at the same height and distance as the monitor is from the user. This

will help the eyes from having to continually refocus. [21] To not use a document holder at all would double or even triple the force put onto the neck, shoulders and back. [89] The document holder should be adjustable to accommodate different sizes of documents, as well as different users. [48]

Glare is an important issue in taking care of the computer operator's vision, which ultimately affects the rest of their body. "Glare is any extraneous scattering of light." The eyes are more vulnerable to incoming light when they are looking straight ahead. Even shiny desktops can reflect glare. [17] The illumination in a typical office is anywhere between 50 and 100 foot-candles. The glare caused by this lighting is rated as the number two office workplace problem, with office temperature being number one. A monochromatic office (white walls and ceilings) setting can be highly reflective and thereby become a major contributor of glare to the computer workstation user. [95] Glare from the VDT screen can be more damaging than people realize. Glare can be produced from overhead lighting, light shining in from windows, from task lighting, desk lamps improperly placed and even from light colored clothing. [62] Glare can be made even worse by the accumulation of electrostatic dust particles, fingerprints or other dirt on the VDT screen. [56] The eyes may have to strain themselves to be able to view an image where there is too much surrounding light hitting the screen, due to the image appearing faded.

There is also a type of glare called disability glare, which causes the VDT screen to look black. The light of the surrounding environment being too bright

causes this. This type of glare leads more to a frustrated worker rather than to any discomfort.

Dark letters against a light background will help reduce glare. This is called positive polarity. [55] A flatter screen will minimize glare. A curved screen will collect reflections from a wide angle. [15] Some people lean their monitors in a backwards tilt. This can cause glare from ceiling lights when positive polarity is present. The user will try to accommodate for the glare, sometimes resulting in bad posture. [42]

Headaches occurring from working at a computer workstation can usually be blamed on a vision problem. People who continually need to lean forward to see the monitor screen may suffer from cervical headaches, increased fatigue and thoracic outlet syndrome. [50,98] A small desk space or a chair with no arms for support, can lead to muscle fatigue or Upper Extremity Cumulative Trauma Disorders (UECTDs) from the user having to constantly lift his arms. This can sometimes be a cause of headaches. [85] Headaches related to visual problems occur during the middle to the end of the day and can be felt towards the front of the head. Tension headaches are the most common among VDT workers. Improper workstation design is only one factor that may cause tension headaches. Poor lighting and glare are the two worst culprits. [9]

Neck injuries can occur when users defer from the 90-degree angle associated with the elbows. This can further increase from a nerve insult in the neck to a repetitive strain injury (RSI). When the neck is made to tilt for 30 degrees or more, the chance of neck extensor fatigue greatly increases. But in

flexion, the neck can tilt to 15 degrees and no noticeable damage is found. [28] Each degree of flexion of the neck requires one degree of elevation in the horizontal line of sight. [69]

**The Effects of Lighting to Computer Workstation Users**

Poynton recommends against using fluorescent lighting, stating that this type of lighting causes "excessively bright ambient illumination" inducing visual stress. [91] The American Academy of Ophthalmology (AAO) goes even further in their claim that the amount of ultra violet radiation emitted by VDTs is relatively small compared of that of fluorescent lighting. Even so, they state that the levels of radiation from VDTs are still not enough to cause eye damage. [3]

One of the most important things about lighting is to find the correct combination of fluorescent and incandescent lighting to reduce or minimize glare. The computer monitor can be like a magnet for reflections. Glass or shiny surfaced objects can contribute to glare as well. Smoke from cigarettes mixed with water vapor can cause a dangerous film on the VDT screen. [21]

Normal VDT office settings usually fall into a class 2. Class 2 is defined as having more than 0.1 cd/$m^2$ background luminance. Detection of color is also included in a class 2. Threshold contrast and perception of luminance difference follows the Weber-Fechner Law. [54] Having too little light is as damaging as having too much light. [55] Distribution of light is an important factor for the computer workstation user. The objects in the user's field of vision having approximately the same brightness can do this. Windows and bright lights can

cause discomfort to the worker. Many office settings think they need bright lights to be able to see their computer work better, but the opposite is actually true for computer workstation users. The lumination in these offices measure between 75-100 foot-candles. This is too high and can result in visual discomfort. The correct lumination for offices having computer workstations would be 18-46 foot-candles. Monitors that have a white background screen can have higher levels of lumination. [16] Indirect lighting can account for 70% of light being bounced off the ceiling. This creates a more uniform office lighting leading to less visual fatigue and virtually no glare from VDT screens. [95] The low humidity in an office environment can contain contaminants, which can also be damaging to the eyes. [11, 46]

**How Monitors and Other Electrical Facets of Computer Workstation Use May Cause Injury**

Most monitors have a cathode ray tube (CRT) in them, as the one shown in Figure 2-5. Although extremely functional in the operation of the monitor, the CRT can be a cause for concern. The CRT emits a stream of electrons to create an image on the screen of

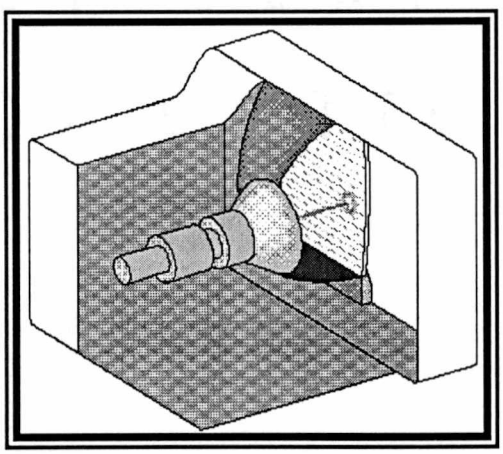


Figure 2-5 Cathode Ray Tube [101]

the monitor. Internal magnetic fields control how well the visual image is seen on the monitor. These images are generated by horizontal and vertical deflection coils, which direct a beam either back and forth or up and down. This is the normal operation of a CRT with normal ambient background and no other interference. As technology grew, so did the advancements in VDTs. There are more colors available; more choices in the size of the monitor and viewing screen and of course the option of higher resolutions. Each of these advancements can make the image sharper, but at the same time they increase the sensitivity of the monitor to external interference. Increased colors and resolution require the electron beam to make a more exact alignment and focus. To account for this, the vertical scan rate had to be increased. As the size of the monitor increases, so must the distance traveled by the electron beam, thus making it more sensitive to outside interference. The newer energy efficient monitors operate at lower anode voltages, which means the electron beam travels slower, making them even more sensitive to the external fields. Setting the monitor to a refresh rate of 60 Hertz (Hz) may reduce the jitter caused by interfering outside magnetic fields, but a flicker will replace this. The human eye is able to detect a refresh rate at 60 Hz. Most monitor manufacturers are increasing refresh rates to avoid the flicker. Strong background interference will not remove the jitter, even with the refresh rate set at 60 Hz. Increasing the refresh rate to higher settings would rid the viewer of both jitter and flicker, but this presents another problem of the applications possibly being incompatible. [53] Webopedia describes refresh rate

as how many times per second the screen is refreshed (redrawn). They suggest setting the refresh rate at 72 Hz to avoid flickering. [102]

NoRad states that monitor interference is a growing problem in not only offices, but in home work areas as well. [80] A VDT uses its 60 Hz of power differently than a toaster might use it. The electromagnetic fields used by the VDT will divide its power into several different frequencies for the various tasks needed to produce the images on a screen. Horizontal and vertical deflection coils, as well as the CRT itself, among others have different electrical characteristics. 'This results in an almost infinite array of electromagnetic fields at various frequencies, power levels and waveforms coming through the front, sides, back and top of the display monitor.' [79]

Although not part of any safety regulations, there are international standards for the distance a computer operator must sit away from the computer monitor. These distances, given by NoRad from the international standards are taken from 12-20 inches from the centerline of the display screen. [77] There are also two measurement and emission guidelines that originated in Sweden. The MRP II suggests limits on electric and magnetic field emissions in the Extremely Low Frequency (ELF) and Very Low Frequency (VLF) ranges. The MRP II also suggests limits on the electrostatic fields as well. These measurements are taken at approximately 20 inches around the monitor, at 3 levels of 16 points each. Other guidelines promoted by the Swedish Confederation of Professional Employees (TCO - Tjänstemännens Central Organisation) do the same as the MRP II, but also includes emissions from the entire computer. The TCO measurements

are taken at approximately 12 inches in front of the monitor and 20 inches around the monitor. Both of these may be seen in Table 2-1. [78]

A computer monitor may have several different names: VDT, display screen, LCD, and of course monitor. There are differences. For instance, the display screen is just the part of the monitor where the image is displayed, where as the term monitor refers to the whole box as well as the display screen. An even further distinction in monitors would be defined by the amount of colors they use. A Liquid Crystal Display (LCDs) will not be affected by any external electro-magnetic fields. These display screens do cost quite a bit more and therefore most people do not own them. [100]

**The Affects of Color**

There are three very specific types of color discriminating monitors. A

Table 2-1 Measurement and Emission Guidelines [39]

| | Electric Fields | | Magnetic Fields | |
|---|---|---|---|---|
| | MPRII | TCO | MPRII | TCO |
| | +/- 500V | +/ 500V | +/- 500V | +/ 500V |
| ELF 5 Hz - 2K Hz | 25 V/M | 10 V/M | 2.5 mG | 2.0 mG |
| VLF 2K Hz - 400K Hz | 2.5 V/M | 1 V/M | .25 mG | 25 mG |
| Above 400K Hz | none | none | none | none |

monochrome monitor only displays two colors – a background and a foreground color. These two colors should contain a good contrast ratio. Another type of monitor is a special variation of the monochrome in which only shades of gray are displayed. The most common type of monitor is the color monitor. These types of monitors are sometimes called RGB monitors since they accept the signals of red, green and blue. In combination, these monitors can display anywhere from 16 to over 1 million colors, as seen in Table 2-2.

Monitors receive these signals in one of two ways – analog and digital. Video Graphics Adapter (VGA) or the Super Video Graphics Adapter (SVGA) accepts analog signals. These are not the only two types, but nearly all modern monitors accept the analog signals. Multi-scanning monitors, such as these just mentioned, are capable of automatically adjusting themselves to the frequency of signals they receive, thereby allowing images to be seen at different resolutions. [103] The most commonly used, the SVGA standard for resolution, is a display of 1024 x 768 pixels. [104]

Screen size plays an important role in respect to the health of the computer workstation user. Screen size is measured in diagonal inches. That is not to say that a monitor labeled as a 17-inch monitor has a viewing screen of 17 inches. This is the measurement of the diagonal inches of the actual display screen. [101]

**Electromagnetic Radiation – A Growing Concern for Computer Workstation Users**

As well as monitor standards for graphic capabilities, a concern of radiation exists in electro-magnetic field environments. There is a natural distribution of electricity consisting of two fields – electric and magnetic. These two fields used together form an

Table 2-2 Video Standards [103]

| *Video Standard* | *Resolution* | *Simultaneous Colors* |
|---|---|---|
| VGA (Video Graphics Array) | 640 by 480 | 16 |
| | 320 by 200 | 256 |
| SVGA | 800 by 600 | 16 |
| | 1,024 by 768 | 256 |
| | 1,280 by 1,024 | 256 |
| | 1,600 by 1,200 | 256 |
| 8514/A | 1,024 by 768 | 256 |
| XGA (Extended Graphics Array) | 640 by 480 | 65,536 |
| | 1,024 by 768 | 256 |
| TI 34010 | 1,024 by 768 | 256 |

electromagnetic field, whenever electricity is used. The term "EMF" refers to both fields being used together. Only at Extremely Low Frequency (ELF) do these fields act independently of one another. [35]

Electric fields are generally referred to as "E-Fields" in science and are generated by something as simple as an electric iron. The iron does not have to be turned on to generate an electric field. E-fields are measured in volts per meter, and are relatively easy to shield in the ELF range. [37] Computer monitors produce electric fields. [36]

Magnetic fields are also found across a wide range of frequencies. They are produced only when an appliance is turned on. This action forms an electric current. Magnetic fields are very difficult and expensive to shield and they can pass through concrete, unchanged. They are measured in milligauss (mG) and referred to as either "H-Field" or "B-Field" in scientific circles.

Magnetic field strength decreases proportionally to the distance of the source (I/P). [38] Magnetic fields can cause interference with computer systems and network systems. They can cause data interruption making the integrity of the data unknown. [37] Research completed in 5,000 offices in Sweden has found that field strengths as low as 2 to 5 mG can cause screen jitter. FMS also found that the newer, lower emission monitors are more sensitive to jitter. This is due to the internal electromagnetic field strength being reduced, making them more susceptible to external magnetic field interference. [40]

The beam of electrons emitted from the cathode ray tube is controlled by the monitors' internal magnetic fields. The magnetic fields, which are generated by horizontal and vertical deflection coils, control the location, direction and focus of the beam. Therefore two monitors side by side can cause distortion to either one or both monitors. [53]

Electrical appliances and hardware found in most offices also produce high magnetic fields. Examples would be copy machines and electric pencil sharpeners. The strength of these fields is dependent on design and current flow, not on size or voltage. Compare on Table 2-3 how the average magnetic field exposure varies for different types of work environment

Many studies have been conducted to try and find out if exposure to EMFs can cause harm. Some of these studies report increases in leukemia or brain cancer and other similar studies found nothing conclusive at all. Out of six other studies with the exception of one, was found a significantly higher cancer rate for men working around exposures above 4 mG. And still yet another study associates EMFs with breast cancer.

Research is still too vague to show conclusive evidence that EMFs can cause damage to humans, but there is still enough question to continue the research. [75]

At the top of the list for exposure to magnetic fields are VDTs. These are followed by televisions, fluorescent lighting, copy and fax machines, telephones, answering machines and many others. These fields are everywhere in a modern society. Magnetic fields can permeate walls, floors and even concrete. [32] At present, scientists investigating EMF exposure have some preliminary studies, which have associated EMF exposure with breast cancer, and one other study linking EMF exposure with Alzheimer's disease. Even so, the National Institute for Occupational Safety and Health (NIOSH) does not regard EMFs as a proven health hazard, but due to the preliminary studies' finding that EMF exposure may be linked to cancer risks, the United States government will continue studying EMFs. [75]

NIOSH continues researching for new evidence that can link EMFs as a workplace hazard. The National Institute of Environmental Health Sciences (NIEHS) was mandated

Table 2-3 Average Magnetic Fields for Different Work Environments [75]

| Type of worker | Average daily exposures Median | Range |
|---|---|---|
| •Workers on the job: | | |
| •Clerical workers without computers | 0.5 | 0.2 - 2.0 |
| •Clerical workers with computers | 1.2 | 0.5 - 4.5 |
| •Machinists | 1.9 | 0.6 - 27.6 |
| •Electric line workers | 2.5 | 0.5 - 34.8 |
| •Electricians | 5.4 | 0.8 - 34.0 |
| •Welders | 8.2 | 1.7 - 96.0 |
| Workers off the job (home, travel, etc.) | 0.9 | 0.3 - 3.7 |

by Congress to conduct research for risks of cancer from EMFs. They concluded that chances of getting cancer were small since laboratory support only provides marginal proof. NIEHS Director, Kenneth Olden, Ph.D., said, "The lack of consistent positive findings in annual or mechanistic studies, weakens the belief that his association is actually due to EMFs, but it cannot completely discount the epidemiological findings. For that reason, and because virtually everyone in the United States of America uses electricity and therefore is routinely exposed to EMFs, efforts to encourage reductions in exposure should continue." From the report presented by NIEHS, Congress appropriated $23 million for extended research, upon which the electrical industry matched. NIEHS contributed $14 million of its own for the research as well. The Department of Energy (DOE) was in charge of where the funds were allocated. [74] That information is not revealed in this study.

FMS asks, "If the current is too weak to penetrate cell membranes, how can it be harmful?" One answer suggested that the current is a signal to the biological cell and could alter the immune system. FMS continues on to say, "Prolonged exposure to EMFs, such as sitting in front of a computer monitor all day, is a source for concern." [36]

Non-ionizing radiation starts at visible light and goes on to include Extremely Low Frequency (ELF). ELF includes the regular household power of 60 Hz. Between visible light and ELF there are a range of other frequencies: RF (Radio Frequency), UHF (Ultra High Frequency), VHF (Very High Frequency), and VLF (Very Low Frequency). Computer monitors emit frequencies into the microwave range, which is beyond the ELF range. [37]

The power inside a VDT can be divided over and over again to make the frequencies much higher. This causes dramatic changes in the original voltage and waveforms. There are four different types of waveforms created: Sinusoidal (ELF: 50-60 Hz); Sawtooth (VLF: 15-45 KiloHz); Spike (VLF: 15-45 KiloHz); and Square (ELF: 50-90 Hz). These waveforms are respectively shown in Figure 2-6. When these waveforms cross each other, even more complex waves are created. The electromagnetic field strength of these waves is proportional to the energy level of the current and voltage that a power source creates. Color monitors, especially those with higher resolution, exhibit high levels of EMFs. And although the EMFs drop off with distance from the source, the rate at which they drop off is dependent on the source. In the case of a computer monitor, the back and sides emit higher radiation levels than anywhere else, thereby

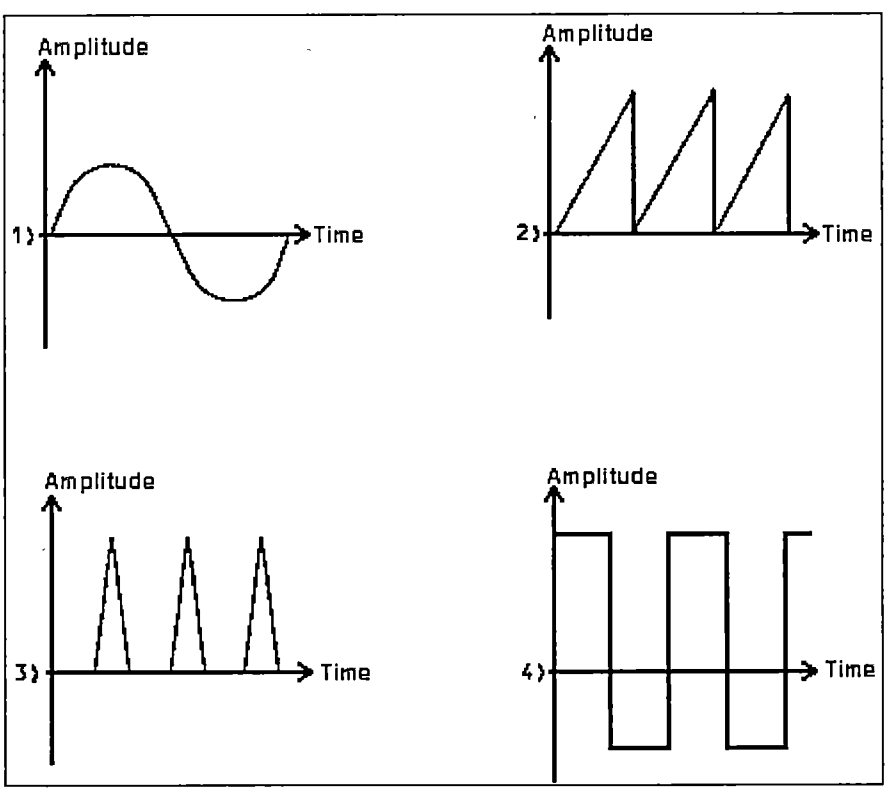


Figure 2-6 Four Different Types of Waveforms [80]

making the front of the monitor less harmful due to distance alone. The CPU, keyboard, printer, and scanner can also emit electromagnetic emissions, but these are extremely small compared to that of the monitor. The manufacturers of these components are able to put in shielding devices to keep them from interfering with one another and the monitor. [80]

The electromagnetic radiation spectrum shown in Figure 2-7 shows that electromagnetic radiation is made up of electric and magnetic fields across all the frequencies shown in the spectrum. The spectrum shows how the frequencies of both fields exist. Notice that the ELF and VLF exist in the electron field and separately and simultaneously in the magnetic field. [34]

Genetic material can be damaged by high amounts of frequencies. Above visible light and starting the ultra-violet frequencies, ionization is capable of breaking a chemical bond. Magnetic fields are measured in Gauss or Telsa and induced by an alternating current (AC) when the equipment is turned on. In ELF and VLF, magnetic fields are fairly difficult to shield, but not impossible. [36] External magnetic fields that can cause interference can come from any number of appliances and machinery. Any electrical equipment placed near a computer monitor can cause interference, including another monitor. Something as simple as an electric clock can cause interference. Even outside power lines can cause interference to a monitor. [40] If the source of interference is from a DC (direct current) field, the culprit could be a magnet associated with an MRI (magnetic resonance imaging) device. Interference from an AC (alternating current) magnetic field can be remedied much easier. Shielding the monitor or simply using LCD

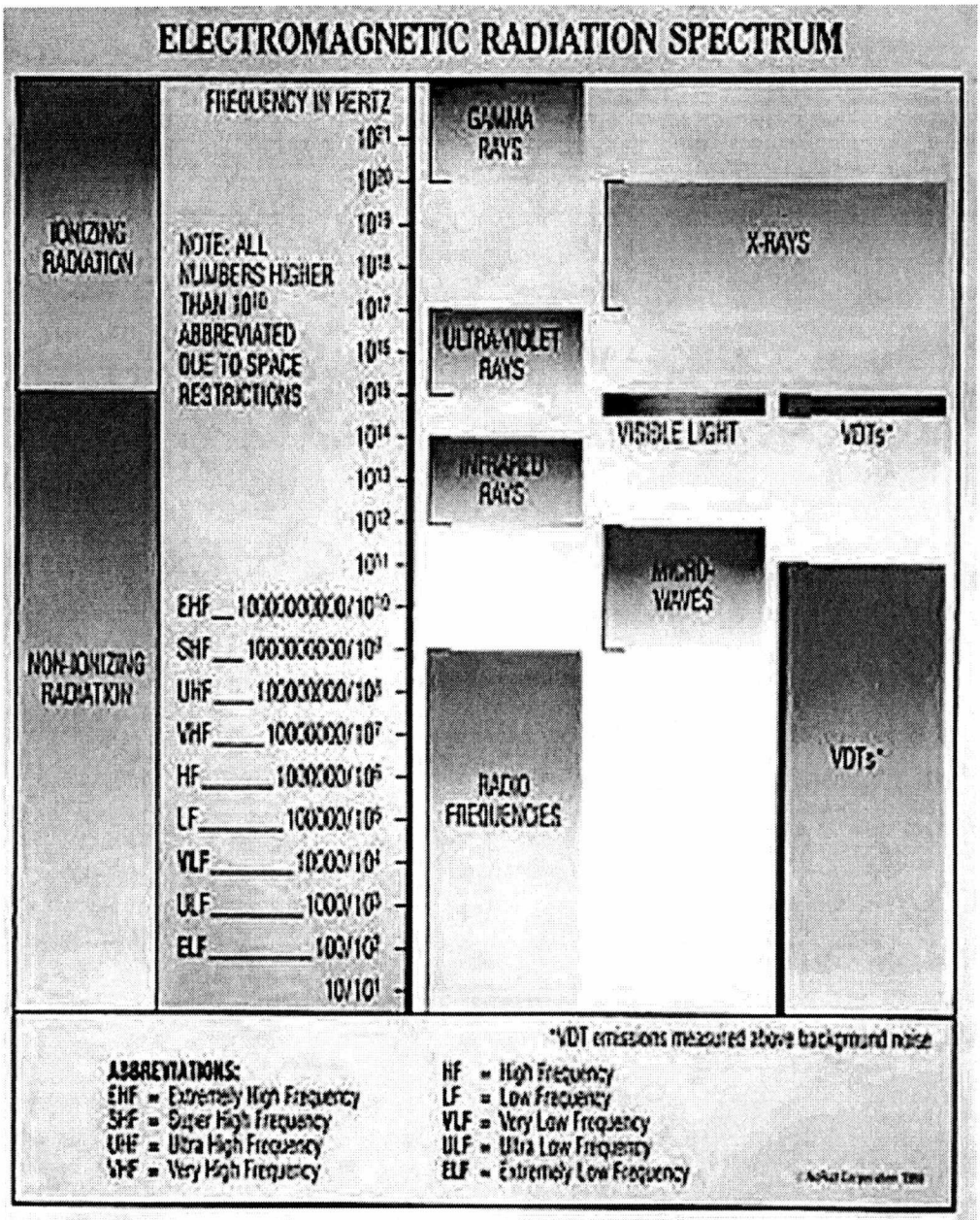



Figure 2-7 Electromagnetic Radiation Spectrum [34]

screens will work effectively to stop interference. Distancing the monitor from the source is usually effective, unless the cause of interference is transmission and distribution lines outside the building. Wiring errors could be another cause of interference. [53]

Jitter on a monitor would be caused by an AC source. The sources could be transformers, wiring or power lines. Color distortion of the monitor will usually prove to be from a DC source. The sources could be steel in the building, speakers or some type of magnet. A magnet will cause the monitor to become magnetized. Degaussing the monitor will demagnetize it. The magnet source should be removed, or over time, the monitor will deteriorate. [37]

Most, if not all offices have computers and monitors in them. Magnetic fields are even more of a problem here. Since they can pass through practically anything in an office, a partition or wall will be of little use. Low energy lamps, laser printers, even electronic locks and ventilation fans can contribute to the interference. Transformers are sometimes built into the main plug of all the cables connecting all the computer workstations equipment. The cables themselves can offer their own magnetic fields. [33, 76]

CRTs can have more problems due to AC fields, rather than DC fields. Interference may show up in AC fields of 10 mG and become unstable at 30 mG. DC fields of 1,500 mG will show as interference on computer monitors. This can be seen in comparison to the Earth's DC field, which is approximately 500 mG. [53] An alternating current (AC) is described as the voltage between objects changing over time. This AC

field is sometimes called a time-varying electric field. The rate of change is expressed in Hertz and called its frequency. [77]

NIEHS was advised by a panel of mostly EMF scientists that EMFs cannot be proven to be a carcinogen in causing cancer, but at the same time, they could not rule it out either. NIEHS reports, "...EMF fields continue to be recognized as a possible cancer hazard, but emphasize the weakness of the data and the low risk involved." [74]

Still other scientists in Sweden believe that EMFs to be a promoter of cancer, instead of an inhibitor. Their reasoning for this belief lies in the melotonin hormone. The melotonin hormone has been shown to slow growth in the cells of breast cancer. EMFs may slow down or completely nullify the melotonin hormones' cancer fighting, thereby becoming an indirect cause of cancer. [36]

The sensitivity of CRTs to EMIs pertains to several factors: Type of system and monitor used, refresh rate, strength of external fields and the individual computer users own sensitivity. Macintosh and Sun Workstations are much more sensitive to interference than most others. Interferences on these types can be seen at thresholds as low as 3-5 mG. The normal ambient field in an office building is usually from 1-4 mG. This shows how ElectroMagnetic Interference (EMI) can be considered great under these systems. [53]

**Electrical Hypersensitivity**

Electrical Hypersensitivity is better known in Sweden than in the United States, but

there are some interesting facts about it that should be made known to all computer operators. Electrical hypersensitivity has only recently been discovered. Its discovery goes back to the early 1970's. Computer operators are a prime target for this fairly new phenomenon. Early symptoms come forth as a minor irritation to the user. When the symptoms become more frequent, warmth or burning sensation is felt on the face, much like sunburn. Other symptoms can include a reddish skin blemish, a tingling sensation in the skin on any part of the body, eye problems and the infected operator may feel like their mucus membranes have dried. These are early warning signs and should be heeded. They may be followed by more symptoms as the person becomes more sensitive. After the initial warning signs, still other symptoms may appear. Dizziness and memory loss, swollen mucus membranes resulting in non viral/bacterial swelling of the nose, throat, ear an sinuses, feelings of developing influenza that never develops, headaches, nausea, teeth and jaw pains, muscle and joint aches and cardiac palpitations. Not everyone receives the same symptoms. This makes electrical hypersensitivity difficult to diagnose. [32]

If the symptoms are allowed to progress, they will last noticeably longer. It may take an evening or all night for them to disappear at the first onset. This progresses on to a weekend and then on to several weeks. Another way to tell is that sitting in front of a VDT will become harder to do since the symptoms can worsen while just sitting there. Even fluorescent lighting can bring an onset of the symptoms. People that are severely oversensitive find it difficult to survive without pain and discomfort in modern society. They virtually have to be away from anything electrical. Even the power lines make

going outside difficult. This has brought on extensive sick leaves. In Sweden, this is an annual cost of 100 million Swedish Crowns or approximately $107,000 U.S. dollars. [33]

This illness not only destroys a person's lifestyle, but also can be emotionally damaging to the entire family. Electrically hypersensitive people can be affected by magnetic fields with strengths as low as 20-30 nT (NanoTelsa). This is close to one thousandth of the emissions from a CRT in a computer monitor. FEB reports at least 10,000 people in Sweden had VDT problems associated with electro-hypersensitivity in 1993 and covered all age groups. This condition is not only dermatological, but neurological as well. Recovery time varies by individual. [33]

Sweden has developed two measurement and emission guidelines. These are shown in Table 2-1. The first, known as MRP II, sets standards on electric and magnetic fields in the ELF and VLF ranges. This also covers electrostatic fields. The second is called the TCO and is promoted by the Swedish Confederation of Professional Employees. This standard has stricter guidelines. The TCO limits monitor emissions and in 1995 was expanded to include the entire computer, energy consumption, flicker, luminance and keyboard usage. [39]

In 1968, the United States Congress held hearings regarding radiation and from these hearings, the Radiation, Health and Safety Act was passed. By 1971, all aspects of this Act were phased in and full compliance was required for all CRTs. [81]

Field Management Services concur the Swedish beliefs in electro-hypersensitivity although they admit the condition is better known in Sweden than elsewhere. [36]

Turning the VDT off or increasing the distance between the VDT and the computer user can prevent further injury to persons initially affected by electrical hypersensitivity. Other preventative steps would include but not be limited to keeping the number of electrical appliances to a minimum, turning off the VDT when it is not in use, unplugging the power cables to ensure magnetic fields are not still present, purchasing VDTs that are using the strictest standards, shielding VDTs, using LCDs instead of VDTs, and replacing fluorescent lighting with incandescent bulbs. Doctors as well as scientists need to become more aware of this condition. An early, correct diagnosis and treatment can be vital. Hospitals need to use other lighting than fluorescent when treating electro-hypersensitive patients. Ninety percent of FEB members were diagnosed as VDTs being the cause of their electro-hypersensitivity symptoms. [33] This information in itself is enough for all VDT users to be concerned about.

# Chapter 3: The Computer Workstation Survey

## Explanation of the Survey

A survey modeled after The Nordic Questionnaires [105] found in Appendix A was compiled using Microsoft FrontPage 2000, to collect statistical data for the purpose of trying to help illustrate the relevant, statistical differences between the known rules of computer workstation ergonomics and the ergonomics that are actually in practice. This interactive survey was posted on the internet at http://www.senzon.com/sanru/default.html, for participants to fill out and submit. The url (universal relay link) could then be forwarded to any other group or individual that had internet access. There were 250 completed surveys used in this study to represent the population of computer workstation operators. The survey was removed from the internet when the study was complete. Each individual took the survey with complete confidence in anonymity. The participants were asked to state their occupation. Two hundred and twenty-seven out of the two hundred and fifty participants stated their specific occupation. The specific occupations are shown in Appendix B. The data from this survey coupled with information collected in the literature review will help demonstrate why there are still so many injuries to users of computer workstations. The information collected was in seven specific categories. These seven categories were broken down into two sub categories – Males and Females.

## Humanistic Information

The first category is entitled, "Humanistic Information." Information from this

category showed the majority of data points for males and females fell into the 140-179 pound range (33.2%). They were also designated as being Caucasian (91.2%), 40-49 years of age (34.4%), with a height of 5'4"-5'8" (41.2%), and married (64.4%) with no children (34.8%). The following information will reveal that these statistics fit the female class more so than the males.

Data points for males were from white (33.6%) (Figure 3-6), married (27.2%) (Figure 3-4) males who weighed between 180 and 219 pounds (13.6%) (Figure 3-1), were between the ages of 40-49 years old (14%) (Figure 3-2), measured between 5'9" to 6'1" in height (16.8%) (Figure 3-3), and had children of ages 20 and older (11.2%) (Figure 3-5). The West Virginia Dietetic Association states that the ideal body weight for males in this class should be between 160 and 184 pounds, with a plus/minus 10% tolerance. [82] Ergonomics states that the 95$^{th}$ percentile for males is 218.46 pounds. This fact alone shows that the design of computer workstations where males are concerned should be designed for above the 95$^{th}$ percentile male of ideal weight. [66]

Information from this data for females showed the majority of data points were from white (57.6%), married females who weighed between 140 and 179 pounds (23.2%), were between the ages of 40 to 49 years of age (20.4%), measured between 5'4"to 5'8" in height (30%) and had no children (24.2%). The West Virginia Dietary Association states that the ideal body weights for females in this class should be between 120 and 140 pounds, with a plus/minus 10% tolerance. Ergonomics states that the 95$^{th}$ percentile for females is 126.94 pounds. [66] Again, this fact dictates the design of computer workstation accessories should be designed for above the 95$^{th}$ percentile female of ideal weight.

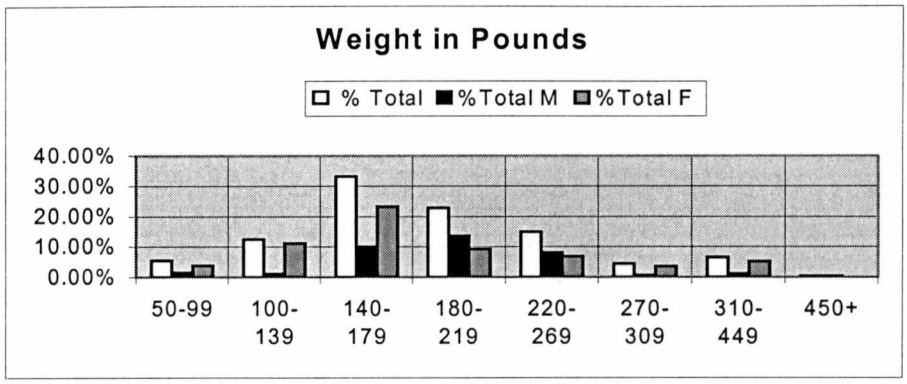



Figure 3-1 Weight in Pounds

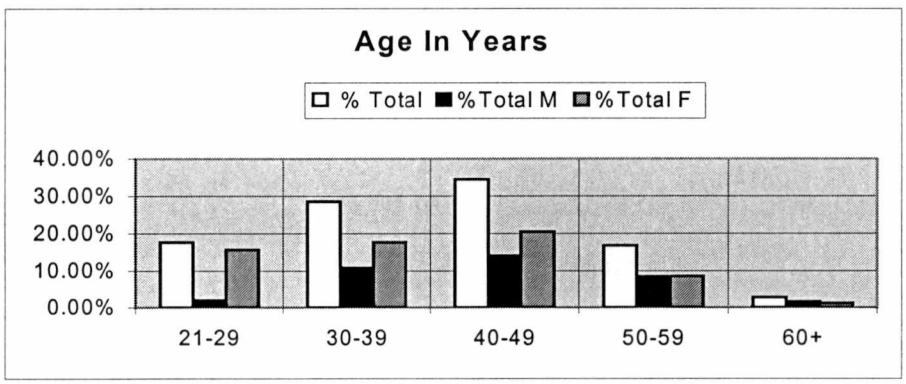



Figure 3-2 Age in Years

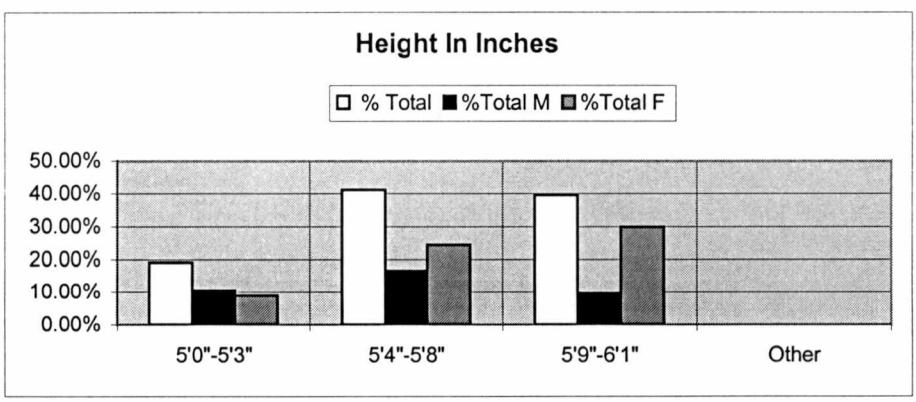



Figure 3-3 Height in Inches

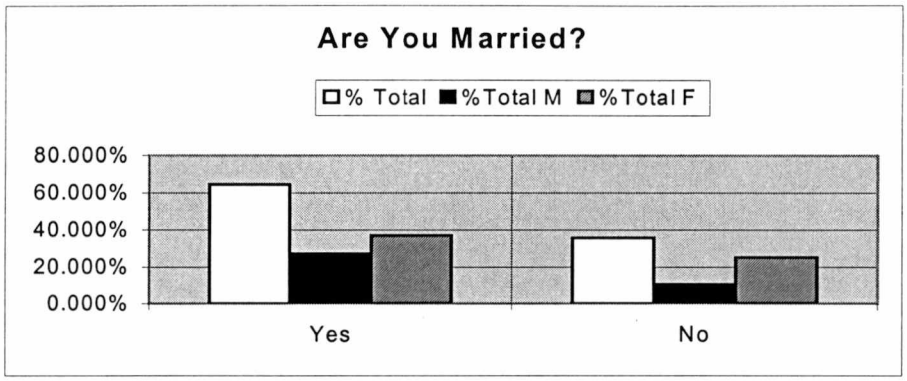



Figure 3-4 Are You Married

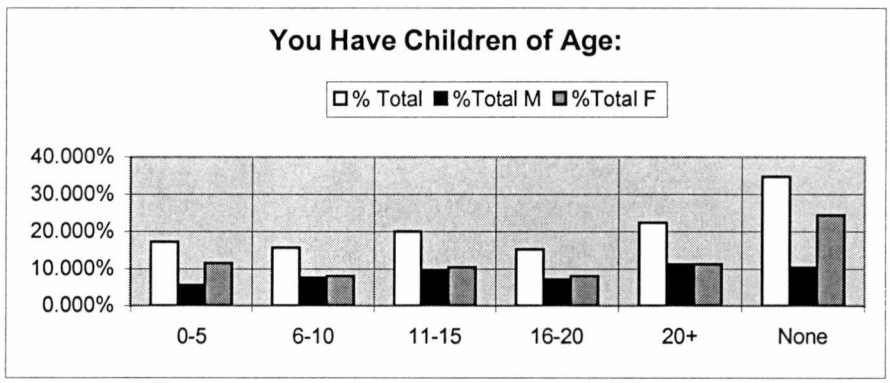



Figure 3-5 You Have Children of Age

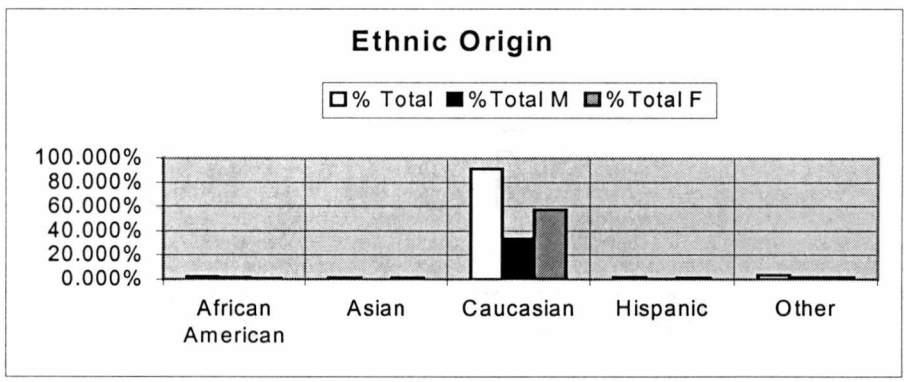



Figure 3-6 Ethnic Origin

**Job Environment Information**

The second category is entitled, "Job Environment Information." Information from this data showed the majority of data points for males and females fell into the range of working at their workstation from 5-8 hours per day (38.55%) (Figure 3-7). They were also right-handed (86.96%) (Figure 3-8) and had been doing computer related work from 4 to 8 years (34%) (Figure 3-9). The climate of the workstation was reported as being "just right" (74%) (Figure 3-10) for the majority of participants, with light colored surroundings (81.2%) (Figure 3-11) and fluorescent lighting (70.8%) (Figure 3-12).

Data for males showed the majority of data points indicate that work is done from 1 to 4 hours a day (16%), followed closely by the class of 5 to 8 hours a day (10.8%), and have been working at a computer from 1 to 3 years (10.8%) with only a .4 difference in the amount of males that have worked from 9 to15 years (10.4%). The majority of men are right-handed (29.6%). The climate of the work environment was reported as being "just right," (26.4%) with light colored surroundings (28.4%) and fluorescent lighting (20.8%) as the most popular type of light fixture.

This information indicates that the people working at the computer workstations have worked there long enough to be considered skilled at their trade by traditional standards and would therefore have a working knowledge of a comfortable work environment. Although the work environment may seem comfortable, the fluorescent lighting is reason for concern due to the electromagnetic emissions.

Information from this data for females showed the majority of data points to be in the ranges of working 5 to 8 years (27.6%) at their workstation per day, being right-

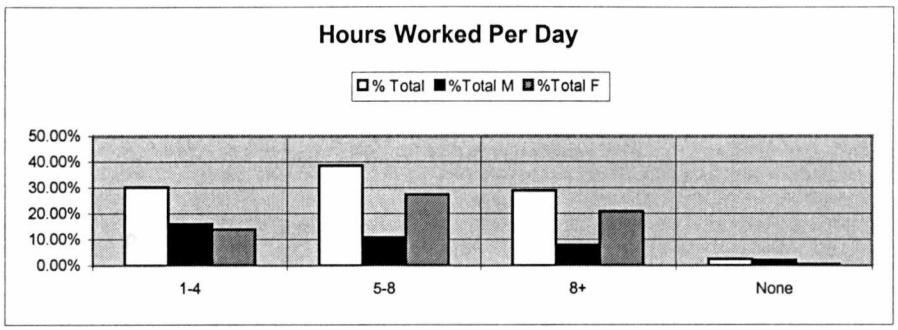



Figure 3-7 Hours Worked Per Day

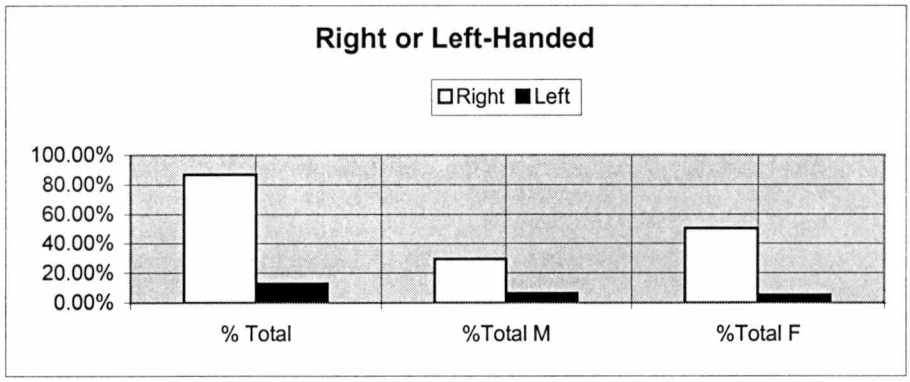



Figure 3-8 Right or Left-Handed

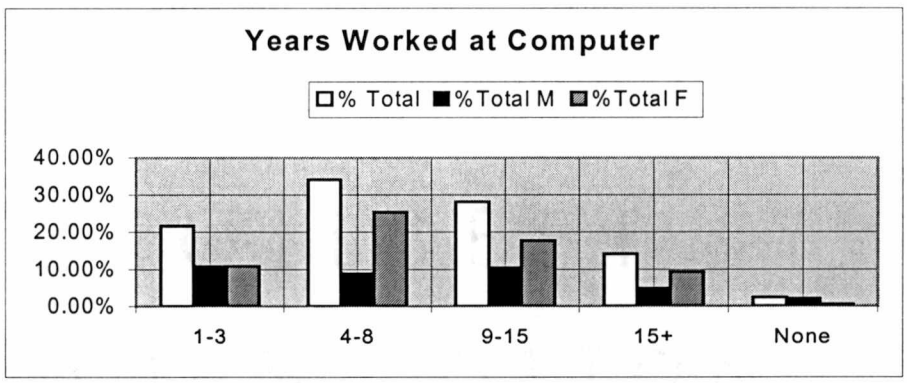



Figure 3-9 Years Worked at Computer

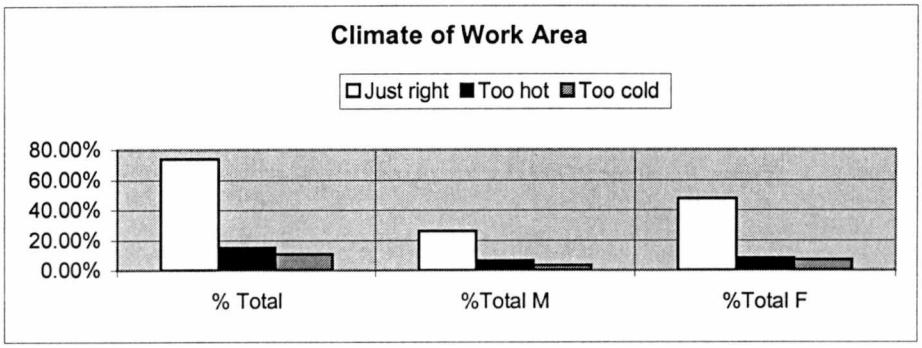



Figure 3-10 Climate of Work Area

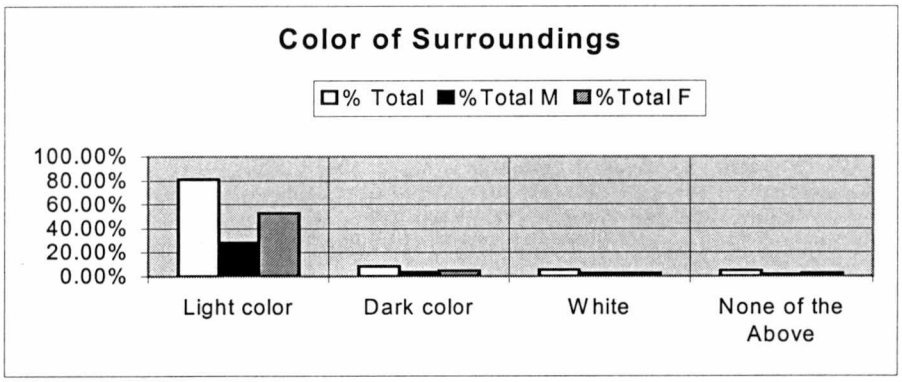



Figure 3-11 Color of Surroundings

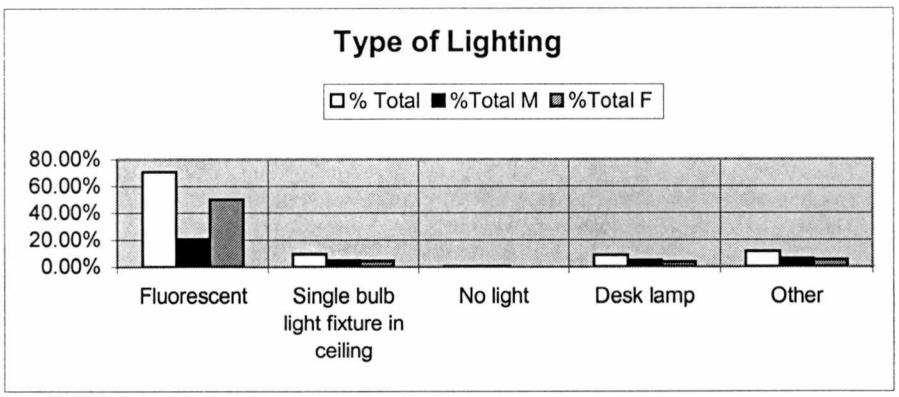



Figure 3-12 Type of Lighting

handed (50.4%), having worked at a computer related job from 4-8 years (25.2%) and the climate being "just right" (47.6%). The light colored surroundings (52.8%) and fluorescent lighting (50%) also ranked among the majority for females, as it did for males. This causes even more concern for females though, due to a risk of breast cancer from the electromagnetic emissions from the fluorescent lighting.

**Workstation Ergonomic Information**

The third category is entitled, "Workstation Ergonomic Information." Information from this data showed the majority of data points for males and females to be within the same ranges. These ranges indicate that each computer workstation operator has a chair with an adjustable height option (85.6%) (Figure 3-13), with armrests (76.4%) (Figure 3-14) and wheels (93.6%) (Figure 3-15) and that the chairs have a high cushioned back (56%) (Figure 3-16) with a cushioned seat (94.4%) (Figure 3-17). The length of the armrests are of consequence, but were not discussed in this study. These summaries indicate that the population is educated about and is using the correct seating appliances for their computer related work. Whether they are using the adjustment levels to the best of their abilities to suit individual needs was not covered in this study.

Information regarding males in this category shows males to have an adjustable chair height (25.2%), with armrests (23.6%), and wheels (32.4%). The chair also has a cushioned seat (33.2%), with a high cushioned back (16.4%). Information regarding females in this category shows females to have an adjustable chair height (60.4%), with armrests (52.8%), and wheels (61.2%). The chair also has a cushioned seat (61.2%), with a high cushioned back (39.6%).

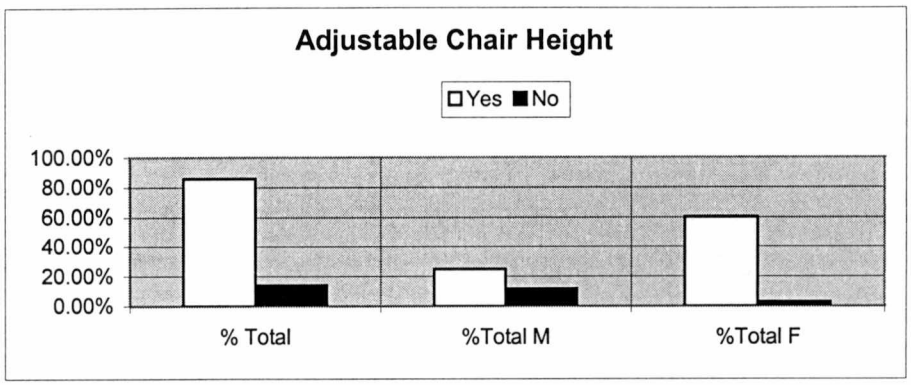



Figure 3-13 Adjustable Chair Height

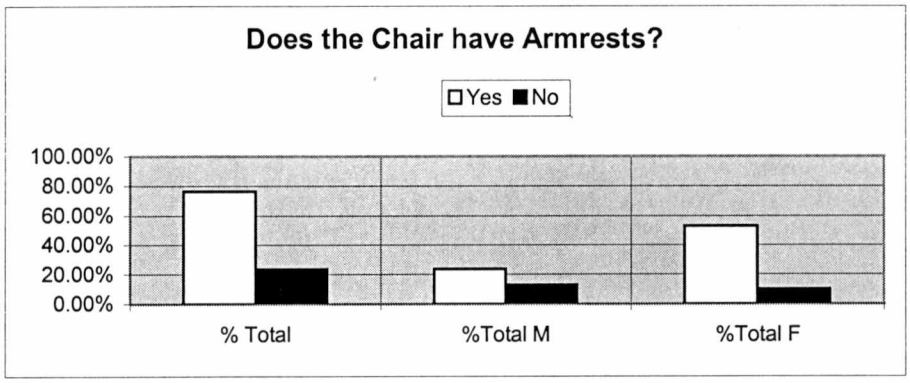



Figure 3-14 Does the Chair have Armrests

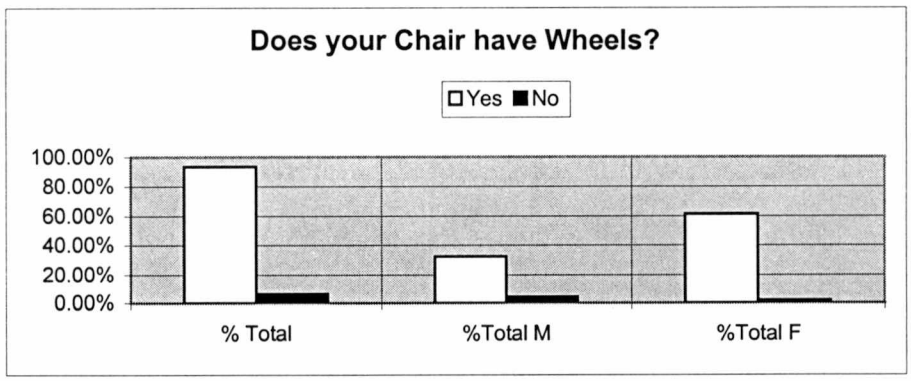



Figure 3-15 Does your Chair have Wheels

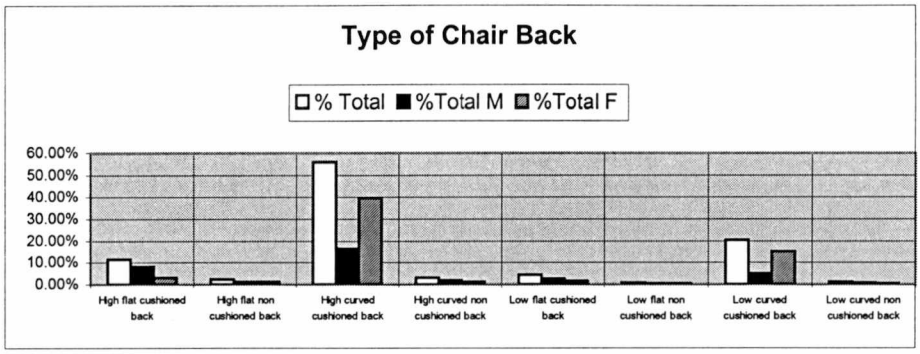



Figure 3-16 Type of Chair Back

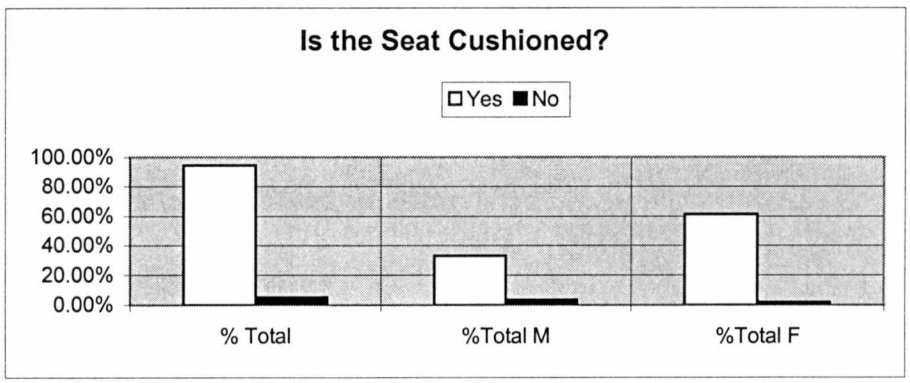



Figure 3-17 Is the Seat Cushioned

**Information Involving Vision**

The fourth category is entitled, "Information Involving Vision". This category attempts to gather information to discover if the computer user is informed about and using the information available to work at a computer workstation while still insuring safety to the eyes. Information from this data showed the majority of data points for males and females to be within the same ranges. The majority of data points indicate that both males and females wear glasses all the time (41.6%) (Figure 3-18), although no special computer glasses are worn (92.8%) (Figure 3-19). This can cause problems for bifocal wearers because of strains to the neck caused by leaning back to see the monitor screen. Both males and females work with a 17-inch ( 44%) (Figure 3-20), color (98.8%) monitor (Figure 3-22) that is placed directly in front of them (58%) (Figure 3-21). The

monitor is neither facing a window without any covering nor obtaining direct light from a lamp or overhead light (74%) (Figure 3-24). While this is good for the eyes, the problem of glare can still be an issue due to other surroundings. Most males and females indicated that they did not use glare screens (76.8%) (Figure 3-23) and are most likely not aware of the problems that can be caused from this lack of knowledge. Eyestrain can develop from a glare problem alone.

Information from this category regarding males specifically shows the male to wear glasses all the time (15.6%), but not to wear any type of special computer glasses (32.8%). The monitor screen is 17 inches (17.6%) and placed directly in front of them (21.6%). The monitor is color (27.2%), has no glare screen (27.2%) and neither faces an uncovered window nor a direct light (25.2%).

Information from this category regarding females specifically shows the female to wear glasses all the time (26%), but not to wear any type of special computer glasses (60%). The monitor screen is 17 inches (26.4%) and placed directly in front of them (36.4%). The monitor is color (63.2%), has no glare screen (49.6%) and neither faces an uncovered window nor a direct light (48.8%).

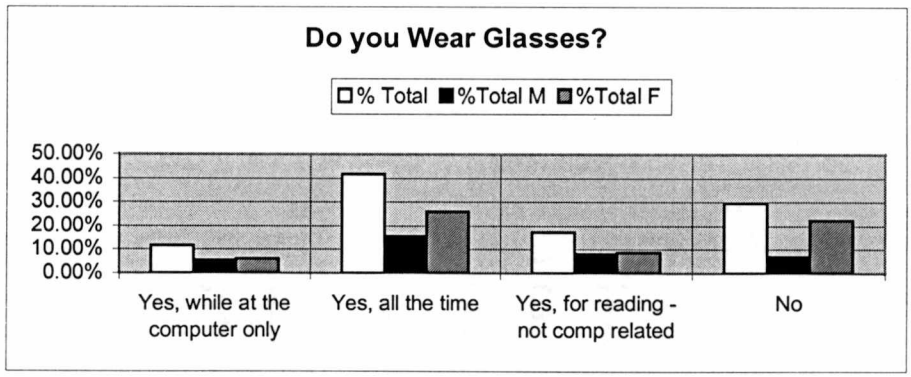



Figure 3-18 Do You Wear Glasses

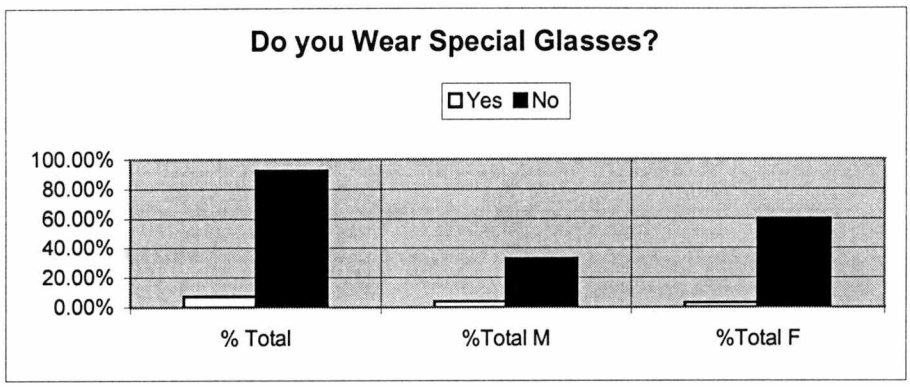



Figure 3-19 Do You Wear Special Glasses

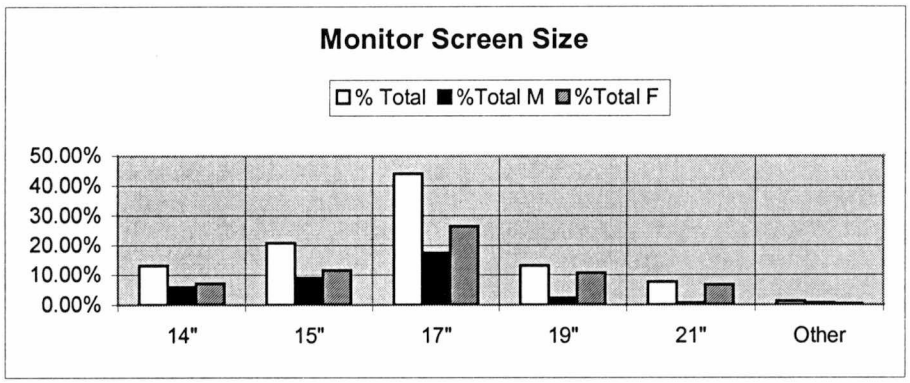



Figure 3-20 Monitor Screen Size

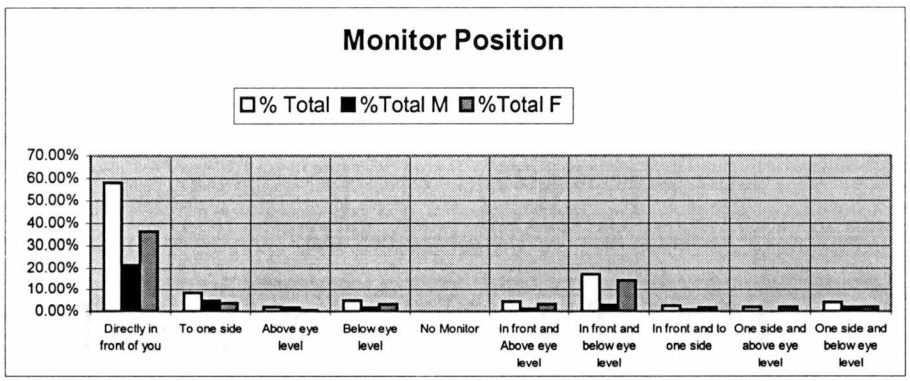



Figure 3-21 Monitor Position

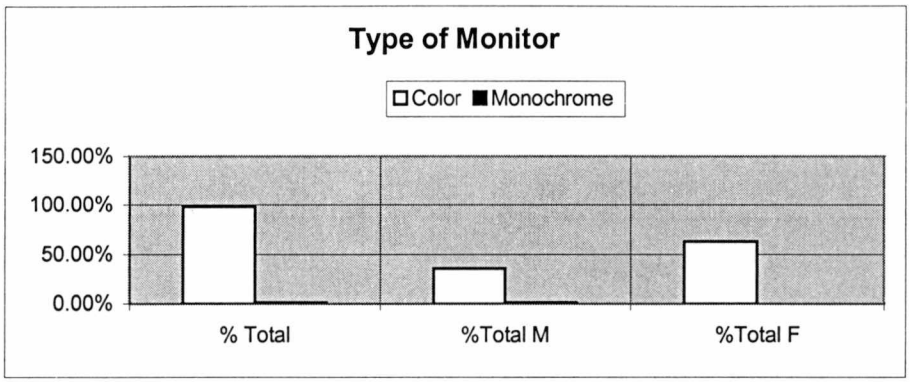



Figure 3-22 Type of Monitor

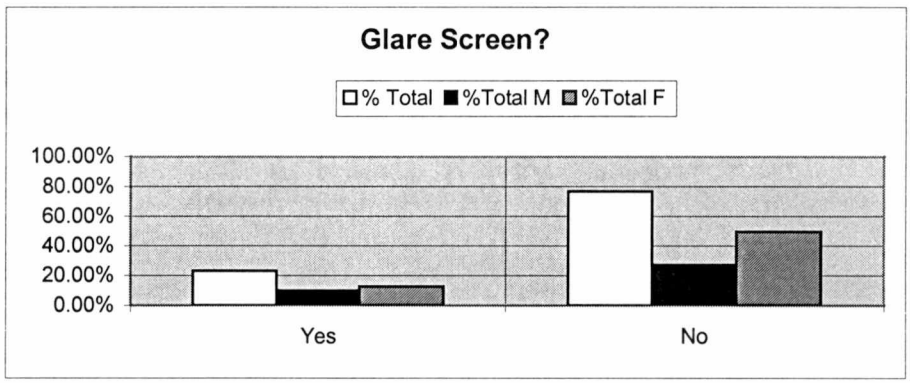



Figure 3-23 Glare Screen

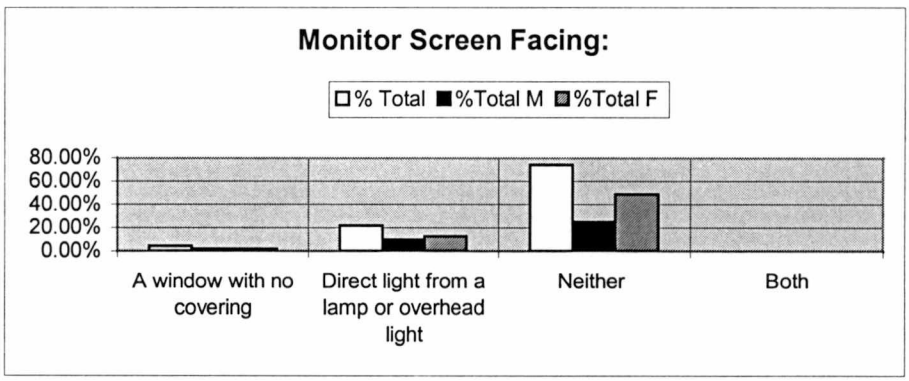



Figure 3-24 Monitor Screen Facing

## Workstation Accessories Information

The fifth category is entitled, "Workstation Accessories Information". This category recovers statistical information about parts of the computer workstation that are additions to the actual computer work area. The majority of data points for the population (94.4%) recorded the keyboard as being placed directly in front (Figure 3-25) of the computer workstation operator. While the keyboard was noted as being tilted (Figure 3-26), it was neither split (Figure 3-27) nor ergonomically designed (Figure 3-28). Nearly two thirds of the majority (62%) claimed to have no wrist support (Figure 3-29). Most of the population, an overwhelming 82.8%, selected their workstation to be a desk (Figure 3-31), and recorded their work area to be carpeted, 69.2% of the time (Figure 3-30).

Males and females differed slightly in this category. Information from this data for males showed the majority (34.4%) of data points indicate that the keyboard is placed directly in front of the user, that the keyboard is tilted (20.8%) and neither split (29.2%) nor ergonomically inclined (27.2%) and that the work area included no wrist support (24.8%). The computer workstations are in a carpeted area and the users work at a desk. Only 8.8% of the total population reported using another type of workstation than the choices given. Those responses are given in Appendix C.

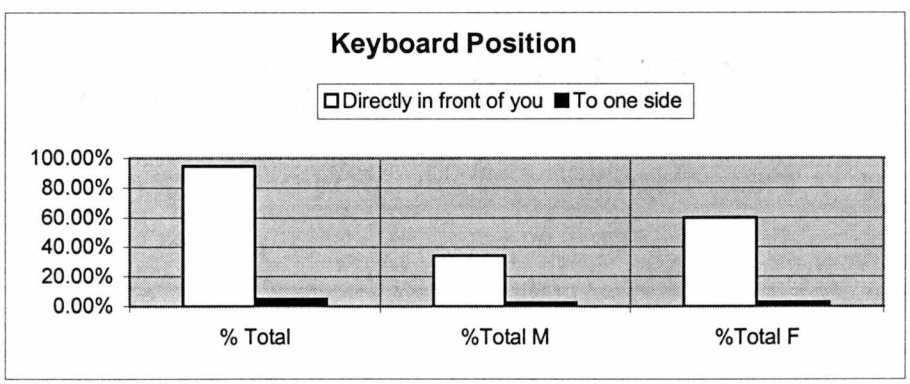



Figure 3-25 Keyboard Position

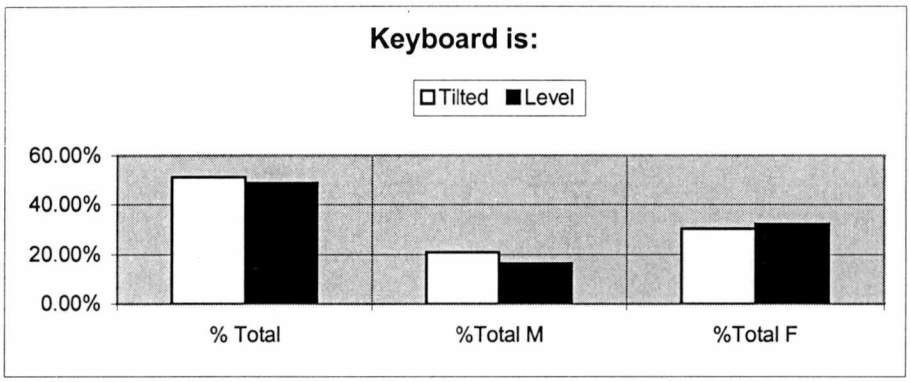



Figure 3-26 Keyboard is

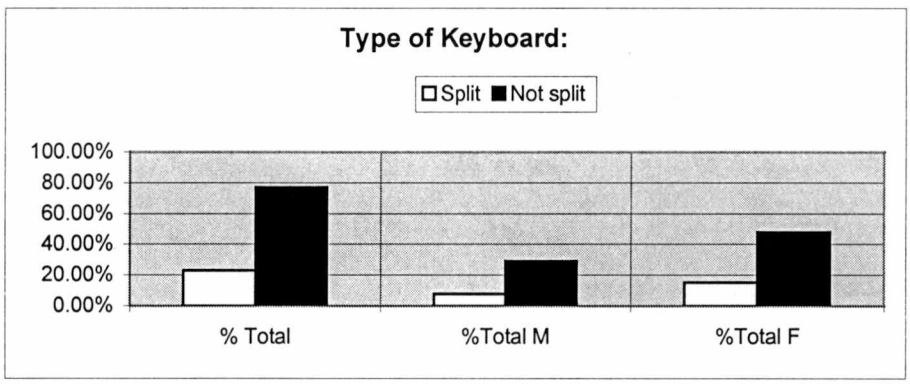



Figure 3-27 Type of Keyboard

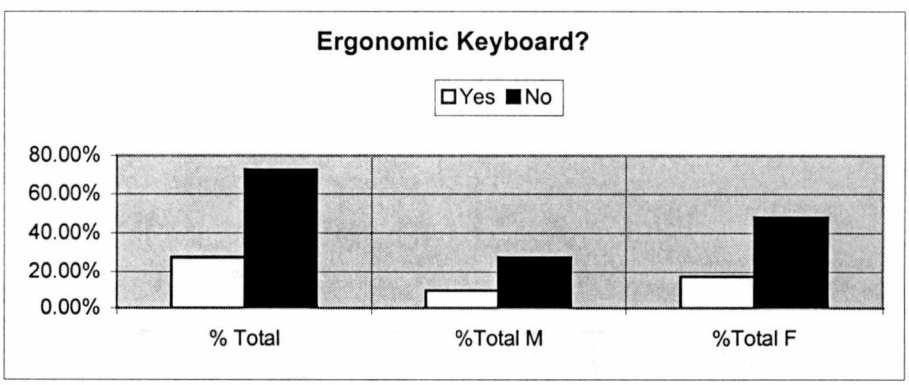



Figure 3-28 Ergonomic Keyboard

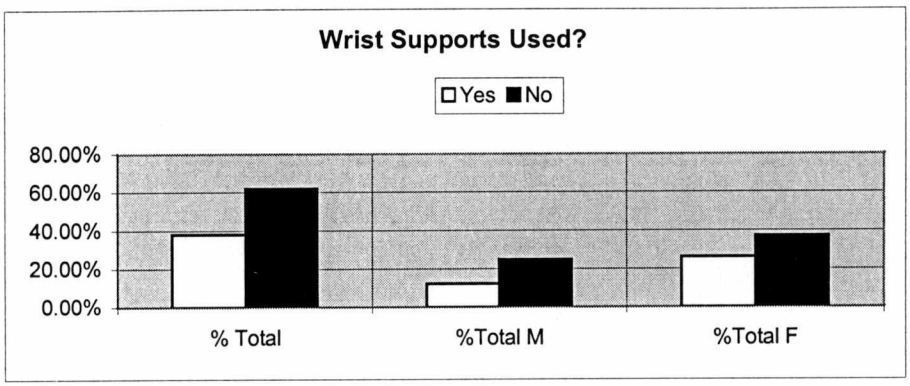



Figure 3-29 Wrists Supports Used

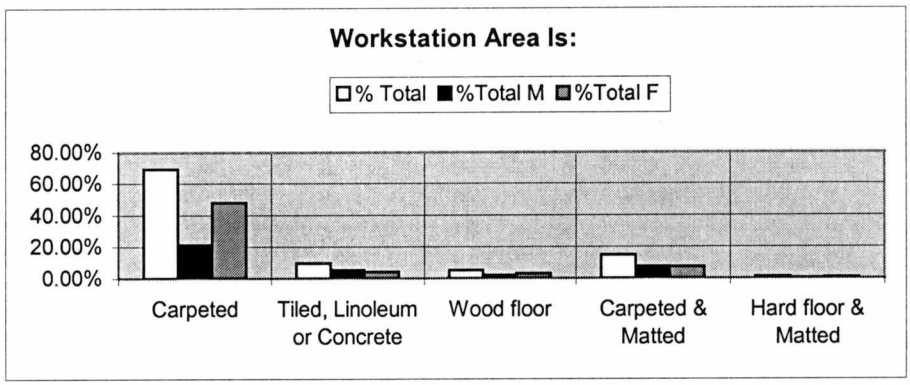



Figure 3-30 Workstation Area Is

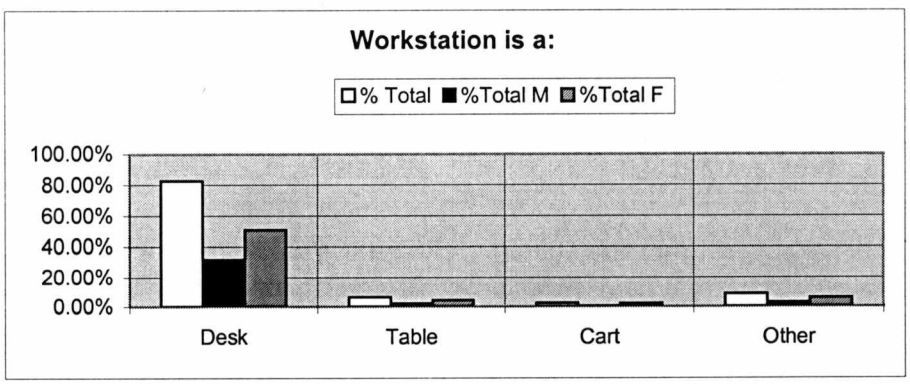



Figure 3-31 Workstation is a

Information from this data for females showed the majority of data points (60%)to indicate that the keyboard is placed directly in front of the user, that the keyboard is level (32.4%) and neither split (48%) nor ergonomically inclined (48%). There was no wrist support (37.2%) used. The user also worked at a desk (50.8%) in a carpeted work area (48%). Females also fall into the majority class of this population.

The difference in this category is in the position of the keyboard, either level for males and tilted for females. The survey did not specify whether the tilt was positive or negative in angle. A positive tilt is assumed, as in the keyboard leaning toward the user. Having the keyboard level or tilted will not matter as long as the user is keeping his wrist flat, so as not to induce carpal tunnel syndrome, or other injuries associated with too much flexion or extension.

The main concern in this category is the lack of wrist support. Wrists supports have been shown to give relief to patients of carpal tunnel syndrome as well as to persons suffering from shoulder aches and pains. The wrist support is not to be used to rest the wrists on while typing, but to rest the wrists on when not typing.

**Characteristics Associated with Pain**

The sixth category is entitled, "Characteristics Associated with Pain." This part of the survey recovered statistical information concerning what times of the day the most pain was felt in different parts of the body. The responses for having pain in the legs (Figure 3-32) showed a majority of 63.6% for both males and females as having no pain. The responses for how often leg pain was felt is given in Appendix D by those survey participants that supported that option of the survey. Some of the other statistics were fairly close in this category and will be discussed a little more intensely. The majority of

responses for both males and females revealed no pain in the neck at any time of the day (Figure 3-33), but male statistics were just slightly below having no pain by .8% in the evenings and 1.6% in the afternoons. The closest time of the day that females reported pain in the neck was during the afternoon, with a difference of 13.2% from the no pain class.

The majority of pain felt in the arm and shoulder (Figure 3-34) fell into the "None of the Above," category at 54%, but the afternoon and evening were close to one another with 26.4% in the afternoon and 28.8% in the evening. Males reported that 10.8% of pain was felt in the afternoon and 12.4% of pain was felt in the evenings, but the majority of males surveyed selected, "None of the Above," for 15.2% of the time. Females

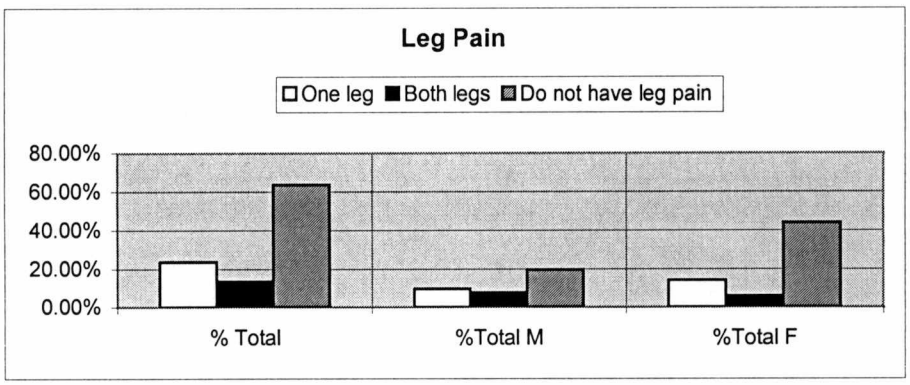



Figure 3-32 Leg Pain

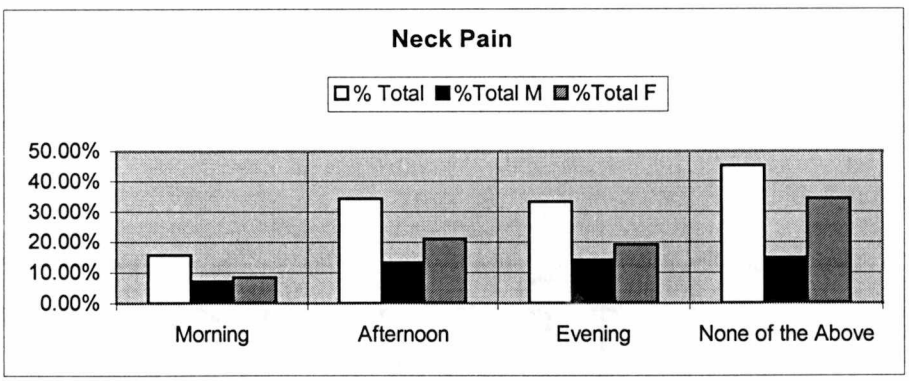



Figure 3-33 Neck Pain

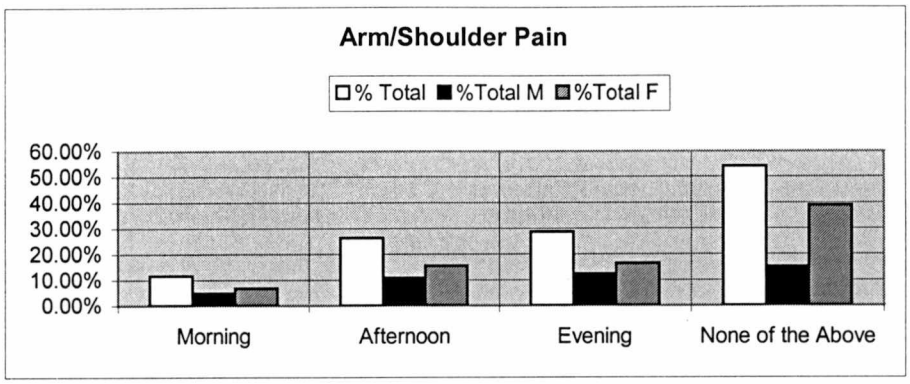



Figure 3-34 Arm/Shoulder Pain

reported that pain was felt almost equally in the afternoons with 15.6% and in the evenings with 16.4%, but the majority of females surveyed selected, "None of the Above," for 38.8% of the time. Therefore, when pain is felt in the arm and/or shoulder area, it is realized mostly in the afternoon to evening time frame. This would suggest an operator who is feeling the pains due to not using the best of ergonomics available to them.

Wrist pain or discomfort affects many computer workstation users. The majority (58.4%) of participants in this category fell into the "None of the Above" class (Figure 3-35). While this is over half, it still leaves 41.6% that do experience wrist pain or discomfort. Out of that 41.6%, the evening ranked as the majority (25.2%) when most users felt wrist pain or discomfort. The afternoon class followed this closely at 23.2%. Only 13.2% of the population experience pain in the morning. This leads to the assumption that when wrist pain or discomfort is felt, it will be either in the evening or afternoon. This further induces that the wrist pain or discomfort is brought on by possible misuse of computer workstation ergonomics.

Eyestrain is becoming more common in computer workstation users. Special glasses

need to be worn at times by some users to help the eyes become better accustomed to the computer viewing screen. The percentage of total participants were the closest in this category with "None of the Above" having the majority at 44% (Figure 3-36). The afternoon and evening choices followed closely at 26% and 35.6% respectively.

The total percentage of males (15.6%) reported to have no eyestrain, but the afternoon and evening percentages were very close in this class as well. There is only a .4% difference in those reporting no eyestrain and those reporting eyestrain in the evening. The difference increased in the afternoon range to 8%, and only 5.2% reported having eyestrain in the morning.

The total percentage of females (28.4%) reported having no eyestrain, but the differences between having no eyestrain and having it in the afternoon or evening ranged from a difference of 10% to 8%, respectively. Those reporting eyestrain in the morning was a mere 6.4%. This shows that although the majority of participants do not have problems with eyestrain, those that do have problems are mostly females and have problems mainly in the evening.

Headache pain can be another crippling ailment to the computer workstation

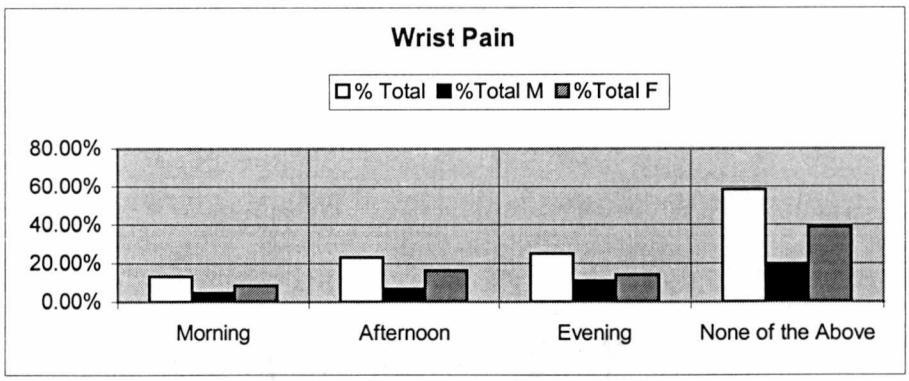



Figure 3-35 Wrist Pain

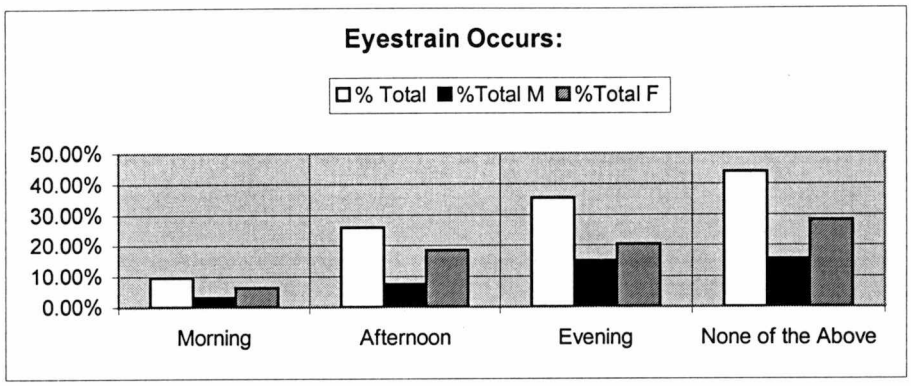



Figure 3-36 Eyestrain Occurs

operator. Headaches can also brought about by the lack of healthy vision care. Eyestrain, fatigue, muscle tension are just a few of the items that can onset a headache. The majority of data points (60%) in this category is overwhelmingly, "None of the Above" (Figure 3-37). The other choices were not even close in this class, with the closest being evening at 23.6%, followed by afternoon at 19.2%. The least percentage of participants reported that the morning (11.6%) was the least likely time they might have a headache.

These percentages did not differ much in males with 20.4% reporting to have no headache problems. That number was cut nearly in half with headaches being reported in the evening only 10% of the time. This dwindles down to just over 5% in the afternoon and mornings.

Females on the other hand, reported with a little bit higher percentages. The majority of females (39.6%) reported as having no headache problems. That number was cut into a third with headaches being reported in the evening at 13.6% of the time. The afternoon percentage (12.4%) nearly doubles that of males and the morning percentage (6.4%) is just barely more than the male counterparts.

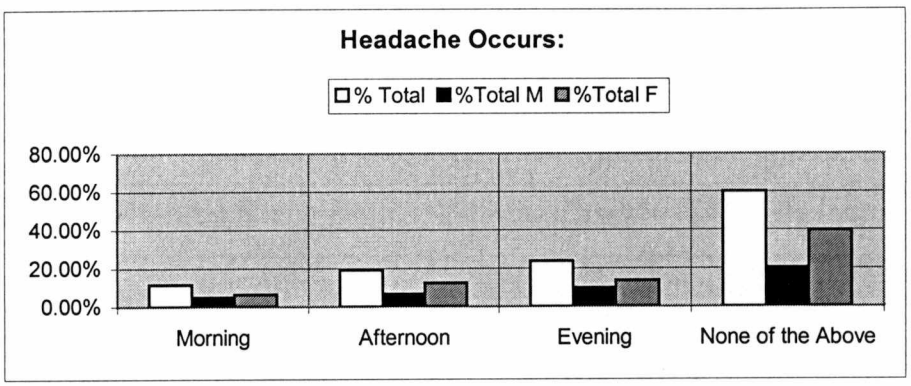



Figure 3-37 Headache Occurs

Posture is very important while working at a computer workstation. It is also something that is constantly changing, especially when working at a computer workstation an entire workday. There were a couple of different views on what the correct posture should be in the literature review, but the majority of participants (42%) in this survey reported that they sit in an upright position while working at their computer workstation (Figure 3-38). This is assumed to be the 90-90 posture of right angles at the elbows and hips. The question of whether the feet were resting flat on the floor was not asked and will not be discussed in this study. The second highest set of data points (32.8%) were those that reported to be leaning forward in their chair while they worked, and the third highest set of data points (22.8%) were those reported to be leaning back in their chair while they worked. Only 1.6% of the participants reported standing and another 1.2% of the participants reported working at their workstation in some other way not mentioned.

The majority of males (15.2%) reported to lean forward in their chairs while working, with the second ranking class (13.6%) to be those males sitting upright while working. Only 6.8% lean back while working and less than 1% reported either standing or working at their workstation in a way that was not listed.

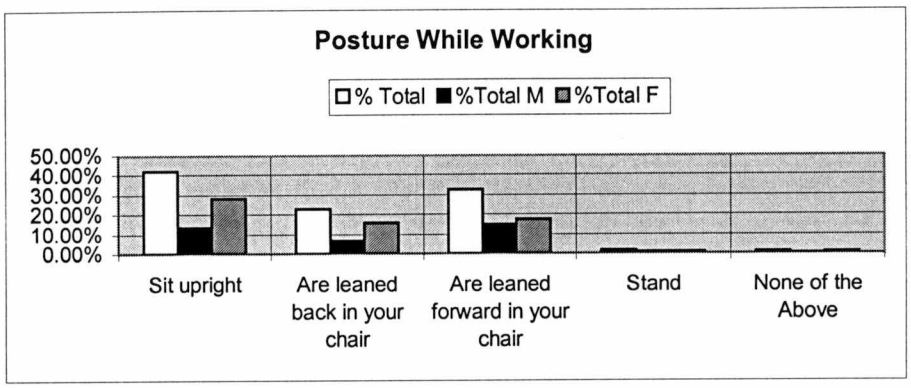



Figure 3-38 Posture While Working

The majority of females (28.4%) reported to sit upright while working at their computer workstation, with the second ranking class (17.6%) reported leaning forward while working. The percentage that reported leaning back while working is only 16%, while less than 1% reported as either standing or working in a way not listed.

The reasons why the participants sat the way they did was not asked in this survey and therefore no results of the reasons as to why so many of the participants are leaning forward cannot be answered during this study. Assumptions can be made that leaning forward in the chair to work at a computer workstation could cause potential problems for the user in the areas of the neck, back, arms, wrists, shoulders and legs. The questions of how long these postures were maintained was not asked, as well, so the assumption lies in that they are in these positions during their entire work cycle at the computer workstation.

**Previous Medical History**

The seventh and final category is associated with the participant's previous medical history. This category is important due to the fact that prior injuries obtained may have an affect on the computer workstation user, as to whether they are using correct ergonomics or not. Prior back or neck injuries may affect the way a computer

workstation user sits at their workstation. Prior surgeries may cause the muscles needed for good posture and working activities to be weak, thereby causing premature work-related injuries. A chronic illness may determine how long a person may work in one sitting, or the types of surroundings needed to function. Mental illnesses can affect the work of the computer workstation user as well. For instance, if a person is depressed over a situation, their mind may not be able to fully concentrate on the job at hand, thereby causing an inadvertent injury. Undue stress on a person caused by a mental illness may cause the muscles in the body to tense more, thereby causing excess strain and tension to various parts of the body. Whether or not a person enjoyed working at a computer workstation would also play into the mental psyche of each individual. Some people may have extra curricular activities that inadvertently affect their health while working. Such things as quilting or knitting could be adversaries to poor typing skills in developing carpal tunnel syndrome. More physically demanding activities such as canoeing, playing physical sports, or just running, could either help strengthen the muscle groups or increase damage if the participant is not following guidelines to maintain a healthy well-being. And one of the most important things to remember is to take frequent breaks away from the workstation. Several small breaks and at least one long break should be taken per eight-hour workday.

The overall responses in the "Previous Medical History," category reflects that a majority of the participants (81.2%) have not had a previous computer related injury (Figure 3-39). This fact remains true when testing for males and females individually. The responses of participants that did state having previous computer related injuries are given in Appendix E.

The majority of the population (51.6%) retains that they have not had surgery at any time prior to taking the survey (Figure 3-40), but that majority is only by a small margin of 3.2%. Therefore it is safe to say that almost half of the population has had some type of surgery. The margin remains close when testing for males and females individually, with males at a 2.4% difference in yes/no responses and females at a .8% difference in yes/no responses. The responses for the different types of previous surgeries are given in Appendix F.

Almost three-fourths of the population (74.4%) reports as not having any chronic illnesses (Figure 3-41). This fact changes for individual males with only a 17.2% difference in yes/no responses and is a little bit more distant for females with a 37.6% difference in yes/no responses.

The majority of the population (87.6%) is reported as never having any mental illnesses (Figure 3-42). The majority remains the same for individual population statistics, but with males reporting at a 26.4% difference in yes/no responses and females reporting at a 48.8% difference in yes/no responses. This leads to the assumption that three times as many females have problems with mental illnesses than males.

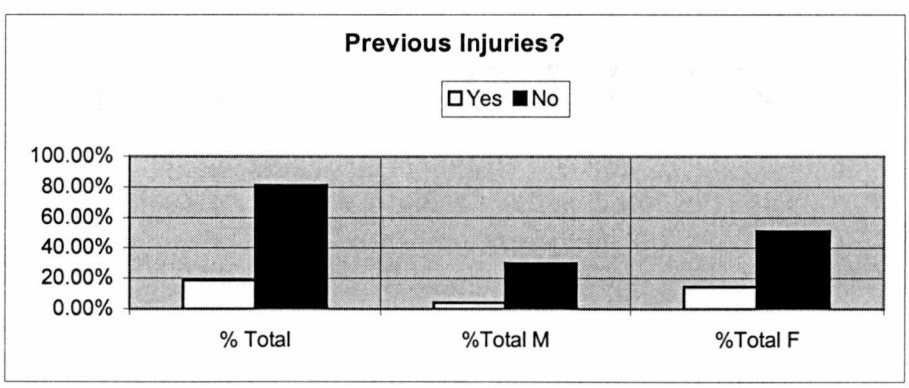



Figure 3-39 Previous Injuries

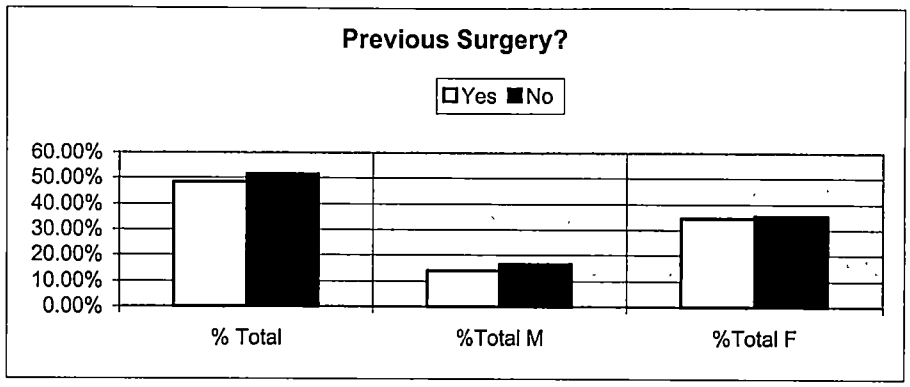



Figure 3-40 Previous Surgery

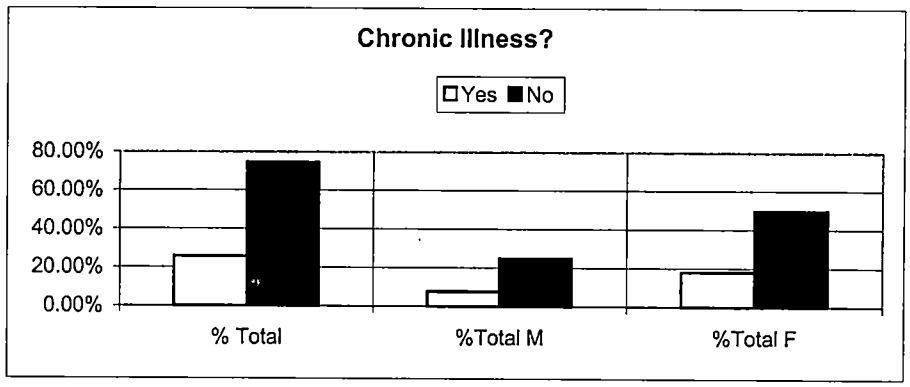



Figure 3-41 Chronic Illness

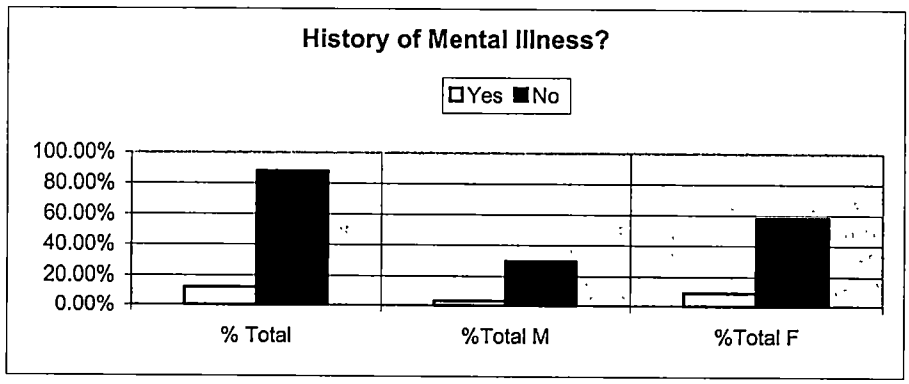



Figure 3-42 History of Mental Illness

An overwhelming 97.6% of the population reported that they enjoy their work (Figure 3-43). This fact remains at almost a constant ratio when testing individual males and females. It is of great importance to the mental well being of the computer workstation operator to enjoy his work. This produces less stress and tension.

A little over three-fourths of the population (79.6%) reported to have frequent hobbies (Figure 3-44). While this is a good thing, it can also complicate a diagnosis being made as to whether a computer workstation operator has been hurt while working or has been hurt previous to coming to work. The added muscular strain needed to be actively involved in extracurricular activities could prove to be a hindrance to the computer workstation operator if proper guidelines and precautions are not heeded during the activities. Of all males in the population, 30.8% reported as having frequent hobbies. The percentage for females in the population that reported having frequent hobbies was 48.8%. Therefore, almost a third more females have frequent hobbies. The responses for the different types of hobbies are given in Appendix G.

Taking frequent breaks are vital to maintain good health while working, especially at a computer workstation. The work is so sedentary that frequent breaks must

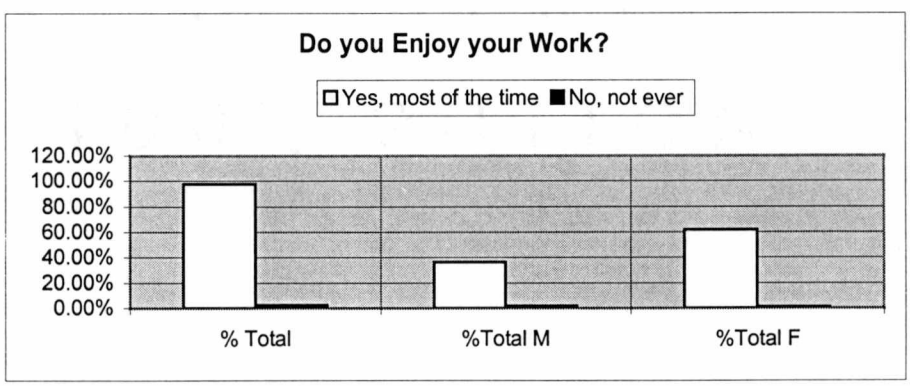



Figure 3-43 Do you Enjoy your Work

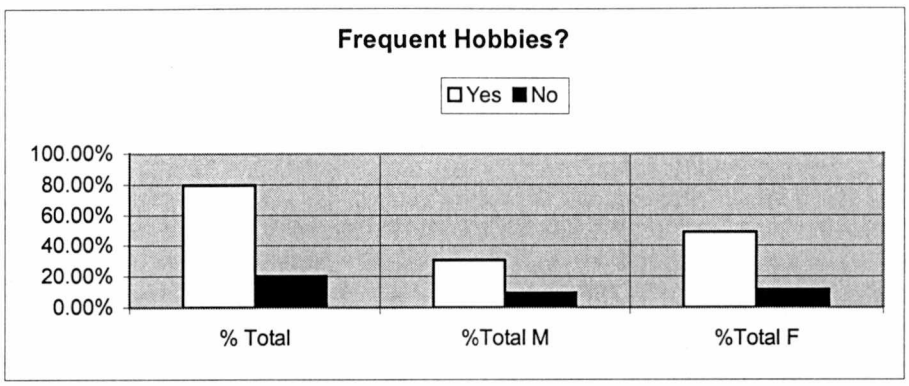



Figure 3-44 Frequent Hobbies

be taken so as to relieve the body of such things as static posture. The eyes also need to be constantly lubricated. Taking frequent breaks is better than by trying to remember to blink. A five-minute break is all that would be needed, several times per day.

The majority of the population (35.2%) reported as only taking 0-1 short breaks per day (Figure 3-45). This category was evenly matched, with 2-3 short breaks per day being recorded at 34.4% and 4 or more short breaks per day being recorded at 31.6%. Being even is not necessarily a good thing in this category. The majority of short breaks should have been 4 or more to accommodate the body to rest between work and it should have been an overwhelming majority, not just a slight margin.

Males actually did a little better at taking short breaks than females did. The majority of males (15.2%) took 2-3 short breaks per day, with 4 or more short breaks following closely at 14.8%. Females were in the majority of 0-1 short breaks at 27.2% and lagging behind that were the choices of 2-3 and 4 or more with 19.2% and 16.8% respectively.

Long breaks are important as well, but no so much as if several short breaks were taken. This is due to the body's need to refresh itself in short intervals, rather than in just one long spurt. The ideal is to have several short breaks and one or two long breaks

during an eight-hour workday. Most computer operators take their long break during the lunch hour, which is a good time since that is usually during the middle of the workday.

The majority of the population (54.4%) takes only 0-1 long breaks per workday (Figure 3-46). The time of day that the long break was taken is not part of this study. The majority of males (24.8%) also fell into the 0-1 long break class, as did the majority of females at 29.6%. From these statistics, it appears that more females take the long breaks then their male counterparts.

The opportunity was given for participants to insert any additional comments. The comments received are given in Appendix H. The completed table for all statistics can be found in Appendix I.

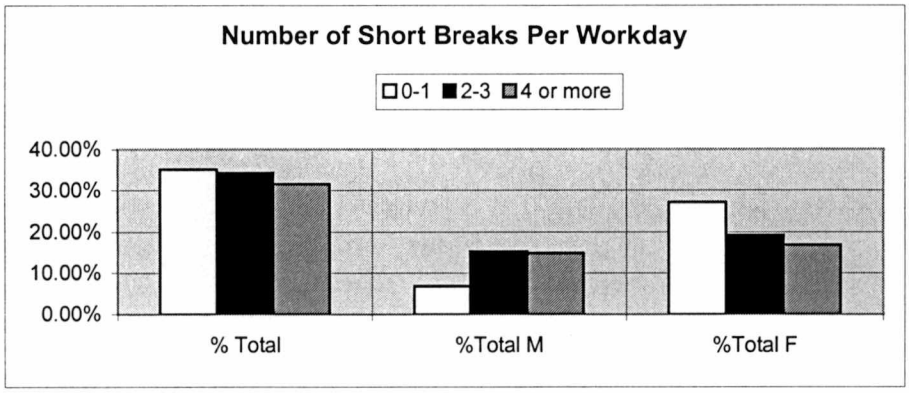



Figure 3-45 Number of Short Breaks Per Workday

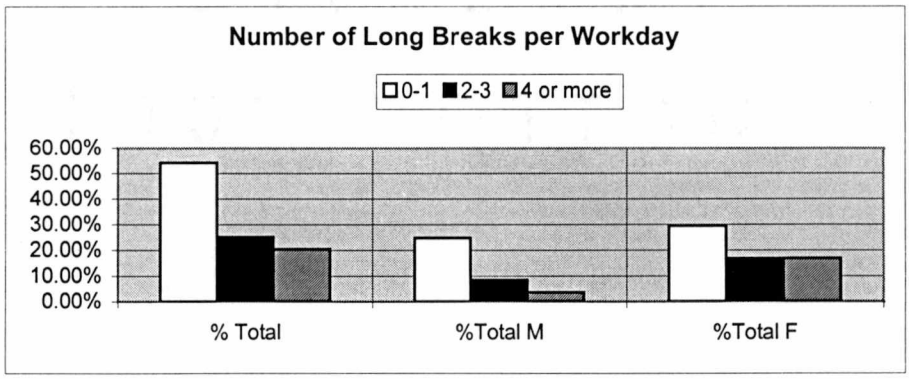



Figure 3-46 Number of Long Breaks per Workday

# Chapter 4: Using the Statistical Survey in the Ergonomic Workplace

Statistical survey methods are an excellent way of studying the ergonomic workplace. A survey can be set up to obtain the information needed. So many variances can be detected from a single survey. For instance, the survey used in this thesis found numerous amounts of information that can be used in future studies of the computer workstation field.

One specific piece of statistical information that was discovered was that of the weights of the participants varying greatly with that of the West Virginia Dietary Association. Three sources of information were used in this discovery: the participants in the Computer Workstation survey, the body dimension tables of U.S. civilian adults in Ergonomics [66] and the ideal weight tables from the West Virginia Dietary Association. [81]

The computer workstation survey showed the majority of males weighing between 180 and 219 pounds. Ergonomics, [66] states that the $50^{th}$ percentile male should weigh 165 pounds and the $95^{th}$ percentile male should weigh 218 pounds. These two statistics comply with one another, but a further look shows that the West Virginia Dietary Association [81] states that the ideal body weight for an adult male in this class should weigh between 160 and 184 pounds. That is a 25-pound difference in maximum weights of adult males with the males in the survey weighing the greater and only 32.9% falling into acceptable range. Calculations are in Appendix J. Figure 4-1 shows this in a normal distribution graph.

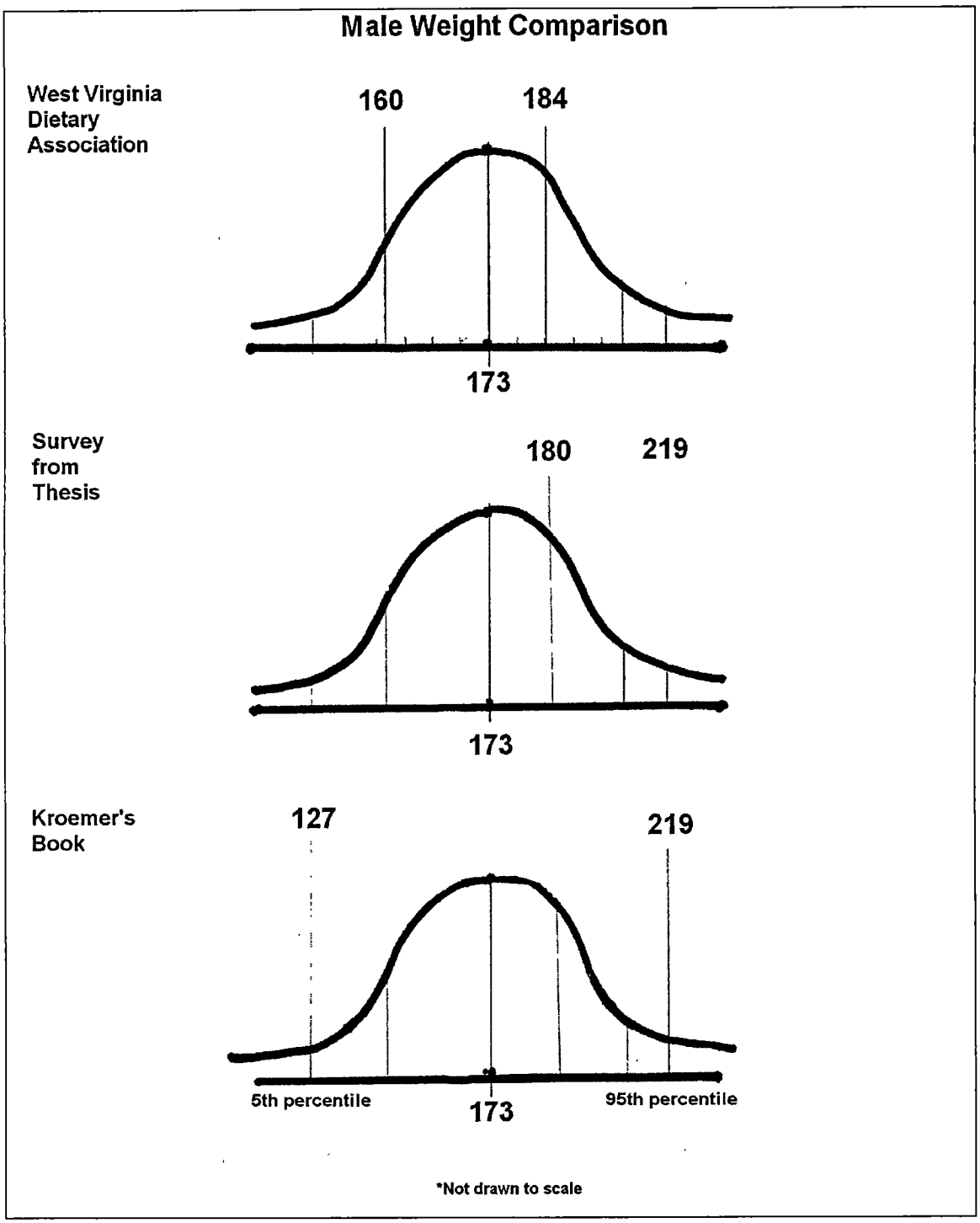



Figure 4-1 Male Weight Comparisons

The computer workstation survey showed the majority of females weighing between 140 and 179 pounds. Ergonomics, states that the 50th percentile female should weigh 136 pounds and the 95th percentile female should weigh 187 pounds. These two statistics comply with one another, but a further look shows that the West Virginia Dietary Association states that the ideal body weight for an adult female in this class should weigh between 120 and 140 pounds. This shows that the 95th percentile female from Ergonomics [66] weighs 33 more pounds that the maximum ideal body weight of the West Virginia Dietary Association and the females in the survey has their minimum weight equal to the West Virginia Dietary's maximum weight. [81] This means that only a mere 25.02% of females will fall into acceptable range for ideal weight. Calculations are in Appendix J.

The problem lies in the question of whether the standards for weight are fallible. Are the industry standards correct for the weights of the adult population? Could the designs in production now, be being designed for the wrong class of people? Could this account for the amounts of computer injuries still existing? Those answers are not in this study, but are some that need answering. Figure 4-2 shows this in a normal distribution graph.

Another difference that came up was that of height. Imagine a person in the 95th percentile of males with a standing height of 6.2', a knee height of 2.02' and working for hours a day at a workstation that only allows for 1.9' for knee height. This would cause some pretty uncomfortable working conditions. The opposite could also hold true for the adult falling in the 5th percentile. In this case, the standing height of 5.5' with a knee height of 1.71' could be less than what the workstation is designed for. Complications

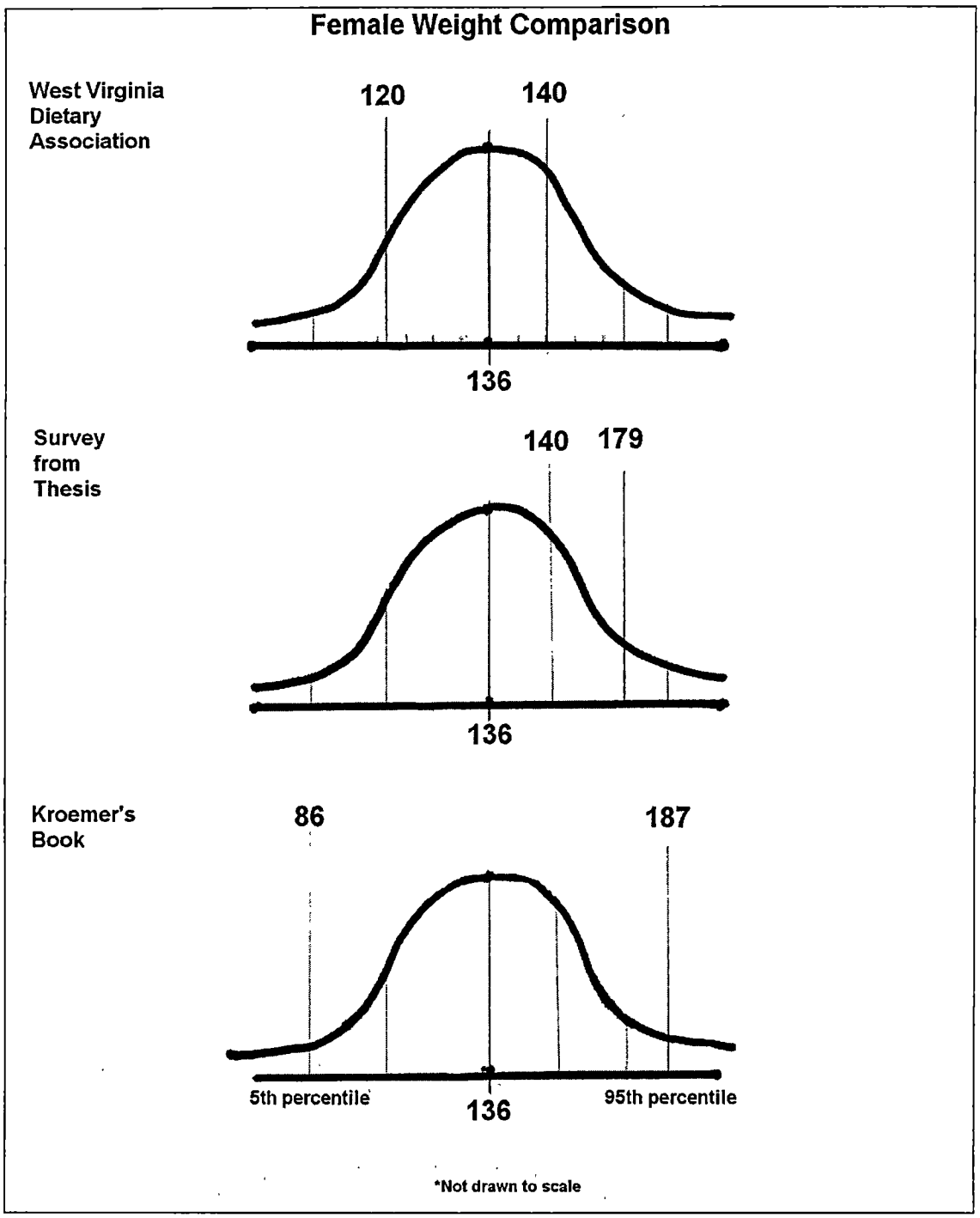



Figure 4-2 Female Weight Comparison

Table 4-1 Height Comparisons

| 5th Percentile | | 50th Percentile | | 95th Percentile | | Standard Deviation |
|---|---|---|---|---|---|---|
| Female | Male | Female | Male | Female | Male | cm/ft |
| 152.78 cm | 164.69cm. | 162.94cm. | 175.58cm. | 173.73cm. | 186.65cm. | Female 6.36/.21 |
| 5.01 ft. | 5.4 ft. | 5.35 ft. | 5.76 ft. | 5.7 ft. | 6.12 ft. | Male 6.68/.22 |

Table 4-2 Knee Height Comparisons

| 5th Percentile | | 50th Percentile | | 95th Percentile | | Standard Deviation |
|---|---|---|---|---|---|---|
| Female | Male | Female | Male | Female | Male | cm/ft |
| 47.40 cm | 51.44cm. | 51.44cm. | 55.88cm. | 56.02cm. | 60.57cm. | Female 2.63/.086 |
| 1.55 ft. | 1.69 ft. | 1.69 ft. | 1.83 ft. | 1.84 ft. | 1.99 ft. | Male 2.79/.092 |

could arise from the user's feet not being able to reach the floor, as well as, the wrists not being capable of maintaining a horizontal working position. Table 4-1 shows the relative differences in heights of adult males and females and Table 4-2 shows the relative differences in their respective knee heights. The neck and shoulders may also suffer from height discrepancies. This could be due to the user tilting back his head repeatedly to compensate for the difference in height.

There was also a difference in what the standards were for height as well as there were for weight. Males ranged from a 5th percentile height of 5.5' to a mean of 5.9' to a 95th percentile of 6.2'. The majority of males in the survey fell into the class of 5'9" to 6'1", thereby falling within acceptable range. Figure 4-3 shows this in a normal.

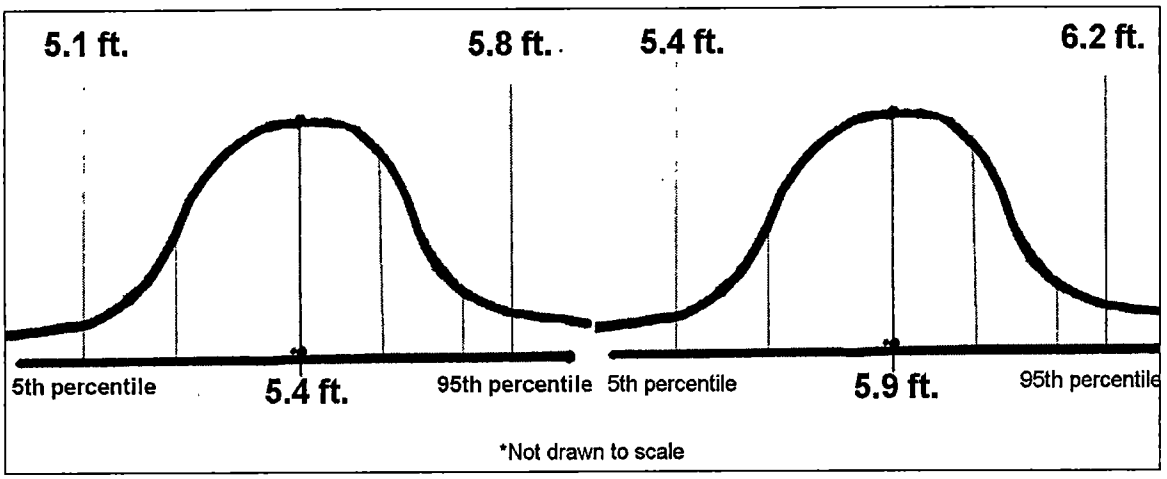



Figure 4-3 Male and Female Height Comparison (from left to right)

distribution graph. Females also showed a difference, but like their male counterparts, still fell into acceptable range for heights.

Weight and height were just two specific items that were discussed in how new designs could be given new considerations. There are other questions that could be asked, such as, "What is the probability that the majority of males in the classes of weight and height, will have some type of work-related pain during the course of a work day?" In the survey used in this thesis, there was a notable difference in the amount of pain that was suffered by females over that of men. Could that be because of the height differences? Could it be due to weight?

Many separate studies could be taken from this one survey. Scientists may want to break down the raw data into categories of just gender and pain. For instance, it is also possible to find out exactly how many males of specific weight and height reported having eyestrain during the evening. The statistics could further be broken down to find out if those same males also reported sitting leaned back in their chair while working.

This could lead to the assumption that males sitting in a leaned back posture while working are more or less probable to develop eyestrain.

There are literally hundreds of possible combinations in this survey to find out statistical evidence of injuries of computer user's while working at a computer workstation. This specific survey would not have to be used. Variations of it could be used instead. Depending on the workplace and specific duties of the computer workstation operator, the survey may want to be adjusted for a better fit. For instance, if most operators are stranding, that should definitely be incorporated into the survey. Another instance would be if different types of lighting were being used throughout the day. The different shades of light could affect the eyes. Or, perhaps all operators are required to wear some type of protective glasses or clothing.

Whether or not the survey is adjusted would be up to the employer. Whether or not the statistical evidence produced by the survey is used by the employer, would still be up to the employer. But whether or not the employee heeds the changes or advice would be left up to the individual operator. What this boils down to is the fact that no one incident or person can be blamed for computer workstation injuries. There are too many factors involved for this to be true. The employer should have an expert in computer workstation ergonomics assess each employee for the work they will be doing and then follow through with successive check-ups to make sure the advice is being followed. The employee has the responsibility of following the advice and the recommendations of the employer and informing them of any discomforts that may still be occurring. Taking every precaution to prevent an injury may still not do so, but making sure everyone is

doing their part and doing it to the best possible medical way known, should make injuries while working at a computer workstation become a concern of the past.

# Chapter 5: Summaries and Conclusion

## Summaries

Injuries obtained while working at a computer workstation have become a growing concern. With the computer becoming more and more popular in just about every office environment as well as other industry environments, special precautions need to be looked at with special care. So much focus on injuries has always been on the musculoskeletal type, and this is not to say that that area still needs addressing, but the computer workstation operator should not be shoved into just that category. Ergonomics experts in the field of computer workstations have accomplished great strides in the last few decades. There are numerous amounts of "ergonomically correct" computer workstation equipment and accessories available to the consumer. But the questions still lie, "Is all this ergonomically correct workstation equipment and accessories being used by the employer and furthermore, is it being used to best fit the computer operator? And last but not least, is the computer operator using this equipment and advice to better help themselves maintain a healthy body?"

From the literature review, it is plain to see that there are many books, journals and articles written on the correct postures, visual aids and "ergonomically correct" workstation equipment. Most of the advice given in the review is fairly concise with one another, with a few variances here and there. It is also plain to see that the science of ergonomics is relatively new in the computer workstation field and new things are being discovered daily. One major variance was that of the computer operator's posture being changed from the 90-90-90 posture, to one of 120 degrees, but the greatest consensus was

that of the computer operator changing positions frequently to avoid stiffness to the joints as well as to help keep the eyes lubricated.

One of the main concerns that arose during the literature review was that of the effects occurring to the eyes. Far little attention is given to the damage involving the eyes. This is due to the fact that musculoskeletal injuries cost the company so much more in workman's compensation claims. Preventative treatment for the eyes could save the company even more money and employee health over time. With the increased time spent working in front of a computer monitor, the eyes, the damage to them and the damage invoked to other parts of the body by the misuse of them, could turn into an increased cost for the employer when instead the employer could just invest in some preventative measures.

Another concern that arose was that of electromagnetic radiation. This is a fairly new concept in the field of computers, and has been better known in the field of television. While still rare world wide, the people that have obtained injuries from electromagnetic radiation find it a far worse problem than either that of the eyes or the musculoskeletal disorders. It is an extremely crippling disease that when obtained can cause a person to become a recluse in an almost primitive living environment. For those persons working at a computer workstation who are electrically hypersensitive, the outcome can be disaster. There are relatively easy steps to overcome this initially. Magnetic shields used with the monitors can prevent any injury to the person working there. LCD screens are another way of avoiding the electromagnetic rays. The monitors of the future will most likely all be of the Liquid Crystal Display type.

The survey presented in this thesis gave statistical evidence that in actuality, people were not using all the helpful ergonomic information available to them. It appears that there are nearly twice as many females as men working at computer workstations and of those females, that they are not all using the best in ergonomics. This could be the case, or the case could be that the standards given by and to the industry are not always the best ones to measure acceptability. The case of different sets of weight standards is of major concern. Out of the two sets of standards used for measuring weight, only one complied with the data retrieved from the survey. This was the set from Kroemer, Kroemer and Kroemer-Elbert. [65] The data retried from the survey was nowhere near acceptable range for the second set of data from the West Virginia Dietary Association. [81]

Fluorescent lighting was found to be greatly used, which is also a concern with regards to glare and electromagnetic radiation. Most people were satisfied with the climate of their work area as well as the color of the surroundings. This makes working more enjoyable.

There were very few people that reported having non-adjustable chairs. Most people's chairs had armrests and wheels. The types of chair backs were of two major types: That of having a high, curved, cushioned back and that of having a low, curved, cushioned back. The high, curved, cushioned back was the most widely used. Measurements of chair back heights were not given in this study. The height was subjective to the individual participant. Nearly all participants reported having a cushioned seat for their chair. As far as chairs are concerned, it appears that most people are using them in a ergonomically correct fashion.

Of all the people surveyed, most people reported wearing glasses all the time, but the same amount also reported as not wearing any type of special computer glasses while working at a computer workstation. With most people reporting using a 17" monitor, the later report of neck and eyestrain may be due to not wearing special glasses. The fact that nearly all user's positioned their color monitor directly in front of them is beneficial to them regarding straining the neck to view the monitor at a correct angle. The lack of glare screen usage is of concern. Prolonged use of computer monitors without a glare screen could eventually cause eyestrain as well as strains to the neck and back. This is due to adjusting the posture to incorrect positions to accommodate the lack of correct visual requirements.

With the monitor being placed directly in front of the user, it was good to find nearly all participants also had their keyboards placed directly in front of them too. The decision by participants to tilt their keyboards was nearly equal to that of those choosing to keep it level. Most people did not use an ergonomic keyboard, but the opinion on whether that is a good thing or not is still too undecided to comment on. Most people did not use wrist supports either, which could bring on further bouts of carpal tunnel or other repetitive strain injuries. A desk seemed to be the most popular choice of workstation with carpet being the most popular type of flooring. The types of desks were not discussed in this study.

While the majority of people did not complain of having any of the body pains listed, there were still significant amounts of pain reported by females in the neck, arms/shoulders and eyes. Both males and females that did report having pain, reported as having it mostly in the afternoon or evening. This would lead to an assumption of work-

induced pain. Posture while working was reported as sitting upright, followed closely by those participants that lean forward in their chairs. Routinely changing posture is suggested as being the best alternative to continually sitting in any position for hours a day.

Almost the entire population of this study has had some type of previous surgery, with the majority of those being females. This could also be a factor in distinguishing computer workstation injuries due to the fact of already having weakened muscles. Chronic or mental illnesses did not seem to be of major concern for the computer workstation users. The work psyche of the user appears stable since most people reported enjoying their work. Another reason for this might be attributed to so many of the participants having frequent hobbies. Of course, the muscles used for working at a computer workstation could also be hindered by hobbies if not used in a safe and correct manner. An alarming amount of users reported as only taking 0-1 short breaks per day. Although this equaled to a little over one-third of the population, that number is still too great. Computer workstation users must learn to take more short breaks. Even though the number of people taking long breaks was greater still, this is not so important as taking short breaks.

**Conclusion**

The beliefs that instigated this thesis were those of computer workstation user's not applying all the ergonomic information that is available to them to help prevent computer related injuries. This alone would be a major factor in the amount of injuries still occurring. But whose responsibility is it to ensure that all possible guidelines are being met? It is the responsibility of everyone. The employer, the employee, the design

engineers, and the medical professionals must constantly work together to provide a safe environment for the computer workstation user. Only by working concurrently will this happen. From the survey, it is plain to see that the population is not fully complying with the information presented in the literature review. From the statistical models, it is obvious that not all standards are equal. As long as these practices remain, the computer workstation user will continue to suffer injuries. This thesis is presented to point out these differences so that the health of the computer workstation user may soon be taken more seriously by all those connected.

# References

## References


1. Access Health, Inc. "Common Vision Problems" June 1999. http://www.yourhealth.com/ahl/1700.html 1996

2. American Academy of Ophthalmology. "Anatomy of the Eye" Feb. 1998. http://www.eyenet.org/public/anatomy/anatomy.html 1996-2000

3. American Academy of Ophthalmology. "Computers and Eye Strain" Feb. 1998. http://www.eyenet.org/public/pi/eye_health/safety/computers_faq.html 1996-2000

4. American Academy of Orthopaedic Surgeons Low Back Pain Park Ridge: Park Ridge: American Academy of Orthopaedic Surgeons. 1996.

5. Ankrum, D.R. Viewing Distance at Computer Workstations. Workplace Ergonomics, 2, 5, 10-13. 1996

6. Ankrum, D.R., Hansen, E.E., and Nemeth, K.J. The vertical horopter and the angle of view, In A. Grieco, G. Molteni, B. Piccoli and E. Occhipinti (eds.), *Work With display Units `94* Elsevier: Amsterdam 1995

7. Anshel, B.S., O.D. "Blurred Vision." Easing Eyestrain for Computer Users. " Dec. 1998. http://www.cvconsulting.com/blurred.htm . January 1999.

8. Anshel, B.S., O.D. "Burning or Red Eyes." Easing Eyestrain for Computer Users. Dec. 1998. http://www.cvconsulting.com/redeye.htm. January 1999.

9. Anshel, B.S., O.D. "Computer Vision Syndrome: Causes and Cures." Easing Eyestrain for Computer Users. Dec. 1998. http://www.cvconsulting.com/cures.htm. January 1999.

10. Anshel, B.S., O.D. "Double Vision." Easing Eyestrain for Computer Users. Dec. 1998. http://www.cvconsulting.com/double.htm. January 1999.

11. Anshel, B.S., O.D. "Dry Eyes." Easing Eyestrain for Computer Users. Dec. 1998. http://www.cvconsulting.com/dryeyes.htm. January 1999.

12. Anshel, B.S., O.D. "Diagnosis and Treatment." Easing Eyestrain for Computer Users. Dec. 1998. http://www.cvconsulting.com/diagnosis.htm. January 1999.

13. Anshel, B.S., O.D. "Providing Eyecare for your VDT Workers." Easing Eyestrain for Computer Users. Dec. 1998. http://www.cvconsulting.com/providing.htm. January 1999.

14. Anshel, B.S., O.D. "Slow Refocusing." Easing Eyestrain for Computer Users." Dec. 1998. http://www.cvconsulting.com/slow.htm. January 1999.

15. Anshel, B.S., O.D. "Sore or Tired Eyes." Easing Eyestrain for Computer Users. Dec. 1998. http://www.cvconsulting.com/sore.htm. January 1999.

16. Anshel, B.S., O.D. "Suggestions for Improving Comfort at a Video Display Terminal Workstation." Easing Eyestrain for Computer Users. Dec. 1998. http://www.cvconsulting.com/suggestions.htm. January 1999.

17. Anshel, B.S., O.D. "Vision Health Management." Easing Eyestrain for Computer Users." Dec. 1998.
http://www.cvconsulting.com/ergonomic.htm. January 1999.

18. Anshel, Jeffrey R. Dr. "Improving Visual Discomfort at a Computer Workstation" Dec. 1998. http://www.tifaq.com/articles/visual_comfort-jan99-jeffrey_anshel.html. January 1999.

19. ANSI. "American National Standards Institute." Standards. http://www.ansi.org/ (22 July 2000).

20. Armstrong, T. "An Ergonomics Guide to Carpal Tunnel Syndrome." Ergonomics Guides. 1983.

21. Bailin, Jonathan, Ph.D. RSI@USC.EDU. "Ergonomics & Computer Injury: FAQs" http://www.netsci.org/Science/Special/feature01.html. 1995.

22. Balfour, David. D.O. "Computer Vision Syndrome." The DoctorVision Homepage. July 25, 1999. http://www.doctorvision.com/cvs.html (July 26, 1999)

23. Borish IM. Clinical Refraction. 3rd ed. Chicago: The Professional Press,1970: 180.

24. Bureau of Labor Statistics, U.S. Department of Labor, (personal email) October 25, 2000.

25. Campbell, F.W. and K. Durden. The visual Display Terminal Issue: A Consideration of Its Physiological, Psychological and Clinical Background. Ophthalmology. Physiology. Opt., Vol. 3(2), pp.175-192,1983

26. Campbell, F.W. and T.C.D. Whiteside. Induced Pupillary Oscillations. British Journal of Ophthalmology, Vol. 34, pp.180-189, 1950

27. Carpal Tunnel Syndrome Home Page. "Carpal Tunnel Syndrome Page." http://www.netaxs.com/~iris/cts/welcome.html May 2000.

28. Chaffin, D.B. "Localized Muscle Fatigue – Definition and Measurement." Journal of Occupational Medicine 15.4 (1973): 346-354.

29. Chicago Legal Net. "Carpal Tunnel Syndrome." http://www.chicagolegalnet.com/carpal.htm March 2000.

30. Collins, C., O'Meara, D., and Scott, A.B. "Muscle strain during unrestrained human eye movements." Journal of Physiology 245 (1975): 351-369.

31. Cornell University Human Factors Group. "Performance Oriented Ergonomic Checklist For Computer (VDT) Workstations" 1996 http://ergo.human.cornell.edu/VDTChecklist.html. December 1999.

32. FEB - The Swedish Association for the ElectroSensitive "About ElectroSensitivity" http://www.feb.se/FEB/AboutES.html August 1999

33. FEB - The Swedish Association for the ElectroSensitive "The development of VDT problems and Electrical Hypersensitivity" 1994 http://www.feb.se/FEB/feb_info.html August 1999.

34. Field Management Services. "Electromagnetic Radiation Spectrum" http://www.fms-corp.com/emf-spectrum.htm July 2000.

35. Field Management Services. "EMF Basics" http://www.fms-corp.com/emf-basics.shtml. July 2000.

36. Field Management Services. "EMFs 101" 1997 http://www.noradcorp.com/emfs101.htm July 2000.

37. Field Management Services. "Frequently Asked Questions" 1999 http://www.fms-corp.com/emf-concern.htm. July 2000.

38. Field Management Services. "Physics" 1996-1998. http://www.fms-corp.com/emf-physics.shtml. July 2000.

39. Field Management Services "The Swedish Standards" http://www.fms-corp.com/mprii-swedish.htm July 2000.

40. Field Management Services "Types of Monitor Interference" 1996-1998. http://www.fms-corp.com/monitorinterference.htm July 2000.

41. Fisher, R.F. "The force of contraction of the human ciliary muscle during accommodation. "Journal of Physiology 270 (1977): 51-74.

42. Fisher cited in Van Noorden, G.K. Binocular vision and ocular motility. St. Louis, MO: C.V. Mosby. 1985

43. Fry, G.A. and V.M. King. The Pupillary Response and Discomfort Glare. Journal of the Illuminating Engineering Society, pp. 307-324, July 1975

44. Grandjean, E. Ergonomics in Computerized Offices. London; New York: Taylor and Francis. 1987. Vol: viii, 227p.: ill.; 26cm.

45. Healthy Computing Newsletter "A Question of Inches" http://www.rsinomore.com/archives.htm June 1999

46. Healthy Computing Newsletter. "Everyday Challenges – Dry Eye" http://www.rsinomore.com/pcguide.htm June 1999.

47. Healthy Computing Newsletter "Factnology" http://www.rsinomore.com/archives.htm June 1999.

48. Healthy Computing Newsletter. "PC and Laptop Ergonomic Guide" http://www.rsinomore.com/pcguide.htm June 1999.

49. Healthy Computing Newsletter "UltraViolet Light – The Invisible Threat" http://www.rsinomore.com/archives.htm June 1999.

50. Healthy Computing Newsletter "Vascular Headaches" http://www.rsinomore.com/archives.htm June 1999.

51. Hedge, Alan. "Minimizing Carpal Tunnel Syndrome Risks." Cornell Theory Center. 1995. http://www.tc.cornell.edu/er95/ff02spring/ff06carpal.html May 2000.

52. Heuer, H., and D. Owens. "Vertical gaze direction and the resting posture of the eyes." Perception 18 (1989): 363-377

53. Hiles, Michael L. "CRT Interference Induced by Magnetic Fields" http://www.fms-corp.com/computer-service.htm (30 April 1999)

54. IBM. "Contrast and Color" The Eye. Apr. 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt13con.html. October 2000.

55. IBM. "Glare Screens" The Eye. Apr. 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt12.html. October 2000.

56. IBM. "Lack of Blinking: Dry Eyes" The Eye. Apr. 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt11eyec.html. October 2000.

57. IBM. "Pupil Size and Acuity" The Eye. Apr. 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt13eyec.html. October 2000.

58. IBM. "Spectral Sensitivity" The Eye. Apr. 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt13conb.html. October 2000.

59. IBM. "The Eye Muscles" The Eye. Apr. 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt13eyeb.html. October 2000.

60. IBM. "The Human Optical System" The Eye. Apr. 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt13eye.html. October 2000.

61. IBM. "Vision Questions & Answers" Question and Answers. Apr. 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt10.html IBM. "Workstation Dimensions and Positioning" The Eye. October 2000. http://www.pc.ibm.com/ww/healthycomputing/vdt11eyea.html

62. Jaschinski-Kruza, W. "Visual strain during VDU work: the effect of viewing distance and dark focus." Ergonomics 31, 10 (1988): 1449-1465.

63. Kimura, J. "Electrodiagnosis in Disease of Nerve and Muscles." 2nd ea., 1985, 14-15. 501-503.

64. Krimsky, E. The Management of Binocular Imbalance. Philadelphia: Lea and Febiger, 1948.

65. Kroemer, Karl, Henrike Kroemer and Katrin Kroemer-Elbert. Ergonomics – How to Design for Ease & Efficiency. Englewood Cliffs, NJ: Prentice Hall, 1994.

66. MacLeod, Dan, CPE. "90-90-90 and All That." http://www.danmacleod.com/right.htm October 2000.

67. Medical Reference Guide. "L – Definition and Links." University of Maryland Medicine Medical Glossary. http://www.umm.edu/glossary/l/index.html. May 2000.

68. Menozzi, M., A.V. Buol, H. Krueger, Ch. Meige and C. Pedrono "Fitting Varifocal Lenses: Strain as a Function of the Orientation of the Eyes in Ophthalmic and Visual Optics." Technical Digest Series – Optical Society of America 3 (1992): 134-137.

69. Moon, Ken. "OUCH! The Physical Toll of Computer Use." ISP/OOP Group's Online Magazine. http://www.online-magazine.com/ouch.htm. April 1998.

70. National Center for Chronic Disease Prevention and Health Promotion. "Arthritis: The Nation's Leading Cause of Disability." http://www.cdc.gov/nccdphp/arthritis/index.htm. October 2000.

71. Nelson, Roxanne. "A Light at the End of the Carpal Tunnel." WebMD. April 2000. http://webmd.lycos.com/content/article/1728.56761. May 2000.

72. Newberry, Johnny. "Choosing the Right Monitor" http://compreviews.about.com/compute/compreviews/library/weekly/aa071400a.htm. November 1999.

73. NIEHS. "ENVIRONMENTAL HEALTH INSTITUTE REPORT CONCLUDES EVIDENCE IS 'WEAK' THAT ELECTRIC and MAGNETIC FIELDS CAUSE CAN." http://www.niehs.nih.gov/emfrapid/html/EMF_DIR_RPT/pressrel.htm. June 1999.

74. NIOSH. "EMFs in the Workplace." Online. http://www.niehs.nih.gov/emfrapid/html/EMF_DIR_RPT/pressrel.htm. May 1999.

75. NoRad. "Jitter Box." http://www.noradcorp.com/jbox.htm. May 1999.

76. NoRad. "Measuring Fields." http://www.noradcorp.com/measure.htm. April 1997.

77. NoRad. "The Swedish Standards." http://www.noradcorp.com/measure.htm. April 1997.

78. NoRad. "Video Display Terminals as a Source of Electromagnetic Fields Part I." Electromagnetic Radiation. http://www.noradcorp.com/2tutor.htm. April 1997.

79. NoRad. "Video Display Terminals as a Source of Electromagnetic Fields Part II." Monitors Emissions. http://www.noradcorp.com/3tutor.htm. April 1997.

80. NoRad. "Video Display Terminals as a Source of Electromagnetic Fields Part III." Monitors and X-Rays. http://www.noradcorp.com/3tutor.htm. April 1997.

81. Nutrition Calculators. "The West Virginia Dietetic Association Dietary Calculators." Calories, Body Mass Index and Ideal Body Weight. http://www.wvda.org/calcs/. November 2000.

82. OSHA, DOL. "OSHA Press Release: Statement by Secretary of Labor Alexis M. Herman." http://www2.dol.gov/dol/opa/public/media/press/osha/osh98408.htm October 1998.

83. OSHA. "Ergonomics." http://www.osha-slc.gov/SLTC/ergonomics/. November 1999.

84. OSHA. "Ergonomic Report - SIC CODE 2711" Dec. 1992. http://www.osha-slc.gov/SLTC/ergonomics/ergonomicreports_pub/tw921209.html. November 1999.

85. OSHA. "Preventing Work-Related Musculoskeletal Disorders." Feb. 1999. Online. http://www.osha-slc.gov/SLTC/ergonomics/ergofactnew.html. November 1999.

86. Pecina, M., J. Krmpotic-Nemanic, A. Markiewitz. "Tunnel Syndromes." 1991, 55-67.

87. Perkinson, Duane A. "Factnology." VDT Solutions. Online. " http://www.rsinomore.com/ergofact.htm. March 1998.

88. Perkinson, Duane A. "Road Warriors: The home work environment – 5 ergonomic mistakes." PC and Laptop Ergonomic Guide. Online. http://www.rsinomore.com/pcguide.htm. March 1998.

89. Powell, Don R. "Your Complete Guide to Symptoms, Solutions, and Self-Care." June 1999. http://www.mcare.org/healthtips/homecare/EYESTRAI.HTM. February 2000.

90. Poynton, Charles. "Reducing Eyestrain from Video and Computer Monitors." March 1997. http://www.inforamp.net/~poynton/notes/reducing_eyestrain/index.html. January 2000.

91. Reeves, P. "The Response of the Average Pupil to Various Light Levels." Journal of the Optical Society of America 4 (1992): 35-43.

92. Rempel, David. "It's Your Body." Ergonomics Program. 1994. http://www.ME.Berkeley.EDU:80/ergo/tips/body.html May 2000.

93. Ripple, P. "Variation of Accommodation in Vertical Directions of Gaze." American Journal of Ophthalmology 35 (1952): 1630-1634.

94. VDT Solutions. "Innovations." Online. http://www.rsinomore.com/filter.htm December 2000.

95. VDT Solutions. "The Weightless State." Online. http://www.rsinomore.com/archives.htm. December 2000.

96. Vogel, Gary O.D. "The Eye-CEE System for VDT Users." Computer Vision Consulting. 1999. http://www.cvconsulting.com/cures.htm. December 1998.

97. Watson, D.H. and P.H. Trott "Cervical headache: an investigation of natural head posture and upper cervical flexor muscle performance." Cephalalgia 13 (1993): 272-284.

98. Webopedia. "CRT." Webopedia Definition and Links. Sept. 1996. http://webopedia.internet.com/TERM/C/CRT.html. January 1999.

99. Webopedia. "LCD." Webopedia Definition and Links. May 1998. http://webopedia.internet.com/TERM/L/LCD.html. January 1999.

100. Webopedia. "Monitor." Webopedia Definition and Links. May 1998. http://webopedia.internet.com/TERM/m/monitor.html. January 1999.

101. Webopedia. "Refresh." Webopedia Definition and Links. May 1998. http://webopedia.internet.com/TERM/r/refresh.html. January 1999.

102. Webopedia. "Resolution." Webopedia Definition and Links. May 1998. http://webopedia.internet.com/TERM/r/resolution.html. January 1999.

103. Webopedia. "Standard." Webopedia Definition and Links. June 1998. http://webopedia.internet.com/TERM/s/standard.html. January 1999.

104. Wilson, John R., E. Nigel Corlett. Evaluation of Human Work. London: Taylor & Francis Ltd, 1990.

105. Woodworth, R.S. and H. Schlosberg Psychology. New York: Holt, Rinehart and Winston, 1938.

# Appendices

# Appendix A

# Computer Workstation Survey

# Computer Workstation Survey

The following is a survey relating to various injuries that may be sustained while working at a computer workstation. I am interested in finding out from this survey if injuries are sustained even though there is a vast amount of ergonomic information available to prevent them. The main purpose for gathering information is to have statistical research data for my thesis. To complete the survey should take less than 20 minutes. If a question is left unanswered, it will show as the default option.

* All information is confidential and will not be disclosed to any source.

** The square choices are capable of more than one selection.

**Humanistic Information:**

1. You are:

   (•) Male

   ( ) Female

2. Your weight is:

- (•) 50-99
- ( ) 100-139
- ( ) 140-179
- ( ) 180-219
- ( ) 220-269
- ( ) 270-309
- ( ) 310-449
- ( ) 450+

3. Your age is within:

- (•) 21-29
- ( ) 30-39
- ( ) 40-49
- ( ) 50-59
- ( ) 60+

4. Your height is between:

- ○ 5'0" - 5'3"
- ○ 5'4" - 5'8"
- ○ 5'9" - 6'1"
- ○ Other

5. Your Occupation or Profession is: _____

6. Are you married?:

- ○ Yes
- ○ No

7. You have children of ages: (check all that apply)

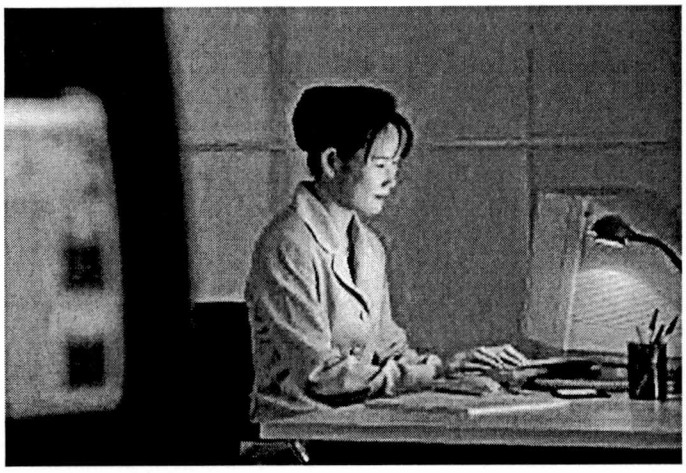
8. ☐ 0-5 ☐ 6-10 ☐ 11-15 ☐ 16-20
   ☐ 20+ ☐ None

9. Your ethnic origin is:

- African American
- Asian
- Caucasian
- Hispanic
- Other

---

**Job Environment Information:**



10. Hours worked at your workstation per work day:

- 1-4
- 5-8
- 8+
- None

11. Are you Right-handed ⌜ or Left-handed ⌜ ?

12. How many years have you been doing computer related work:

- (•) 1-3
- ( ) 4-8
- ( ) 9-15
- ( ) 15+
- ( ) None

13. Would you say that generally the climate of your workstation environment is:

- (•) Just right
- ( ) Too hot
- ( ) Too cold

14. For the most part, the colorings surrounding your workstation are:

- (•) Light color
- ( ) Dark color
- ( ) White
- ( ) None of the above

15. The type of lighting for your workstation is:

- (•) Fluorescent
- ( ) Single bulb light fixture in ceiling
- ( ) No light
- ( ) Desk lamp
- ( ) Other

---

**Workstation Ergonomic Information:**

16. Does your chair adjust to change height if needed:

- (•) Yes
- ( ) No

17. Does your workstation chair have arm rests:

- (•) Yes
- ( ) No

18. Does your workstation chair have wheels:

- (•) Yes
- ( ) No

19. Choose the best option that describes the back of your workstation chair:

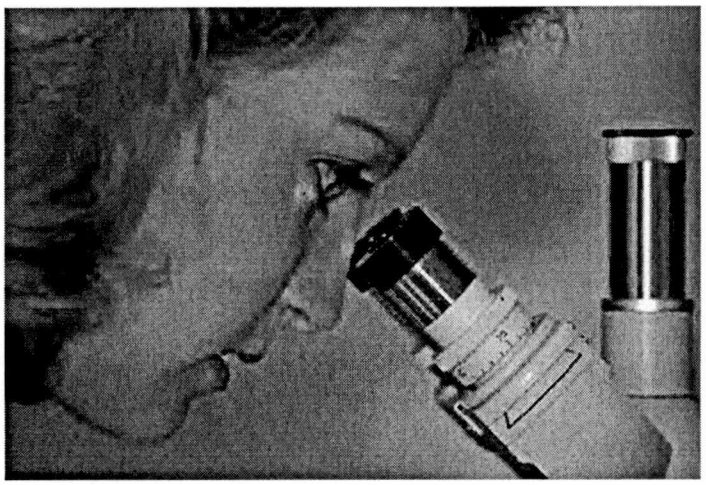
- [ ] High, flat, cushioned back
- [ ] High, flat, non-cushioned back
- [ ] High, curved, cushioned back
- [ ] High, curved, non-cushioned back
- [ ] Low, flat, cushioned back
- [ ] Low, flat, non-cushioned back
- [ ] Low, curved, cushioned back
- [ ] Low, curved, non-cushioned back

20. Is the seat of your workstation chair cushioned:

- (•) Yes
- ( ) No

---

**Information Involving Vision:**



21. Do you wear glasses:

- (•) Yes, while at the computer only.
- ( ) Yes, all the time.
- ( ) Yes, for reading - not computer related
- ( ) No

22. Do you wear special computer glasses:

- (•) Yes
- ( ) No

23. Your monitor screen size is:

- (•) 14"
- ( ) 15"
- ( ) 17"
- ( ) 19"
- ( ) 21"
- ( ) Other

24. Your monitor is positioned: (choose all that apply)

- [ ] Directly in front of you.
- [ ] To one side
- [ ] Above eye level
- [ ] Below eye level
- [ ] No monitor

25. Your monitor is:

- (•) Color monitor
- ( ) Monochrome monitor (one color)

26. Does your monitor have a glare screen:

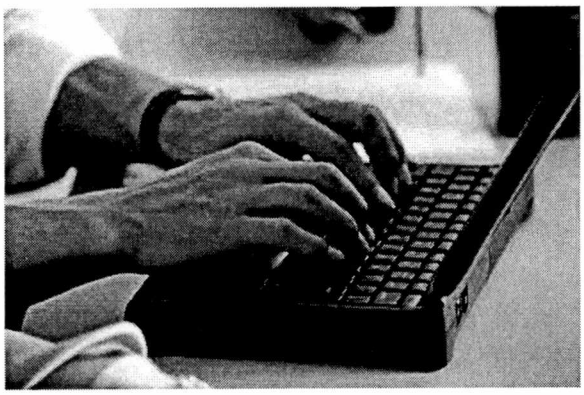
- (•) Yes
- ( ) No

27. Is your monitor screen facing:

- (•) A window with no covering
- ( ) Direct light from a lamp or overhead light
- ( ) Neither
- ( ) Both

---

**Workstation Accessories Information:**



28. Your keyboard is placed:

- ◉ Directly in front of you
- ○ To one side

29. Your keyboard is:

- ◉ Tilted
- ○ Level

30. You keyboard is:

- ◉ Split
- ○ Not Split

31. Do you have an ergonomic keyboard?

- ◉ Yes
- ○ No

32. Do you use wrist supports while working at your computer?

- ◉ Yes
- ○ No

33. Your workstation area is:

- ◉ Carpeted
- ○ Tiled, Linoleum or Concrete
- ○ Wood floor
- ○ Carpeted and Matted
- ○ Hard Floor and Matted

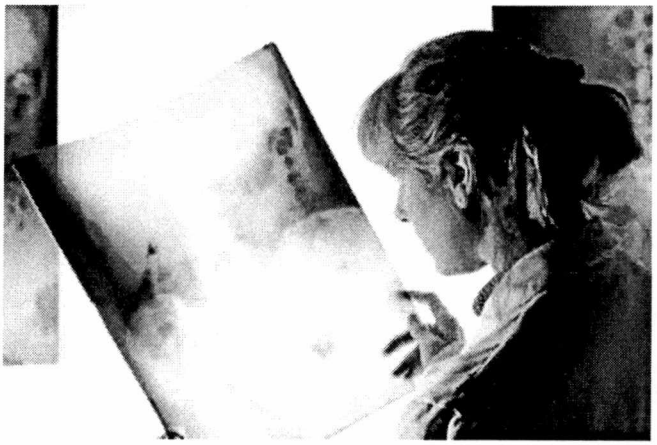
34. Your workstation is a:

- ◉ Desk
- ○ Table
- ○ Cart
- ○ Other

If Other, please describe:

---

## Characteristics Associated with Pain



35. If you have leg pain, it is usually in:

○ One leg ○ Both legs

○ Do not have leg pain.

How often?

36. Your neck pain usually occurs: (check all that apply)

37. ☐ **All day** ☐ **Morning**

38. ☐ **Afternoon** ☐ **Evening**

☐ **None of the above**

39. Your arm/shoulder pain occurs: (check all that apply)

40. ☐ **Morning** ☐ **Afternoon** ☐ **Evening**

☐ **None of the above**

41. Your wrist pain occurs: (check all that apply)

☐ **Morning** ☐ **Afternoon** ☐ **Evening**

☐ **None of the above**

42. Eyestrain occurs: (check all that apply)

☐ **Morning** ☐ **Afternoon** ☐ **Evening** ☐ **None of the above**

43. Pain from headaches occur: (check all that apply)

☐ **Morning** ☐ **Afternoon** ☐ **Evening** ☐ **None of the above**

44. Most of the time, while working at your workstation you:

◉ Sit upright

○ Are leaned back in your chair

○ Are leaned forward in your chair

○ Stand

○ None of the Above

**Previous Medical History:**

45. Have you ever had any previous computer related injuries:

- ◉ Yes
- ○ No

If Yes, please explain briefly: _____

46. Have you ever had any surgery:

- ◉ Yes
- ○ No

If yes, what type? (please list all and in what year) _____

47. Do you have any chronic illnesses: (Chronic meaning life-long)

- ◉ Yes
- ○ No

If yes, what type? (please list all and in what year)

48. Do you have *any* history of mental illness:

- ◉ Yes
- ○ No

49. Do you enjoy your work:

- ◉ Yes, most of the time
- ○ No, not ever

50. Do you have any frequent hobbies:

- ◉ Yes
- ○ No

If yes, please list them here and how often:

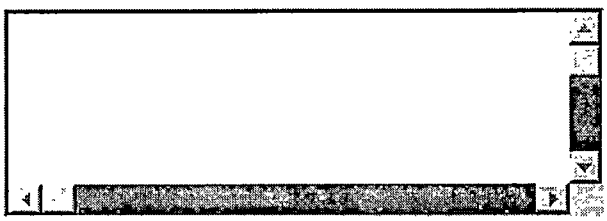
51. How many 5-15 minute breaks per day away from your workstation:

- 0-1
- 2-3
- 4 or more

52. How many breaks longer than 15 minutes away from your workstation:

- 0-1
- 2-3
- 4 or more

53. Additional Comments: (optional)



Press the Submit button when ready to send. Thank-you!

Submit Reset

Sandra Rudd, Graduate Student at The University of Tennessee
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# Appendix B

# Occupations

| | Occupation | Total | Male | Female |
|---|---|---|---|---|
| 1 | Accounting | 5 | 0 | 5 |
| 2 | Administrative | 19 | 0 | 19 |
| 3 | Architect | 28 | 19 | 9 |
| 4 | Attorney | 3 | 0 | 3 |
| 5 | Auditor | 1 | 0 | 1 |
| 6 | Baker | 1 | 0 | 1 |
| 7 | Banking | 2 | 0 | 2 |
| 8 | Biologist | 1 | 0 | 1 |
| 9 | Bum | 1 | 0 | 1 |
| 10 | Bus Driver | 2 | 0 | 2 |
| 11 | CAD | 4 | 3 | 1 |
| 12 | CENA | 1 | 0 | 1 |
| 13 | Chiropractor | 1 | 1 | 0 |
| 14 | Computer Tech | 8 | 3 | 5 |
| 15 | Construction | 1 | 1 | 0 |
| 16 | Disabled | 4 | 0 | 4 |
| 17 | Dock Work | 1 | 0 | 1 |
| 18 | Draftsman | 3 | 2 | 1 |
| 19 | Educator | 15 | 4 | 11 |
| 20 | Engineer | 11 | 9 | 2 |
| 21 | Ergonomics | 17 | 10 | 7 |
| 22 | Exec. Secretary | 11 | 1 | 10 |
| 23 | Food Service | 1 | 0 | 1 |
| 24 | Government | 1 | 0 | 1 |
| 25 | Graphic Arts | 3 | 1 | 2 |
| 26 | Homemaker | 8 | 0 | 8 |
| 27 | Insurance | 3 | 0 | 3 |
| 28 | Librarian | 4 | 0 | 4 |
| 29 | Management | 1 | 1 | 0 |
| 30 | marketing | 2 | 1 | 1 |
| 31 | Network Admin | 1 | 1 | 0 |
| 32 | Nursing | 11 | 1 | 10 |
| 33 | Pet Groomer | 1 | 0 | 1 |
| 34 | Pilot | 1 | 1 | 0 |
| 35 | Police | 2 | 2 | 0 |
| 36 | Radiology | 1 | 1 | 0 |
| 37 | Researcher | 1 | 0 | 1 |

| | | | | |
|---|---|---|---|---|
| 38 | Retired | 7 | 3 | 4 |
| 39 | Safety | 12 | 6 | 6 |
| 40 | Sales | 1 | 1 | 0 |
| 41 | Self-Employed | 3 | 0 | 3 |
| 42 | Sign Maker | 1 | 1 | 0 |
| 43 | Software Trainer | 1 | 1 | 0 |
| 44 | Student | 5 | 2 | 3 |
| 45 | Technical Writer | 5 | 1 | 4 |
| 46 | Therapist | 2 | 1 | 1 |
| 47 | Unknown | 31 | 14 | 13 |
| 48 | Webmaster | 1 | 0 | 1 |

# Appendix C

# Types of Workstations

| | |
|---|---|
| 1. | 36" Work station |
| 2. | A corner cubical with work areas on both sides of the monitor |
| 3. | A Counter |
| 4. | adjustable height table (crank assembly) |
| 5. | Built in Workstation |
| 6. | Computer Cubicle |
| 7. | Computer Hutch |
| 8. | Computer Work Station |
| 9. | Counter |
| 10. | Credenza |
| 11. | Cubicle |
| 12. | Dual height adjustable surface computer table plus an height adjustable table desk |
| 13. | Ergotron Organizer 2000 |
| 14. | Height-adjustable computer desk |
| 15. | modular cubicle furniture |
| 16. | Modular Workstation |
| 17. | Nursing Station, multiple work areas |
| 18. | Pod - 6 triangular desks in a circle |
| 19 | Special Computer Desk |
| 20. | U-shaped counter w/45degree corner for computer |
| 21. | VDT workstation |
| 22. | Weighted sit to stand table |

# Appendix D

# Frequency of Leg Pain

| | |
|---|---|
| 1. | 1-2 times pre week |
| 2. | 2x/week |
| 3. | a couple of times a week |
| 4. | after sitting for long periods of time |
| 5. | All the time |
| 6. | bimonthly |
| 7. | Constant - increases with long sittings |
| 8. | Daily (*12) |
| 9. | Daily (own fault due to illness, not related to computers) |
| 10. | Daily, not computer related |
| 11. | Every couple of hours; Worse if I am seated for aover an hour |
| 12. | EVERYDAY TOWARDS THE END OF THE DAY |
| 13. | few days and nights per week |
| 14. | Frequently |
| 15. | Have bad leg for circulation |
| 16. | I sit on my foot, so it's often |
| 17. | most every day |
| 18. | Occasionally (*2 ) |
| 19. | often |
| 20. | once monthly |
| 21. | Once or twice a month (*2) |
| 22. | Once per day for a short time |
| 23. | ongoing off and on |
| 24. | Quite a bit |
| 25. | rarely |
| 26. | Rarely,chiropractor keeps hips in place pretty well |
| 27. | Seldom |
| 28. | Several times per week |
| 29. | Too often (* 2) |
| 30. | Unknown (* 43) |
| 31. | Upon rising from a sitting position |
| 32. | usually 2-3 times per week |
| 33. | Usually twice a week |
| 34. | Very Frequently |
| 35. | weekly |

# Appendix E

# Previous Computer Related Injuries

| | |
|---|---|
| 1. | Began having shooting wrist pains and numbness; went away when I added wrist rest to keyboard |
| 2. | A little CTS that went away when I took corrective measures |
| 3. | Bilateral carpal tunnel syndrome |
| 4. | Bi-lateral repetitive strain injury - arms |
| 5. | Carpal Tunnel symptoms, tendonitis in left forearm, muscle spasms in shoulders and neck and assoc. migraines |
| 6. | Carpel Tunnel and Tennis elbow |
| 7. | Cervical Pain |
| 8. | CTS x 11 |
| 9. | CTS-both wrists |
| 10. | cyst on right wrist (from mousing) |
| 11. | Dequari Tendinitious/Carpal Tunnel Syndrome |
| 12. | Epicondylitis, from mousing |
| 13. | Lower back, due to an uncomfortable chair |
| 14. | Nerve damage due to overuse with mouse |
| 15. | Not computer, old football and beeflugging |
| 16. | Numbness in right hypothenar emminence |
| 17. | Overuse syndrome both wrists |
| 18. | Pregnancy related CTS |
| 19. | Repetitive motion injury to neck caused by cradeling phone on shoulder while working aggrevated by poor chiropractic care bordering on criminal. |
| 20. | Repetitive motion strain/pain |
| 21. | right elbow tendonitis |
| 22. | RSI |
| 23. | Severe pain in upper back/neck - undiagnosed though |
| 24. | Stubbed toes getting out of area, tripping over chair |
| 25. | tendinitis in elbow |
| 26. | Tenditis (right elbow) current |
| 27. | Tendonitis |
| 28. | Tendonitis in elbow, other wrist, arm, shoulder, neck strains and pains |
| 29. | Unknown x 9 |
| 30. | wrist and neck problems |

# Appendix F

# Previous Surgeries

| | |
|---|---|
| 1 | 1977 T&A, D&C; 1983 - Repair torn ligament on R ankle; 1989 Hysterectomy |
| 2 | 2000 Carpal Tunnel Release |
| 3 | 4 knee operations 86-88-92-94, kidney stones 90-99 |
| 4 | 6 Knee surgeries between 1988 and 1999; Gallbladder 1988 |
| 5 | 82 Gallbladder; 99 Appendectomy; 99 Gastric Bypass |
| 6 | 91 & 96, Arthroscopy of left knee |
| 7 | Abdominal 1982,1983,1989 |
| 8 | all kinds |
| 9 | ankle |
| 10 | Ankle Reconstruction |
| 11 | Ankle surgery 1999 |
| 12 | Anterior cervical discectomy and spinal fusion in 1994 (removed herniated disk and fused C6-7 vertebra using autologous bone graft from my hip) |
| 13 | Appedicitis 1960 |
| 14 | Appendectomy, gallbladder removed, plantar fasciotomy, removal of mortons neuroma |
| 15 | Appendix removed |
| 16 | Appendix, Tonsils, hysterectomy |
| 17 | Appendix, Varicose Veins |
| 18 | Appendix; Tonsils; C-section |
| 19 | Arthroscopic Knee surgery - torn cartilidge |
| 20 | Arthroscopic knee surgery 1996; Hysterectomy 1990; Repair of broken bones in leg 1996 |
| 21. | Back 1996 |
| 22. | Back 1997 |
| 23. | Bilateral Carpel Tunnel Release 1990; Right Ankle Synovectomy 1992; Cholecystectomy 1998; Gastric Bypass 2000. |
| 24. | Bilateral orbital decompression, C-section, gall bladder removal |
| 25. | Bone cyst in left hand - 1994 |
| 26. | Broken bone repair 1985; Tubiligation 1994 |
| 27. | Broken elbow 1996; have several due to SLE |
| 28. | Broken leg (skiing accidnet 1981); ankle (related to skiing accident 1999) |
| 29. | Carpel Tunnel - bilateral |
| 30. | Carpel Tunnel 1997 |
| 31. | Carpel Tunnel Bilateral 1987 |
| 32. | Carpel Tunnel Release (both wrists) |
| 33. | Cervical Graft and Fusion |
| 34. | Child tonsilectomy |
| 35. | Corneal Transplant 1996 |
| 36. | C-Section 1983 |
| 37. | C-Section 1988 |
| 38. | C-Section; Gastric Bypass Surgery |
| 39. | C-section; Urethral surgery |
| 40 | C-sections 1982, 1985 |

| | |
|---|---|
| 41. | C-sections, 1988 and 1990 |
| 42. | CTR 1994 |
| 43. | CTS 1997 |
| 44. | CTS release |
| 45. | Cyst removed from left wrist 1990; C-section 1999 |
| 46. | Detached retina 1979; Cubital tunnel 2000 |
| 47. | Diskectomy 5/00; Bunionectomy 1/99; 6/89; 3 C-sections 62,64,66; Gallbladder '71, pylonidal cyst '63. |
| 48. | gall bladder removal 1989 |
| 49. | Gallbladder |
| 50. | Gallbladder removal |
| 51. | Gallbladder, May 1998 |
| 52. | Ganglion in left wrist |
| 53. | Gastric Bypass 1997 |
| 54. | Gastric Bypass 2000 x 2 |
| 55. | Gunshot to left knee |
| 56. | Gut surgeries, many from 1964 to 1980 |
| 57. | Gynecological 1996 |
| 58. | Gynecology 1985 |
| 59. | Hernia |
| 60. | Hernia Repair |
| 61. | Hysterectomy x 2 |
| 62. | Hysterectomy 1976; ankle surgery 1992 |
| 63. | Hysterectomy 1981; Gallbladder removal 1972 |
| 64. | Hysterectomy 1981; WLS 2000 |
| 65. | Hysterectomy 1993 |
| 66. | Hysterectomy 1997 |
| 67. | Inguinal hernia, 1985 |
| 68. | Kidney Transplant |
| 69. | knee |
| 70. | Knee - 1992 |
| 71. | Knee and foot surgeries |
| 72. | Knee surgery |
| 73. | Knees |
| 74. | L/H Carpel Tunnel Release 1995 |
| 75. | Laminectomy 1990, hernia repair 1998; gastric bypass 1999 |
| 76. | Laminectomy, 1993 |
| 77. | Lap RNY 1999; Lumbar Laminectomy 1986; Bilateral ovarian wedge resection 1980. |
| 78. | Lasik 1999 |
| 79. | LASIK eye surgery 100% successful 1/24/00 |
| 80. | Left hip 1993 |
| 81. | Leg reconstruction due to motorcycle accident/abdominal sugery due to military wound |

| | |
|---|---|
| 82. | Lumbar Disc surgery 1989 |
| 83. | Male surgery 1974 |
| 84. | maxilofacial |
| 85. | minor nasal surgery |
| 86. | None cómputer related; multiple |
| 87. | None related to computer |
| 88. | None related to these types of injuries yet |
| 89. | Not back, neck or computer related |
| 90. | Not related to computer work |
| 91. | Nothing work/computer related |
| 92. | Open Heart |
| 93. | Open RNY 2000 |
| 94. | Orthopedic hand surgery (stemming from a dog bite) 1983 |
| 95. | orthoscopic-left knee |
| 96. | Release of tendon at the elbow-2000 |
| 97. | removal of cyst Dec. 1998 |
| 98. | rhinoplasty (nose job)--1974, gall bladder--1982, hand (tendon replacement)--1997 |
| 99. | Septoplasty |
| 100. | sinus surgery 2000 |
| 101. | Spinal fusion, Gallbladder, WLS, Lazer on Voice box, Hysterectomy, C-Section, Breast Reduction |
| 102. | Sports injury related only - numerous arthroscopes to both knees, left shoulder and inguinal hernia |
| 103. | Surgery on left thumb and wrist 3 times, 1990, 1991, 1991. |
| 104. | TMJ 1985 |
| 105. | Tonsilitis |
| 106. | Tonsils removed |
| 107. | Umbilical hernia 1961 |
| 108. | Unknown x 8 |
| 109. | Vein removal 12/98 |
| 110. | wisdom teeth removal 1992 |
| 111. | WLS 2000 x 2 |

# Appendix G

# Types of Hobbies

| | |
|---|---|
| 1. | home improvement, cooking |
| 2. | working out, writing, needlecrafts, reading, photography |
| 3. | 1)Reading-several hours/week, mostly on weekends 2)Walking-mostly on weekends |
| 4. | All forms of needlework |
| 5. | Alpine skiing and snowboarding - seasonal 2-3x/week |
| 6. | Anything Offline |
| 7. | AOL |
| 8. | AOL; Reading |
| 9. | arts and crafts, jogging, gardening |
| 10. | Athletic 7 days a week |
| 11. | automotive repair once a week, photography once @ 2 weeks, reading daily |
| 12. | Bicycle riding, weight lifting |
| 13. | bicycling, tennis |
| 14. | biking |
| 15. | BIKING,SKIING TWO OR THREE TIMES/WEEK |
| 16. | biking-weekly, weightlifting-daily, travel-once a month |
| 17. | Boating, Fishing & Camping at least 2 times a month |
| 18. | Bonsai |
| 19. | Bowling once a week |
| 20. | Brewing beer, design, build and fly high powered rockets; reading; writing short stories. |
| 21. | Camping & Reading whenever possible |
| 22. | Camping, fishing 2x monthly, computer work daily, walking daily |
| 23. | Canoe, bike, read, travel |
| 24. | Ceramics 6mo./year |
| 25. | Collect owls and read when I can |
| 26. | Compiling music for a DJ in a club; enjoy politics and c-span. |
| 27. | Computer |
| 28. | Computer for daily relaxation |
| 29. | Computer, Reading, Movies |
| 30. | Computers, wood working, gardening, daily for most. |
| 31. | Computers; Photography; Reading |
| 32. | Computing is my hobby; I tutor on AOL and have a Web site that I update frequently. I also sing in the church choir and am active at work and in other roles at church |
| 33. | Crafting & Gardening |
| 34. | Crafts, 2-3 times a week |
| 35. | Cross Stitch, reading AOL, movies |
| 36. | cross stitch,stained glass,scouts, reading,computers,spiritual studies |
| 37. | cross stitchoing (monthly), stamping (monthly) |
| 38. | Custom build computers; Hunting and fishing also love to go camping |
| 39 | Cycling 5x/week; rock climbing 1x/week; baseball 3x/week; guitar playing daily |
| 40.. | Cycling, rowing, sailing |

| | |
|---|---|
| 41. | Cycling; Gardening |
| 42. | Drawing every other day I draw something |
| 43. | Drawing, minutes to hours daily; computer art hours vary; writing, usually on computer, hours occasionally, roleplaying games, paper and computer, about 2-3 hours daily. |
| 44. | ebay shopping |
| 45. | Exercise |
| 46. | Exercise (rowing-kayaking), outdoors stuff all the time I'm not working |
| 47. | Exercise, black poweder shooting, great sex. |
| 48. | Exercising daily |
| 49. | Fishing, try to at least once a week or so |
| 50. | Fishing. |
| 51. | Gardening |
| 52. | Gardening |
| 53. | Gardening & Reading |
| 54. | gardening -spring, summer fall |
| 55. | Gardening, Crocheting, Cross Stitching, Internet |
| 56. | gardening, jogging, art |
| 57. | Gardening, reading, feeding/watching hummingbirds, caring for pets |
| 58. | gardening, reading, travel, training my dogs, |
| 59. | Gardening, swimming, riding Harely Davidson motorcycles, growing orchids and other houseplants. |
| 60. | Gardening, walking, reading |
| 61. | Gardening, watching my children's sporting events, computering. |
| 62. | Gardening; Raising miniature donkeys |
| 63. | Genealogy 30 hours a week |
| 64. | Genealogy Research |
| 65. | Golf |
| 66. | golf - twice per week; cooking - twice per week |
| 67. | golf, cycling 3x/week |
| 68. | Golf/3x's per week |
| 69. | Golf; Reading |
| 70. | Golfing |
| 71. | GOLFING, FISHING - OCCASIONAL |
| 72. | Guitar playing 1/week; Singing 1/week; Carpentry/furniture building 1/week; Hiking 1/week; Swimming 2/week; Working out 3/week. |
| 73. | Ham radio; Computers |
| 74. | Hiking, Walking, working out |
| 75. | hockey, racquetball |
| 76. | Home Improvement, camping, reading, computers |
| 77. | Horseback Riding |
| 78. | Horses daily; Playing with my kids; Playing on the internet; Going to the beach/park |
| 79. | Horses, Motorcycles, Flying, Restoring Cars…various. |

| | |
|---|---|
| 80. | Hunting |
| 81. | Hunting, Photography, Skiing, Sex |
| 82. | Internet usage, bike riding, swimming, reading , listening to music, gardening... all constant |
| 83. | Internet use and Web page development, 2x/week |
| 84. | Jewlery making about once a week |
| 85. | Kayaking, hiking, biking. Beach activities. |
| 86. | Knitting, crocheting, painting, crafting |
| 87. | Learning things computer related; Video Games |
| 88. | misc sports, travel, photography, creating things |
| 89. | mountain biking - weekly (1-2 times) |
| 90. | movies 4x week; crafting 3x week; reading daily; seraching web daily |
| 91. | Music, Family |
| 92. | Needlework; Reading |
| 93. | Painting weekly; Golf every other week |
| 94. | Painting, cooking, reading, writing |
| 95. | PC at home - AOL; Computer Gaming |
| 96. | Piano |
| 97. | PIANO, BIKING, CAR MAINTENANCE (COUPLE TIMES/WEEK) |
| 98. | Play viola once/week; quilt sporadically |
| 99. | Playing with children and fencing |
| 100. | Quilt making, daily AND horse riding weekly |
| 101. | Quilting/sewing several hours/weekend; computers approx 1 hour/day after work |
| 102. | read books--daily |
| 103. | Read; Cross stitch |
| 104. | Reading |
| 105. | Reading books |
| 106. | Reading books every day |
| 107. | Reading daily |
| 108. | Reading daily |
| 109. | Reading daily |
| 110. | Reading daily, surfinf the net 1-2x/week, making wooden puzzles 1-2x/week, sewing 1-2x/month. |
| 111. | Reading daily; Kayaking weekends |
| 112. | Reading daily; Quilting monthly; Gardening weekly |
| 113. | Reading nightly before sleep |
| 114. | Reading, almost as much as breathing |
| 115. | Reading, Building Web Sites, Girl Scouts, camping, tennis, biking, grandchildren....all the time. |
| 116. | Reading, collecting pottery, swimming. Daily. |
| 117. | Reading, Computer, Internet |
| 118. | Reading, crocheting |
| 119. | Reading, Houseplants, Movies |
| 120. | reading, movies, crafting |

| | |
|---|---|
| 121. | Reading, plants, computer |
| 122. | Reading, spending time with my children/dogs, bicycling, walking |
| 123. | reading, swimming, gardening probably once a day for each |
| 124. | Reading, travel, crafts, sewing, hiking |
| 125. | reading, walking with dog |
| 126. | Reading, Walking, Darts |
| 127. | Reading, Walking, Movies |
| 128. | Reading, Walking, Playing with grandchildren |
| 129. | Reading, Writing, Exercising, Crafts |
| 130. | Reading, Writing, Travel, Crafts |
| 131. | reading: 5-10 hours per week; playing electric bass: 1-3 hours per week; playing computer games: 2-3 hours per week |
| 132. | Reading; Games |
| 133. | reeading, photography, movies |
| 134. | Rollerblading 1-3x/week; walking 1-3x/week; piano 5+ x/week. |
| 135. | rowing 3x week, playing music daily |
| 136. | Run and Gym normally 5 sessions in a total per week (4 hours/week) |
| 137. | Running, Hiking, Cooking |
| 138. | Running, Sailing, Fishing, Bowling |
| 139. | running, sailing, rowing, painting, stained glass |
| 140. | SCA related Renassaince faires |
| 141. | singing, reading, playing with kids |
| 142. | Ski, swim, read |
| 143. | Sports, outdoors, anything that gets me exercise |
| 144. | Stamping, Reading, Internet and cribbage. |
| 145. | Surfing the web |
| 146. | swimming reading 3-4 times per week |
| 147. | Swimming, Singing |
| 148. | Swimming; Raising Amazon parrots. |
| 149. | Taking care of baby; Reading |
| 150. | Target shooting |
| 151. | Trathlon 6 days/week |
| 152. | TV; Movies and Trivia all the time now that I'm retired |
| 153. | Unable to do them now - crocheting, automechanics, computer stuff, crafts, ceramics, reading, music (flute-piano-guitar) biking |
| 154. | Unknown x 23 |
| 155. | VARIOUS SPORTS - COUPLE TIMES/WEEK |
| 156. | Visiting museums, flea markets, reading. |
| 157. | volleyball (twice a week) |
| 158. | Volleyball 3-4x/week |
| 159. | Volleyball every week; Reading daily; Other sports every week |
| 160. | Walking |
| 161. | walking daily for 45-60 min |
| 162. | Walking daily; Reading daily; Gardening in summer |

| | |
|---|---|
| 163. | Walking, Reading |
| 164. | water skiing-4X/week; tennis-1X/week |
| 165. | Watercolor Painting, free-hand acrylic painting, writing, reading, ceramics. Photography. All are often and for many years. |
| 166. | Weight Lifting |
| 167. | Weight lifting |
| 168. | Weightlifting, Bicycling, Reading |
| 169. | Weights, running, reading, driving (I like to go for long drives) |
| 170. | Wood Crafts |
| 171. | Wood working, fishing, occasional hunting |
| 172. | wood working; 2 to 3 times per week for 4 hours per time |
| 173. | Woodworking once a week; dog agility once a week |
| 174. | Working online with graphics and lupus and FMS groups |
| 175. | Writing weekly; Walking daily; Watercolor painting occasionally; crochet occasionally. |
| 176. | Yoga twice a week |

# Appendix H

# Additional Comments

| | |
|---|---|
| 1. | My mousepad has a gel insert to support my wrist. I divert my gaze often and focus on a distant object to stretch my eyeballs. I play music at a low volume at all times. |
| 2. | I work in a unique environment. I might stand in front of a computer screen to move some file sfor half a night shift, but only for a minutes or so. This process involves moving materials from one place to another during the night. I don't need to be right in front of a computer screen all the time. Then sit at another workstation for an hour...then move to another. Each station is set up differently. To be honest, the only "work station" that I use that is setup correctly is the one that I use at home. |
| 3. | In my many years behind one of these things, I have found that not using the keyboard tray seemed to help wrist problems...also sitting back in the chair rather than sitting straight up helped the back pain I was having. Since sitting in this position, usually with feet in lap (indian style) I have had no back pain in 2 years. Hope this helps..good luck :) |
| 4. | I don't work at my computer, it's just for home and leisure. |
| 5. | I currently do not work outside the home, but I was a secretary for many years and began using computers in the early 1980's |
| 6. | Typing doesn't affect the pain in my arm as much as using a mouse does. I answered the work station questions based on my main office but I work under various conditoins at clients' offices. |
| 7. | Working the midnight shift has contributed to additional discomfort. It is uknown whether it is the acclimation to the odd hours, or additional computer work. |
| 8. | After being online awhile, my back just screams in pain |
| 9. | My workstation is not at my job, but at home for pesonal computing. I do use a computer at work briefly to receive emails. |
| 10. | Most of the time I use my computer for non-related job areas. I do use the computer to get info to help me with some of the objectives I plan on teaching in my classes. |
| 11. | Q44.- mental illness=deep grief and depression when husband was killed in an auto crash, lasted more than 2.5 years. Reclusive now due to morbid obesity. |
| 12. | While currently not employed, I have responded to the questions as if I was still in the job I had done for the longest period of time in my life. At my home office workstation, I have a split keyboard, which helps, and I move away from the screen often - many times a day, and suffer no computer related problems - even the CTS is "under control". |
| 13. | 3 days one week, 4 days next week, working 12 hour shifts |
| 14. | I am at the workstation for my PC because of my own desire, not because of a job. However, I do stay at the workstation longer than I shouuld and sometimes have problems getting out of my chair when I do get up. |
| 15. | I do have cardio-vascular disease and arthritis |
| 16. | Glad to help out. |
| 17. | I use a workstation at home to volunteer for the AAC, plus do lesson plans |
| 18. | I have a workstation at school (I'm a teacher) that I use enough to take attendance and record grades, and now and then to Web surf for info. The workstation at home is where I put in many hours, often 3-4 a night preparing school materials and |

| | |
|---|---|
| | tutoring online. I have put my computer desk on wood blocks to raise it to the correct height and have the monitor on a stand, too, for the same purpose. I love my ergo keyboard (with touch pad). I have found that the most damaging thing I do is play Mine Sweeper, probably because my hand has to stay in one position all the time. I don't play it much any more. Good luck with your research. |
| 19. | I get stiffness to the neck once in a while. |
| 20. | I don't have a career yet working on computers, just going to college for now. This survey is based on how my personal PC is set up in my personal office. |
| 21. | I am currently disabled from a car accident so answerd your survey based on work conditions when I worked and included relevant info relative to AAC duties. I can't work in tutoring rooms because of my slow typing and loss of coordination, etc and my assistiive devices don't work in the rooms either. |
| 22. | Just wanted you to know that your plea in the last AAC ACES worked! I came here to fill this in after reading it. |
| 23. | I have conducted ergo evaluations for our company for about 4 years. We have found that adjustable work surfaces and chairs along with education help prevent injuries. |
| 24. | My use of the workstation depends on if and when I may need to retrieve or put in requests for lab work and that may be frequently and again infrequently depending on the patient population. |
| 25. | I am in and out of my office a lot. Sometimes I am at my computer most of the day, but mostly I am at the beck and call of others who need ergonomic intervention or for other safety/health related issues. |
| 26. | Default sections will bias your study |
| 27. | I work mostly on a laptop computer. |
| 28. | My S&S are related to my prior auto accident and weight lifting and are only aggrevated by my computer work. This is a good survey and I will forward it to my department colleagues. I teach an introductory ergonomics course here at CSU and would love to see your survey results. Please touch base with me. David P. Gilkey, D.C., Ph.D (C) @ dgilkey@lamar.colostate.edu. |
| 29. | Although the surgery was a success, I still experience a certain amount of pain and loss of mobility in my neck area. However, I no longer have pain in the right side of my body and am rated at 10% disability. I also have a life-long fear of chiropractors and an extreme loathing for the State of Connecticut WOrkmans's Compensation System. |
| 30. | I travel 3 states and I do not toake the laptop with me. I do ergo evals for people in our company. The chair is the most frequent source of the problem. |
| 31. | Realizing that you are well on your way to your degree, you probably do not want to change this form. But I think you could get more useful information on non-work contributors by putting in a few questions about exercise, driving, etc. Good Luck. |
| 32. | Job is varied; I am not obliged to work at any particular pace and choose when to use the computer; Generally use computer less than 4 hours/day; Neckache present intermittently in afternoons/evenings and consists of stiffness/tiredness in the trapezius/levator scapulae region as well as cervical paraspinals - no history of |

| | |
|---|---|
| | cervical injury and is almost directly proportional to the maount of time spent on the computer. |
| 33. | m.carreno@napier.ac.uk |
| 34. | You say that your purpose for this survey is to determine if injuries sustained at the computer can be permanently disabling or only temporary disabling. I don't see any correlation betwseen what you have on the survey and the ability to determine either one of those outcomes. I believe you also have a fundamental flaw in the study in that you are beginning with the assumption that the computer caused the problem. There are so many factors that contribute to the deveilopment of these problems. Certainly having a comfortable computer setup is importatn but it is no guarantee that you will never have an inury or that if you do your work had nothing to do with it. The fact that you have an ijury and also work on a computer doesnt mean the intervention and appropriate treatment these injuries can be progressive, permanent and devatating. |
| 35. | In questions 47, 48 I assumed "breaks" meant time away from the station doiong other tasks. It is not time "doing nothing/relaxing". My job rquires me to meet and work with many people; which include others in the office or plant floor. |
| 36. | I am an Industrial Hygienist. I am one of two people charged with Ergonomic Workstation Evaluations for my company. I am a self-corrected Carpal Tunnel Syndrom patient. I would be interested in the results of this survey. mailto: cub@cfl.rr.com |
| 37. | http://www.j-reed.com |
| 38. | As a teacher I am free to move around the classroom whenever I want and sit at the computer when I have time. My computer is on a "Smart Cart" which also has a large TV for the students to view what is on the computer when I do presentations for the class. |
| 39. | Cause of CTS has not been directly linnked to computer usage. Other factors in my earlier occupation may have contributed/caused it. |
| 40. | Good luck on your thesis! |
| 41. | My problem has to do with hunching my shoulders, causing neck, shoulder and arm discomfort. Can't seem to find a solution. |
| 42. | By "wrist support," I assumed you meant wrist rests as well. Keyboard has negative tilt (away from me). Nice short survey. |
| 43. | Best Wishes on your studies. You're in my prayers. |
| 44. | Hurt middle back @ 18 yrs old. When chiropractor took x-rays, informed me I had small chip between 5 & 6 cevical, probably from football. I am 40 yrs. now. Have AAS in Arch. and BSME. Not bad enough for surgery. Chiro not for every one, but works very well for my type of injuries. Correct posture very important for me. Solutions: Sit to stand podium(variation very good). Slant board for input, lots of CAD work(In my 40 yrs. I have witnessed only a handfull of people capable of touch typing). Monitor adjustable up & down and back & forth. Seating so can sit with 120 degress between torso and thigh. |
| 45. | Part of my work responsibilities concern ergonomic issues including adaptive computer technologies. Some of your questions seem a little "suggestive" in nature e.g. "Your neck pain occurs ..." which may result in skewed data. Just a thought. |

| | |
|---|---|
| | Good luck. M.S. from Canada |
| 46. | My work on computers is not a daily thing, I might work for more than a few hours a couple times a week. |
| 47. | You might want to look at adjustable keyboard trays as an option. I use one and have found them to be invaluable when I'm trying to accomodate different people and their various injuries. They are cheaper than fully adjustable workstations and very easy to use. |
| 48. | Breaks away from workstation include meetings and other job duties. Monitor height is at eye level, not below or above. |
| 49. | you have nothing related to back ache which i believe may be included in your survey. |
| 50. | This is not fair! - I design workstations for a living (as an ergonomist) and therefore are very aware, and have allowed for all computer-related syndromes in my work, which is research -related in the area of human engineering, Good luck with your survey. |
| 51. | All answers are correct. I left some parts out, which I didn't think you needed to know. |
| 52. | History of fractured right clavical |
| 53. | For your chair...you may want to add a medium back... |
| 54. | The group of which I belong, and through which have been exposed to this survey may bias the results, having the knowledge and chosing the appropriate, ergonomically sound answer rather than an honest choice ~ an observation |
| 55. | THANKS AND GOOD LUCK TO YOU ! |

# Appendix I

# Completed Table of Statistics

| Humanistic Information | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **You are:** | | | | | | | | |
| Male | 92 | 36.800% | | | | | | |
| Female | 158 | 63.200% | | | | | | |
| **Your Weight Is (in pounds)** | | | | | | | | |
| Weight | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| 50-99 | 14 | 5.60% | 4 | 28.57% | 10 | 71.43% | 1.60% | 4.00% |
| 100-139 | 31 | 12.40% | 3 | 9.68% | 28 | 90.32% | 1.20% | 11.20% |
| 140-179 | 83 | 33.20% | 25 | 30.12% | 58 | 69.88% | 10.00% | 23.20% |
| 180-219 | 57 | 22.80% | 34 | 59.65% | 23 | 40.35% | 13.60% | 9.20% |
| 220-269 | 37 | 14.80% | 20 | 54.05% | 17 | 45.95% | 8.00% | 6.80% |
| 270-309 | 11 | 4.40% | 2 | 18.18% | 9 | 81.82% | 0.80% | 3.60% |
| 310-449 | 16 | 6.40% | 3 | 18.75% | 13 | 81.25% | 1.20% | 5.20% |
| 450+ | 1 | 0.40% | 1 | 100.00% | 0 | 0.00% | 0.40% | 0.00% |
| **Your age is within:** | | | | | | | | |
| Age | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| 21-29 | 44 | 17.60% | 5 | 11.36% | 39 | 88.64% | 2.00% | 15.60% |
| 30-39 | 71 | 28.40% | 27 | 38.03% | 44 | 61.97% | 10.80% | 17.60% |
| 40-49 | 86 | 34.40% | 35 | 40.70% | 51 | 59.30% | 14.00% | 20.40% |
| 50-59 | 42 | 16.80% | 21 | 50.00% | 21 | 50.00% | 8.40% | 8.40% |
| 60+ | 7 | 2.80% | 4 | 57.14% | 3 | 42.86% | 1.60% | 1.20% |
| **Your Height Is Between (in inches)** | | | | | | | | |
| Height | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| 5'0"-5'3" | 48 | 19.20% | 0 | 0.00% | 48 | 100.00% | 0.00% | 19.20% |
| 5'4"-5'8" | 103 | 41.20% | 17 | 16.50% | 86 | 83.50% | 6.80% | 34.40% |
| 5'9"-6'1" | 99 | 39.60% | 75 | 75.76% | 24 | 24.24% | 30.00% | 9.60% |
| Other | 0 | 0.00% | 0 | 0.00% | 0 | 0.00% | 0.00% | 0.00% |
| **Are you married?** | | | | | | | | |
| Reply | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 161 | 64.400% | 68 | 42.24% | 93 | 57.76% | 27.20% | 37.20% |
| No | 89 | 35.600% | 26 | 29.21% | 63 | 70.79% | 10.40% | 25.20% |
| **You have children of ages: (Check all that apply)** | | | | | | | | |
| Ages | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| 0-5 | 43 | 17.200% | 14 | 32.56% | 29 | 67.44% | 5.60% | 11.60% |
| 6-10 | 39 | 15.600% | 19 | 48.72% | 20 | 51.28% | 7.60% | 8.00% |
| 11-15 | 50 | 20.000% | 24 | 48.00% | 26 | 52.00% | 9.60% | 10.40% |
| 16-20 | 38 | 15.200% | 18 | 47.37% | 20 | 52.63% | 7.20% | 8.00% |
| 20+ | 56 | 22.400% | 28 | 50.00% | 28 | 50.00% | 11.20% | 11.20% |
| None | 87 | 34.800% | 26 | 29.89% | 61 | 70.11% | 10.40% | 24.40% |
| **Your ethnic origin is:** | | | | | | | | |
| Origin | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| African American | 6 | 2.400% | 4 | 66.67% | 2 | 33.33% | 1.60% | 0.80% |
| Asian | 3 | 1.200% | 0 | 0.00% | 3 | 100.00% | 0.00% | 1.20% |
| Caucasian | 228 | 91.200% | 84 | 36.84% | 144 | 63.16% | 33.60% | 57.60% |
| Hispanic | 4 | 1.600% | 1 | 25.00% | 3 | 75.00% | 0.40% | 1.20% |
| Other | 9 | 3.600% | 5 | 55.56% | 4 | 44.44% | 2.00% | 1.60% |
| **Job Environment Information** | | | | | | | | |
| **Hours worked at your workstation per work day:** | | | | | | | | |

| Hours | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
|---|---|---|---|---|---|---|---|---|
| 1-4 | 75 | 30.12% | 40 | 53.33% | 35 | 46.67% | 16.00% | 14.00% |
| 5-8 | 96 | 38.55% | 27 | 28.13% | 69 | 71.88% | 10.80% | 27.60% |
| 8+ | 72 | 28.92% | 20 | 27.78% | 52 | 72.22% | 8.00% | 20.80% |
| None | 6 | 2.41% | 5 | 83.33% | 1 | 16.67% | 2.00% | 0.40% |
| **Are you right-handed or left-handed?** | | | | | | | | |
| Hand | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Right | 200 | 86.96% | 74 | 37.00% | 126 | 63.00% | 29.60% | 50.40% |
| Left | 30 | 13.04% | 16 | 53.33% | 14 | 46.67% | 6.40% | 5.60% |
| **How many years have you been doing computer related work?** | | | | | | | | |
| Years | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| 1-3 | 54 | 21.60% | 27 | 50.00% | 27 | 50.00% | 10.80% | 10.80% |
| 4-8 | 85 | 34.00% | 22 | 25.88% | 63 | 74.12% | 8.80% | 25.20% |
| 9-15 | 70 | 28.00% | 26 | 37.14% | 44 | 62.86% | 10.40% | 17.60% |
| 15+ | 35 | 14.00% | 12 | 34.29% | 23 | 65.71% | 4.80% | 9.20% |
| None | 6 | 2.40% | 5 | 83.33% | 1 | 16.67% | 2.00% | 0.40% |
| **Would you say that generally the climate of your workstation environment is:** | | | | | | | | |
| Climate | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Just right | 185 | 74.00% | 66 | 35.68% | 119 | 64.32% | 26.40% | 47.60% |
| Too hot | 38 | 15.20% | 17 | 44.74% | 21 | 55.26% | 6.80% | 8.40% |
| Too cold | 27 | 10.80% | 9 | 33.33% | 18 | 66.67% | 3.60% | 7.20% |
| **For the most part, the colorings surrounding your workstation are:** | | | | | | | | |
| Coloring | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Light color | 203 | 81.20% | 71 | 34.98% | 132 | 65.02% | 28.40% | 52.80% |
| Dark color | 21 | 8.40% | 9 | 42.86% | 12 | 57.14% | 3.60% | 4.80% |
| White | 14 | 5.60% | 7 | 50.00% | 7 | 50.00% | 2.80% | 2.80% |
| None of Abo | 12 | 4.80% | 5 | 41.67% | 7 | 58.33% | 2.00% | 2.80% |
| **The type of lighting for your workstation is:** | | | | | | | | |
| Lighting | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Fluorescent | 177 | 70.80% | 52 | 29.38% | 125 | 70.62% | 20.80% | 50.00% |
| Single bulb light fixture in ceiling | 23 | 9.20% | 12 | 52.17% | 11 | 47.83% | 4.80% | 4.40% |
| No light | 1 | 0.40% | 1 | 100.00% | 0 | 0.00% | 0.40% | 0.00% |
| Desk lamp | 21 | 8.40% | 12 | 57.14% | 9 | 42.86% | 4.80% | 3.60% |
| Other | 28 | 11.20% | 15 | 53.57% | 13 | 46.43% | 6.00% | 5.20% |
| **Workstation Ergonomic Information** | | | | | | | | |
| **Does your chair adjust to change height if needed?** | | | | | | | | |
| Height | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 214 | 85.60% | 63 | 29.44% | 151 | 70.56% | 25.20% | 60.40% |
| No | 36 | 14.40% | 29 | 80.56% | 7 | 19.44% | 11.60% | 2.80% |
| **Does your workstation chair have armrests?** | | | | | | | | |
| Armrests | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 191 | 76.40% | 59 | 30.89% | 132 | 69.11% | 23.60% | 52.80% |
| No | 59 | 23.60% | 33 | 55.93% | 26 | 44.07% | 13.20% | 10.40% |
| **Does your workstation chair have wheels?** | | | | | | | | |
| Wheels | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 234 | 93.60% | 81 | 34.62% | 153 | 65.38% | 32.40% | 61.20% |
| No | 16 | 6.40% | 11 | 68.75% | 5 | 31.25% | 4.40% | 2.00% |

| Choose the best option that describes the back of your workstation chair: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Chair Back | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| High flat cushioned back | 29 | 11.60% | 21 | 72.41% | 8 | 27.59% | 8.40% | 3.20% |
| High flat non cushioned | 6 | 2.40% | 3 | 50.00% | 3 | 50.00% | 1.20% | 1.20% |
| High curved cushioned back | 140 | 56.00% | 41 | 29.29% | 99 | 70.71% | 16.40% | 39.60% |
| High curved non cushioned back | 8 | 3.20% | 5 | 62.50% | 3 | 37.50% | 2.00% | 1.20% |
| Low flat cushioned back | 11 | 4.40% | 7 | 63.64% | 4 | 36.36% | 2.80% | 1.60% |
| Low flat non cushioned back | 2 | 0.80% | 1 | 50.00% | 1 | 50.00% | 0.40% | 0.40% |
| Low curved cushioned back | 51 | 20.40% | 13 | 25.49% | 38 | 74.51% | 5.20% | 15.20% |
| Low curved non cushioned | 3 | 1.20% | 2 | 66.67% | 1 | 33.33% | 0.80% | 0.40% |
| **Is the seat of your workstation chair cushioned?** | | | | | | | | |
| Seat | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 236 | 94.40% | 83 | 35.17% | 153 | 64.83% | 33.20% | 61.20% |
| No | 14 | 5.60% | 9 | 64.29% | 5 | 35.71% | 3.60% | 2.00% |
| **Information Involving Vision** | | | | | | | | |
| **Do you wear glasses?** | | | | | | | | |
| Glasses | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes, while at the computer only | 29 | 11.60% | 14 | 48.28% | 15 | 51.72% | 5.60% | 6.00% |
| Yes, all the time | 104 | 41.60% | 39 | 37.50% | 65 | 62.50% | 15.60% | 26.00% |
| Yes, for reading - not computer related | 43 | 17.20% | 21 | 48.84% | 22 | 51.16% | 8.40% | 8.80% |
| No | 74 | 29.60% | 18 | 24.32% | 56 | 75.68% | 7.20% | 22.40% |
| **Do you wear special computer glasses?** | | | | | | | | |
| Special Glass | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 18 | 7.20% | 10 | 55.56% | 8 | 44.44% | 4.00% | 3.20% |
| No | 232 | 92.80% | 82 | 35.34% | 150 | 64.66% | 32.80% | 60.00% |
| **Your monitor screen size is:** | | | | | | | | |

| Monitor | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
|---|---|---|---|---|---|---|---|---|
| 14" | 33 | 13.20% | 15 | 45.45% | 18 | 54.55% | 6.00% | 7.20% |
| 15" | 52 | 20.80% | 23 | 44.23% | 29 | 55.77% | 9.20% | 11.60% |
| 17" | 110 | 44.00% | 44 | 40.00% | 66 | 60.00% | 17.60% | 26.40% |
| 19" | 33 | 13.20% | 6 | 18.18% | 27 | 81.82% | 2.40% | 10.80% |
| 21" | 19 | 7.60% | 2 | 10.53% | 17 | 89.47% | 0.80% | 6.80% |
| Other | 3 | 1.20% | 2 | 66.67% | 1 | 33.33% | 0.80% | 0.40% |
| **Your monitor is positioned: (choose all that apply)** | | | | | | | | |
| Position | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Directly in front of you | 145 | 58.00% | 54 | 37.24% | 91 | 62.76% | 21.60% | 36.40% |
| To one side | 21 | 8.40% | 12 | 57.14% | 9 | 42.86% | 4.80% | 3.60% |
| Above eye level | 5 | 2.00% | 4 | 80.00% | 1 | 20.00% | 1.60% | 0.40% |
| Below eye level | 12 | 4.80% | 4 | 33.33% | 8 | 66.67% | 1.60% | 3.20% |
| No Monitor | 0 | 0.00% | 0 | 0.00% | 0 | 0.00% | 0.00% | 0.00% |
| In front and Above eye level | 11 | 4.40% | 3 | 27.27% | 8 | 72.73% | 1.20% | 3.20% |
| In front and below eye level | 43 | 17.20% | 7 | 16.28% | 36 | 83.72% | 2.80% | 14.40% |
| In front and to one side | 6 | 2.40% | 2 | 33.33% | 4 | 66.67% | 0.80% | 1.60% |
| One side and above eye level | 5 | 2.00% | 0 | 0.00% | 5 | 100.00% | 0.00% | 2.00% |
| One side and below eye level | 10 | 4.00% | 5 | 50.00% | 5 | 50.00% | 2.00% | 2.00% |
| **Your monitor is:** | | | | | | | | |
| Type | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Color | 247 | 98.80% | 89 | 36.03% | 158 | 63.97% | 35.60% | 63.20% |
| Monochrome | 3 | 1.20% | 3 | 100.00% | 0 | 0.00% | 1.20% | 0.00% |
| **Does your monitor have a glare screen?** | | | | | | | | |
| Glare | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 58 | 23.20% | 26 | 44.83% | 32 | 55.17% | 10.40% | 12.80% |
| No | 192 | 76.80% | 68 | 35.42% | 124 | 64.58% | 27.20% | 49.60% |
| **Is your monitor screen facing:** | | | | | | | | |
| Facing | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| A window with no covering | 10 | 4.00% | 5 | 50.00% | 5 | 50.00% | 2.00% | 2.00% |
| Direct light from a lamp or overhead light | 55 | 22.00% | 24 | 43.64% | 31 | 56.36% | 9.60% | 12.40% |
| Neither | 185 | 74.00% | 63 | 34.05% | 122 | 65.95% | 25.20% | 48.80% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Both | 0 | 0.00% | 0 | 0.00% | 0 | 0.00% | 0.00% | 0.00% |
| **Workstation Accessories Information** | | | | | | | | |
| **Your keyboard is placed:** | | | | | | | | |
| Placed | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Directly in front of you | 236 | 94.40% | 86 | 36.44% | 150 | 63.56% | 34.40% | 60.00% |
| To one side | 13 | 5.20% | 6 | 46.15% | 7 | 53.85% | 2.40% | 2.80% |
| **Your keyboard is:** | | | | | | | | |
| Type | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Tilted | 128 | 51.20% | 52 | 40.63% | 76 | 59.38% | 20.80% | 30.40% |
| Level | 122 | 48.80% | 41 | 33.61% | 81 | 66.39% | 16.40% | 32.40% |
| **Your keyboard is:** | | | | | | | | |
| Type | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Split | 57 | 22.80% | 19 | 33.33% | 38 | 66.67% | 7.60% | 15.20% |
| Not split | 193 | 77.20% | 73 | 37.82% | 120 | 62.18% | 29.20% | 48.00% |
| **Do you have an ergonomic keyboard?** | | | | | | | | |
| Type | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 68 | 27.20% | 24 | 35.29% | 44 | 64.71% | 9.60% | 17.60% |
| No | 182 | 72.80% | 68 | 37.36% | 120 | 65.93% | 27.20% | 48.00% |
| **Do you use wrist supports while working at your computer?** | | | | | | | | |
| Wrists | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 95 | 38.00% | 30 | 31.58% | 65 | 68.42% | 12.00% | 26.00% |
| No | 155 | 62.00% | 62 | 40.00% | 93 | 60.00% | 24.80% | 37.20% |
| **Your workstation area is:** | | | | | | | | |
| Area | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Carpeted | 173 | 69.20% | 53 | 30.64% | 120 | 69.36% | 21.20% | 48.00% |
| Tiled, Linoleum or Concrete | 24 | 9.60% | 14 | 58.33% | 10 | 41.67% | 5.60% | 4.00% |
| Wood floor | 13 | 5.20% | 5 | 38.46% | 8 | 61.54% | 2.00% | 3.20% |
| Carpeted & Matted | 37 | 14.80% | 19 | 51.35% | 18 | 48.65% | 7.60% | 7.20% |
| Hard floor & Matted | 3 | 1.20% | 1 | 33.33% | 2 | 66.67% | 0.40% | 0.80% |
| **Your workstation is a:** | | | | | | | | |
| Work Area | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Desk | 207 | 82.80% | 80 | 38.65% | 127 | 61.35% | 32.00% | 50.80% |
| Table | 16 | 6.40% | 5 | 31.25% | 11 | 68.75% | 2.00% | 4.40% |
| Cart | 6 | 2.40% | 1 | 16.67% | 5 | 83.33% | 0.40% | 2.00% |
| Other | 22 | 8.80% | 7 | 31.82% | 15 | 68.18% | 2.80% | 6.00% |
| **Characteristics Associated with Pain** | | | | | | | | |
| **If you have leg pain, it is usually in:** | | | | | | | | |
| Pain | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| One leg | 59 | 23.60% | 24 | 40.68% | 35 | 59.32% | 9.60% | 14.00% |
| Both legs | 34 | 13.60% | 19 | 55.88% | 15 | 44.12% | 7.60% | 6.00% |
| Do not have leg pain | 159 | 63.60% | 49 | 30.82% | 110 | 69.18% | 19.60% | 44.00% |

| Your neck pain usually occurs: (check all that apply) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Neck | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Morning | 39 | 15.60% | 18 | 46.15% | 21 | 53.85% | 7.20% | 8.40% |
| Afternoon | 86 | 34.40% | 33 | 38.37% | 53 | 61.63% | 13.20% | 21.20% |
| Evening | 83 | 33.20% | 35 | 42.17% | 48 | 57.83% | 14.00% | 19.20% |
| None of the Above | 113 | 45.20% | 37 | 32.74% | 86 | 76.11% | 14.80% | 34.40% |
| **Your arm/shoulder pain occurs: (check all that apply)** | | | | | | | | |
| Pain | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Morning | 29 | 11.60% | 12 | 41.38% | 17 | 58.62% | 4.80% | 6.80% |
| Afternoon | 66 | 26.40% | 27 | 40.91% | 39 | 59.09% | 10.80% | 15.60% |
| Evening | 72 | 28.80% | 31 | 43.06% | 41 | 56.94% | 12.40% | 16.40% |
| None of the Above | 135 | 54.00% | 38 | 28.15% | 97 | 71.85% | 15.20% | 38.80% |
| **Your wrist pain occurs: (check all that apply)** | | | | | | | | |
| Pain | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Morning | 33 | 13.20% | 12 | 36.36% | 21 | 63.64% | 4.80% | 8.40% |
| Afternoon | 58 | 23.20% | 17 | 29.31% | 41 | 70.69% | 6.80% | 16.40% |
| Evening | 63 | 25.20% | 28 | 44.44% | 35 | 55.56% | 11.20% | 14.00% |
| None of the Above | 146 | 58.40% | 49 | 33.56% | 97 | 66.44% | 19.60% | 38.80% |
| **Eyestrain occurs: (check all that apply)** | | | | | | | | |
| Eyestrain | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Morning | 24 | 9.60% | 8 | 33.33% | 16 | 66.67% | 3.20% | 6.40% |
| Afternoon | 65 | 26.00% | 19 | 29.23% | 46 | 70.77% | 7.60% | 18.40% |
| Evening | 89 | 35.60% | 38 | 42.70% | 51 | 57.30% | 15.20% | 20.40% |
| None of the Above | 110 | 44.00% | 39 | 35.45% | 71 | 64.55% | 15.60% | 28.40% |
| **Pain from headaches occur: (check all that apply)** | | | | | | | | |
| Headache | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Morning | 29 | 11.60% | 13 | 44.83% | 16 | 55.17% | 5.20% | 6.40% |
| Afternoon | 48 | 19.20% | 17 | 35.42% | 31 | 64.58% | 6.80% | 12.40% |
| Evening | 59 | 23.60% | 25 | 42.37% | 34 | 57.63% | 10.00% | 13.60% |
| None of the Above | 150 | 60.00% | 51 | 34.00% | 99 | 66.00% | 20.40% | 39.60% |
| **Most of the time while working at your workstation you:** | | | | | | | | |
| Posture | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Sit upright | 105 | 42.00% | 34 | 32.38% | 71 | 67.62% | 13.60% | 28.40% |
| Are leaned back in your chair | 57 | 22.80% | 17 | 29.82% | 40 | 70.18% | 6.80% | 16.00% |
| Are leaned forward in your chair | 82 | 32.80% | 38 | 46.34% | 44 | 53.66% | 15.20% | 17.60% |
| Stand | 4 | 1.60% | 2 | 50.00% | 2 | 50.00% | 0.80% | 0.80% |
| None of the Above | 3 | 1.20% | 1 | 33.33% | 2 | 66.67% | 0.40% | 0.80% |
| **Previous Medical History** | | | | | | | | |
| **Have you ever had any previous computer related injuries** | | | | | | | | |

| Injury | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
|---|---|---|---|---|---|---|---|---|
| Yes | 47 | 18.80% | 11 | 23.40% | 36 | 76.60% | 4.40% | 14.40% |
| No | 203 | 81.20% | 75 | 36.95% | 128 | 63.05% | 30.00% | 51.20% |

| **Have you ever had any surgery?** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surgery | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 121 | 48.40% | 35 | 28.93% | 86 | 71.07% | 14.00% | 34.40% |
| No | 129 | 51.60% | 41 | 31.78% | 88 | 68.22% | 16.40% | 35.20% |
| **Do you have any chronic illnesses?** | | | | | | | | |
| Illness | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 64 | 25.60% | 19 | 29.69% | 45 | 70.31% | 7.60% | 18.00% |
| No | 186 | 74.40% | 62 | 33.33% | 124 | 66.67% | 24.80% | 49.60% |
| **Do you have any history of mental illness?** | | | | | | | | |
| Mental | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 31 | 12.40% | 8 | 25.81% | 23 | 74.19% | 3.20% | 9.20% |
| No | 219 | 87.60% | 74 | 33.79% | 145 | 66.21% | 29.60% | 58.00% |
| **Do you enjoy your work?** | | | | | | | | |
| Enjoy | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes, most of the time | 244 | 97.60% | 91 | 37.30% | 154 | 63.11% | 36.40% | 61.60% |
| No, not ever | 6 | 2.40% | 4 | 66.67% | 2 | 33.33% | 1.60% | 0.80% |
| **Do you have any frequent hobbies?** | | | | | | | | |
| Hobbies | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| Yes | 199 | 79.60% | 77 | 38.69% | 122 | 61.31% | 30.80% | 48.80% |
| No | 51 | 20.40% | 23 | 45.10% | 28 | 54.90% | 9.20% | 11.20% |
| **How many 5-15 minute breaks per day away from your workstation:** | | | | | | | | |
| Breaks | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| 0-1 | 88 | 35.20% | 17 | 19.32% | 68 | 77.27% | 6.80% | 27.20% |
| 2-3 | 86 | 34.40% | 38 | 44.19% | 48 | 55.81% | 15.20% | 19.20% |
| 4 or more | 79 | 31.60% | 37 | 46.84% | 42 | 53.16% | 14.80% | 16.80% |
| **How many breaks longer than 15 minutes away from your workstation:** | | | | | | | | |
| Breaks | Total | % Total | Males | % Males | Females | % Females | %Total M | %Total F |
| 0-1 | 136 | 54.40% | 62 | 45.59% | 74 | 54.41% | 24.80% | 29.60% |
| 2-3 | 63 | 25.20% | 21 | 33.33% | 42 | 66.67% | 8.40% | 16.80% |
| 4 or more | 51 | 20.40% | 9 | 17.65% | 42 | 82.35% | 3.60% | 16.80% |

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**Revised:**

# Appendix J

# Calculations

Calculations for Female Weights – Ergonomics vs. West Virginia Dietary Association

$$Z_1 = \frac{120-136}{30.36} = -.527$$

and from the Normal Distribution table we get a value of .1985

.50 - .1985 = 30.15%

$$Z_2 = \frac{140-136}{30.36} = .1317$$

and from the Normal Distribution table we get a value of .0517

.50 - .0517 = 55.17%

$$\nabla = 55.17\% - 30.15\% = 25.02\%$$

Calculations for Male Weights – Ergonomics vs. West Virginia Dietary Association

$$Z_1 = \frac{160-172.68}{27.72} = -.457$$

and from the Normal Distribution table we get a value of .1736

.50 - .1736 = 32.64%

$$Z_2 = \frac{184-172.68}{27.72} = .4083$$

and from the Normal Distribution table we get a value of .1554

.50 - .1554 = 65.54%

$$\nabla = 65.54\% - 32.64\% = 32.9\%$$

# VITA

Sandra Rudd graduated from Bearden High School in June of 1974. She worked for 20 years in the manufacturing industry before attending Pellissippi State Technical College and earning an Associate of Science degree in engineering. She continued her academic career at the University of Tennessee, earning a Bachelor of Science degree in Industrial Engineering. This was completed in December 1996. Upon graduation, Your Employment Service, Inc., in North Little Rock, Arkansas, employed her as a safety engineer. She was solely responsible for orchestrating an employee safety program for 1200 employees. This was done with much success. In August of 1997, a division of the Brunswick Corporation in Dandridge, Tennessee employed Sandra. She was responsible for implementing a new quality and safety awareness program. Downsizing of Brunswick employees was seen as an opportunity by Sandra to continue her education at the University of Tennessee. She will be graduating in May 2001 with a Masters of Science degree in Industrial Engineering. Her concentration is in Human Factors. Ms. Rudd has been accepted into the doctoral program.