# Ergonomic Assessment of Computer Workstations for Student Employees and Faculty Members at Saint Louis University School of Public Health

Xue. Liu, Rhoda. Kuziez, Kee-Hean. Ong, Saint Louis University School of Public Health, 3545 Lafayette Ave. St. Louis, MO 63104

## Abstract

*Objective:* To evaluate ergonomic hazards of computer workstations. *Methods:* This cross-sectional study consisted of one initial survey (computer workstation components, ergonomic injury-related symptoms, perceptions of current workstation, and ergonomics knowledge), work posture measurements, and a follow-up survey to gauge intervention effectiveness. *Results:* We recruited 90 participants in this study, whom we divided into two groups: office and cubicle workers. The top five areas of discomfort complaints were the neck, shoulders, hands/wrists, upper back, and lower back. We found that both groups underwent similar experiences of discomfort at their workstations in the past three months; however office workers endured significantly more chronic discomfort/pain ($p=0.018$). The office workers suffered twice as much neck pain as the cubicle workers ($p=0.034$), perhaps due to an association between longer working hours at the computer and the frequency of experiencing discomfort ($p=0.043$). Furthermore, we found a significant difference between our participants' actual working postures in comparison to the neutral/ideal postures ($p<0.05$). However, no significant difference existed between groups regarding their mastery of ergonomic knowledge. The follow-up survey data indicated effectiveness of the intervention: more than 80% of all the participants agreed they learned more about ergonomics and felt confident to recognize and fix their ergonomic problems in the future. *Conclusions:* This study indicates that office and cubicle workers are both exposed to certain ergonomic hazards and associated health problems. The intervention targeting people's knowledge has proven to be effective. In the long-term, it will be helpful to reduce the risk of ergonomic hazards at computer workstations.

**Keywords:** Ergonomics, Computer workstation, Work-related discomfort

## Introduction

Millions of employees today conduct their work activities sitting at a desk, behind a computer for hours on end. With long work shifts, poor workstation set up, and inappropriate seating postures, ergonomic hazards exist at computer workstations, as demonstrated by multiple literary sources.[1,2,3] The Occupational Safety and Health Administration (OSHA) defines ergonomics as "the science of fitting workplace conditions and job demands to the capabilities of the working population."[4] Ergonomics at a computer workstation involves the presence of suitable components and accessories and a proper working posture, allowing the employee to feel physically comfortable to prevent pains that could potentially result.

Each year, thousands of individuals are diagnosed with an illness directly related to poorly designed workstations, and among these are Musculoskeletal Disorders (MSDs). MSDs are the repeated trauma and deteriorating of the tissues, joint, tendons, and nerves that affect the muscles and supporting structures of the body, caused by the work nature or by an employee's working environment.[5] The body parts affected are the arms, hands, fingers, neck, back, wrists, legs, and shoulders; and early warning signs include muscle cramping, stiffness, aching, pain, and weakness in an area. An example of an MSD is Repetitive Strain Injury (RSI), which refers to disorders that result from performing a repetitive task, such as typing, writing, or clicking a mouse. Overall ergonomic disorders are the fastest growing category of work-related illness and account for thousands of work-related illnesses reported to OSHA, according to the United States Bureau of Labor Statistics.[6] On the same note, OSHA reports that musculoskeletal disorders in the United States account for over 600,000 injuries and illnesses that are serious enough to result in days away from work.[7]

A prospective study conducted by Ariens, *et al.* found that sitting at work for more than 95% of the working time is a risk factor for neck pain, and non-neutral positions are associated with musculoskeletal symptoms.[8]Another study by Gerr, *et al.* reported that individuals in computer workstations have a prevalence of 10-62% musculoskeletal symptoms in their neck and shoulder region.[9]The treatment for these problems includes the modifications of posture and the working environment.

Considering ergonomics as a Public Health concern, the aim of this project was thus to evaluate the ergonomic conditions in the computer workstations at Saint Louis University's School of Public Health. This project was conducted as a cross-sectional field study to evaluate the ergonomic hazards that student employees and faculty members are exposed to in their computer workstations on the Salus Center's 3rd and 4th floors. Additionally, this project was designed to promote ergonomics knowledge and to evaluate the association between the design of the computer workstations for student employees and faculty members and any pains or discomforts they may experience. The goal of occupational health is to foster a safe and healthful work environment, and our aim was see if that goal is realized in our School of Public Health and to raise ergonomic awareness among our community in the Salus Center.

**Methods**

Participants were recruited randomly from among the total 150 employees and separated into two groups: office workers and cubicle workers. This project consisted of five parts.

*Initial survey*

The initial survey completed by the participants included questions on demographics, physical workstation characteristics, ergonomics injury-related symptoms, perceptions towards the current working environment, and ergonomics knowledge.

*Measurements of linear and postural angles*

The measurements were designed to quantify the actual working posture of each individual employee while at his/her computer workstation. The employee was asked to maintain his/her usual keying position while measurements were taken using the L510 Lufkin brand 10' measuring tape and a Fiskars brand protractor. The linear measurement (**Figure 1**) indicators included: current seat height from the floor, elbow height from the floor (while seated and working at the computer), eye height from the floor, and distance between the eyes and the computer monitor. The specific postural angles measured were the bent angle of the neck relative to the vertical direction (backward or forward), the twist angle of the neck (left or right) in order to face the computer, and the lower back angle relative to the thigh and the vertical direction.

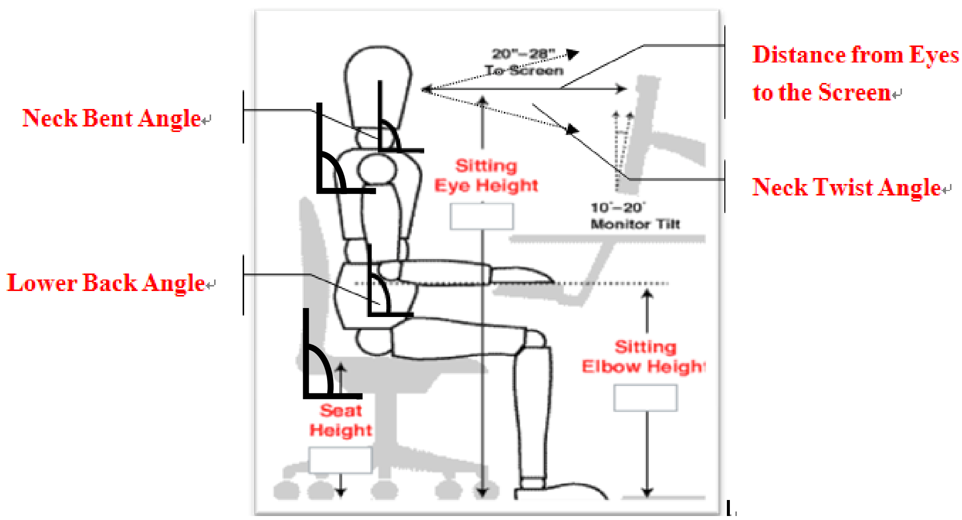


**Figure 1.** Linear and postural angles measurements[10]

*Informational brochure and follow-up survey*

An informational brochure was handed out to every participant as an intervention method targeting to improve people's mastery of ergonomics knowledge. One week later, a follow-up survey was handed out to detect whether there was an increase in ergonomics knowledge, and the survey was also used to evaluate people's willingness and competency to fix ergonomic problems in the future. In general, the follow-up survey was utilized to gauge the intervention effectiveness.

*Statistical analysis*[11]

All the data collected from the initial survey, follow-up survey, and field measurements, were entered into SPSS 18.0 for statistical analysis. Descriptive and frequency analysis were used to summarize the data distribution, including demographic information, health status, workload characteristics, and physical workstation characteristics. Chi-Square analysis was conducted to evaluate the association between the workload characteristics (average working hour per week, average working hour per day, and average percent of time working at a computer) and frequency/duration of the discomfort ( $\alpha$ =0.05). Additionally, it was used to figure out whether there exists a significant difference between the two groups for the nominal variables, including: workload characteristics, physical workstation characteristics, perceptions towards working environment, and ergonomics knowledge before/after intervention. The independent t-test was used for the comparison of continuous variables. The one t-test analysis was used to compare measurements of the actual working postures from our data collection to the neutral working posture for each specific individual height ( $\alpha$ =0.05).[10]

## Results

*Demographic characteristics*

There are 150 employees working at the School of Public Health, including 75 office workers and 75 cubicle workers. 90 of them participated in this study and were separated into two groups according to their workplace, namely as office workers and cubicle workers. The sample sizes and selected demographic characteristics are shown in **Table 1**. The average age of all the participants was 33.9 years (SD, 13.3). The average age for office workers was 42 years (13.6), and 27(6.4) years for cubicle workers.

**Table 1.**Demographic Characteristics of Study Population by Sex and Workplace (N=90)

| | **Males** | **Females** | **Total** |
|---|---|---|---|
| **Office** | 20.0% | 26.7% | 46.7% |
| **Cubicle** | 14.4% | 38.9% | 53.3% |
| **Total** | 34.4% | 65.6% | 100.0% |

*Health status*

Of the study population, 18.9% did not feel physically comfortable at their computer workstation. The data indicated similar results for both groups (p=0.276). The prevalence of experiencing discomfort in some part of body after working at the computer workstation during the past 3-months was approximately 57.4% overall. It was 59.5% for the office workers, which was not significantly higher than the 53.8% for the cubicle workers (p=0.222). **Table 2** represents the Frequency of Experiencing Discomfort among the workers. 23.2% of all participants reported that they often had uncomfortable feelings in some parts of their body after working at the computer workstation during the past 3-months; and 46.5% of them sometimes experienced discomfort. No significant difference (p=0.112) existed between two groups regarding their frequency of discomfort.

**Table 2.** Frequency of Experiencing Discomfort (percentage, %)

| | **Often** | **Sometimes** | **Rarely** |
|---|---|---|---|
| **Office** | 14.3% | 21.4% | 7.2% |
| **Cubic**le | 8.9% | 25.0% | 23.2% |
| **Total** | 23.2% | 46.5% | 30.4% |

**Table 3** lists the top five body parts reported to suffer the most discomfort. They were the neck (37.8%), lower back (35.6%), shoulders (22.2%), hands/wrists (21.1%), and upper back (13.3%) (**Figure 2**). The uncomfortable feelings included pain, aching, and burning. The office workers suffered twice as much neck pain as the cubicle workers (p=0.034).

**Table 3.** Discomfort at Each Body Part (percentage, %)

| | **Neck** | **Shoulder** | **Hand /Wrist** | **Upper back** | **Lower back** |
|---|---|---|---|---|---|
| **Office** | 24.4% | 8.9% | 7.8% | 3.3% | 14.4% |
| **Cubicle** | 13.3% | 13.3% | 8.9% | 10.0% | 21.1% |
| **Total** | 37.8% | 22.2% | 21.1% | 13.3% | 35.6% |

The percentage distribution of people with different durations of uncomfortable feelings is shown in **Table 4**. It varied between the two groups (p=0.018). Approximately 56.3% of all the participants (Office: 21.8%; cubicle: 34.5%) reported that the symptoms last no more than 2 hours. However, compared with the cubicle workers, the office workers were more likely to have chronic discomfort/pain (p=0.018)

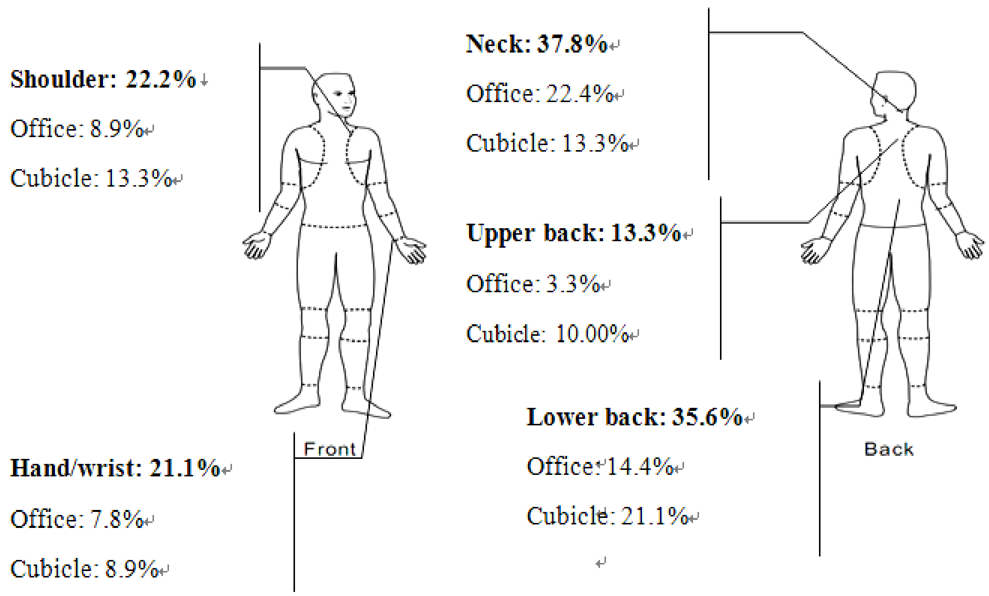


**Figure 2.** Discomfort at Each Body Part[12]

**Table 4.** Distribution of Duration of Discomfort (percentage, %)

| | **<1 hr** | **1-2hr** | **3-4hr** | **5-6hr** | **7-8hr** | **1 day** | **2-3 day** | **1 month** |
|---|---|---|---|---|---|---|---|---|
| **Office** | 12.7% | 9.1% | 1.8% | 3.6% | 3.6% | 3.6% | 1.8% | 5.5% |
| **Cubicle** | 3.7% | 30.8% | 3.7% | 0.0% | 1.8% | 14.5% | 3.7% | 0.0% |
| **Total** | 16.4% | 39.9% | 5.5% | 3.6% | 5.4% | 18.2% | 5.5% | 5.5% |

*Work characteristics*

**Table 5** contains the basic workload characteristics for the two groups. The office workers spent more time per week ($p<0.0001$) and per day ($p=0.001$) working at the computer workstation than the cubicle workers. However, these two groups spent a similar percent of time working at the computer ($p=0.070$), which was approximately 73%. Chi-square analysis found a significant association between longer working hours at the computer and the frequency of experiencing discomfort ($p=0.043$).

**Table 5.** Workload Characteristics No. (SD)

| | **Average working hr/week** | **Average working hr/day** | **Average percent of time working at computer** |
|---|---|---|---|
| **Office** | 36.0 (1.1) | 7.0 (1.9) | 72.4% (1.5) |
| **Cubic** | 21.5 (1.0) | 5.0 (1.9) | 73.5% (2.2) |
| **Total** | 27.9 (1.3) | 5.8 (2.1) | 72.3% (2.0) |

*Physical workstation characteristics*

The results of the percentage of participants who had adjustable office equipments (chair and monitor) in their workplace are shown in **Table 6**. The percentages for each of our two groups are similar with regards to the office equipment, except for the chair armrest. 30.6% of chairs with armrests in the office were adjustable, while only 7.5% in the cubicles were adjustable. A significant difference has been found (p=0.015).

**Table 6.** Distribution of Adjustable Workstation Equipment (percentage, %)

| | Chair | | | Monitor | |
|---|---|---|---|---|---|
| | **Height** | **Tilt** | **Armrest** | **Height** | **Tilt** |
| **Office** | 41.3% | 41.6% | 30.6% | 34.1% | 40.6% |
| **Cubicle** | 42.2% | 25.0% | 7.5% | 28.6% | 40.7% |
| **Total** | 83.5% | 66.6% | 38.1% | 62.7% | 81.3% |

*Perceptions and behaviors*

52.5% of all the participants agreed or somewhat agreed that they were currently exposed to ergonomic hazards. Both groups had the same attitudes towards their exposure situation (p=0.207). The data (**Table 7**) to examine people's mastery of ergonomic knowledge indicated that overall only 10.1% of all participants knew a lot about ergonomics, while 25.9% of them hardly knew anything about ergonomics, and the specific results were similar among groups (p=0.471). However, around 64.2% of all the participants (office workers: 65.9%, cubic workers: 61.5%) indicated willingness to learn more about ergonomics. **Table 8** contains an array of indicators used to evaluate people's behaviors related to ergonomic health problems. Only 33.3% of all the participants often paid attention to their working postures, while 25.6% of them rarely paid attention. Although a higher percent of the cubicle workers often paid attention to their working postures, there is no significant difference (p=0.306) between these two groups for the overall situation. Further evaluation of people's behaviors indicated that the cubicle workers were more often likely to twist their neck when they were looking at monitor than the office workers (p=0.002). But the cubicle workers were more often likely to take a rest when they experienced discomfort (p=0.035) and take a regular rest regardless of experiencing discomfort (p<0.0001).

**Table 7.** Different Mastery Level of Ergonomics Knowledge (percentage, %)

| | A lot | Some | A little bit | Hardly any |
|---|---|---|---|---|
| **Office** | 5.6% | 16.9% | 14.6% | 9.0% |
| **Cubic** | 4.5% | 13.5% | 19.1% | 16.9% |
| **Total** | 10.1% | 30.3% | 33.7% | 25.9% |

**Table 8.** Evaluation of Behaviors regarding Ergonomic Health Problems (percentage, %)

| | Frequency | Pay attention to working posture | Take a rest because of discomfort | Take a regular rest | Effort to adjust chair | Effort to adjust monitor | Effort to adjust keyboard | Use mouse supporter | Twist neck while looking at monitor |
|---|---|---|---|---|---|---|---|---|---|
| | Often | 11.1% | 23.3% | 5.6% | 17.6% | 18.7% | 15.1% | 38.9% | 6.7% |
| **Office** | Sometimes | 20.0% | 11.1% | 11.1% | 19.2% | 21.8% | 15.1% | 11.7% | 15.8% |
| | Rarely | 15.6% | 12.2% | 30.0% | 25.6% | 21.8% | 16.5% | 11.7% | 24.8% |
| | Often | 22.2% | 24.6% | 13.4% | 13.7% | 12.0% | 35.1% | 6.3% | 16.5% |
| **Cubicle** | Sometimes | 21.1% | 24.6% | 12.2% | 13.7% | 8.6% | 18.2% | 6.3% | 7.7% |
| | Rarely | 10.0% | 4.1% | 27.7% | 10.2% | 17.1% | 0.0% | 25.1% | 28.5% |
| | Often | 33.3% | 48.0% | 18.9% | 31.3% | 30.7% | 50.2% | 45.2% | 23.2% |
| **Total** | Sometimes | 41.1% | 35.7% | 23.3% | 32.9% | 30.4% | 33.3% | 17.9% | 23.5% |
| | Rarely | 25.6% | 16.3% | 57.7% | 35.8% | 39.0% | 16.5% | 36.8% | 53.3% |

*Working posture*

The frequency of sitting at each of the following three working postures for the two groups is shown in **Table 9**. 47.7% of all the participants often sat at the first neutral working posture. It was the most common seating posture for both the office and cubicle groups (p=0.156). Second to that, 37.7% of individuals sat leaning forward; and only 9.3% of people bent backwards while sitting.

**Table 9.** Seating Posture Frequency (percentage, %)

| | | Neutral posture | Leaning forward | Bending backward |
|---|---|---|---|---|
| **Office** | Often | 25.3% | 20.3% | 6.2% |
| | Sometimes | 29.9% | 29.0% | 12.2% |
| | Rarely | 6.0% | 11.6% | 41.6% |
| **Cubicle** | Often | 22.4% | 17.4% | 3.1% |
| | Sometimes | 10.4% | 10.2% | 10.8% |
| | Rarely | 6.0% | 11.6% | 26.2% |
| **Total** | Often | 47.7% | 37.7% | 9.3% |
| | Sometimes | 40.3% | 39.1% | 23.0% |
| | Rarely | 12.0% | 23.1% | 67.7% |

**Table 10** contains the descriptive information on the differences of each working posture field measurement indicator. This was defined as the difference between the actual measured value and neutral value of one working posture indicator. The negative values in **Table 10** signify that the actual value of one indicator was smaller than the neutral value. It varied for the thigh angle difference and bent neck angle difference. The negative value indicates the degree of bending forward either the lower back or neck, while the positive value indicate the degree of leaning either the lower back or neck backwards. **Figure 3** compares the differences in values of the two groups for each indicator. Most of them are overlapped with each other. According to the results of independent t-test, there is no significant difference between two groups for the difference in value of each indicator ($p>0.05$). However, a significant difference ($p<0.05$) does exist between the actual and neutral working posture.

**Table 10.** Descriptive Information of Each Working Posture Measurement Indicators

| | Location | Range | Mean (Std. Deviation) |
|---|---|---|---|
| **Δ Seat height** | Office | [-1”,6”] | 3.13 (1.60) |
| | Cubicle | [-2”,6”] | 2.85 (1.55) |
| **Δ Elbow height** | Office | [-2”,6”] | 3.27 (1.76) |
| | Cubicle | [-1”,9”] | 3.70 (2.13) |
| **Δ Eye height** | Office | [-7”,4”] | 2.22 (1.91) |
| | Cubicle | [-7”,3] | 1.75 (1.41) |
| **Δ Distance (eye to monitor)** | Office | [-2”,10”] | 1.47 (2.55) |
| | Cubicle | [-8”,10”] | 1.28 (2.56) |
| **Δ Neck bent angle** | Office | [-30$^o$,20$^o$] | 11.00 (7.07) |
| | Cubicle | [-30$^o$,15$^o$] | 9.75 (8.54) |
| **Δ Neck twist angle** | Office | [0$^o$,30$^o$] | 7.46 (8.08) |
| | Cubicle | [0$^o$,40$^o$] | 9.13 (10.68) |
| **Δ Thigh angle** | Office | [-30$^o$,20$^o$] | 8.08 (6.82) |
| | Cubicle | [-30$^o$,45$^o$] | 11.75 (13.52) |

*Follow-up*

**Table 12** contains the data indicating the effectiveness of the intervention in this study. Approximately 95% of all the participants agreed or somewhat agreed that they learned more about ergonomics after reading the ergonomic brochure. Around 85% of them felt confident to detect the ergonomics hazards in their workplace and fix them. 80% reported they were going to fix their current ergonomic problems and be more aware of them in the future. The intervention was equally effective for both groups (p>0.05).

**Figure 3**. Error Bar of Differences in Values for Working Posture Indicators (Difference= ABS |Actual value-Neutral value|)

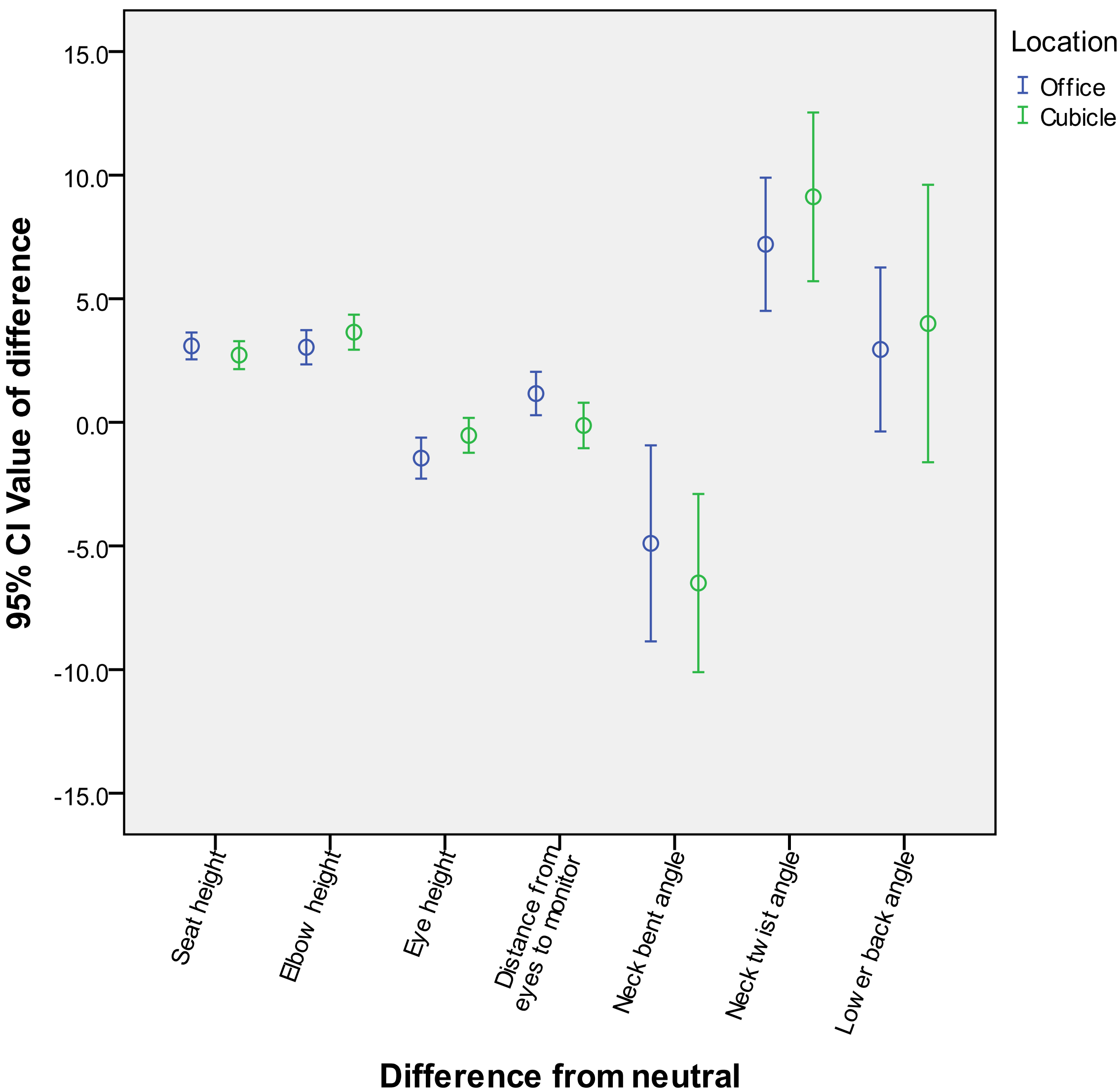

**Table 12.** Attitudes toward of Ergonomic post intervention (percentage, %)

| | | Know more about ergonomics | Confident to recognize ergonomic hazards | Fix ergonomic problems |
|---|---|---|---|---|
| **Office** | Agree | 24.4% | 20.9% | 18.6% |
| | Somewhat agree | 38.3% | 36.6% | 32.2% |
| | Somewhat disagree | 1.7% | 6.9% | 13.6% |
| | disagree | 1.7% | 1.7% | 1.7% |
| **Cubic** | Agree | 13.6% | 11.9% | 5.1% |
| | Somewhat agree | 18.6% | 16.9% | 25.4% |
| | Somewhat disagree | 0.0% | 5.1% | 3.4% |
| | disagree | 1.7% | 0.0% | 0.0% |
| **Total** | Agree | 38.0% | 32.8% | 23.7% |
| | Somewhat agree | 56.9% | 53.5% | 57.6% |
| | Somewhat disagree | 1.7% | 12.0% | 16.9% |
| | disagree | 3.4% | 1.7% | 1.7% |

## Discussion

Through this project, we were able to evaluate the association between computer workstation design and ergonomic-related health status of the office and cubicle workers at Saint Louis University's School of Public Health. Our data indicates 57% prevalence among all study participants to have experienced discomfort in some parts of their body after working at a computer workstation over the past three months. The top five body parts suffering most discomfort were the neck, shoulders, hands/wrists, upper back, and lower back. According to the surveys, symptoms usually disappeared within two hours, and thus acute health effects were the primary concern, although some office workers did have chronic problems. This indicates the possibility that employees (faculty, staff, and students) working at the School of Public Health are being exposed to certain ergonomic hazards.

Multiple studies[13,14,15,16,17] have found that ergonomic-related health problems are associated with: workload characteristics, physical workstation characteristics (office equipment), perceptions towards ergonomics, and human behaviors. The results of the Workload Characteristics Analysis indicate that office workers spent significantly more time working at their computers than the cubicle workers; and the significant relationship between the average percent of time working at computer with the frequency of experiencing discomfort has been verified in this study. What is worse was that office workers did not take regular breaks as often as cubicle workers. Therefore, theoretically we could assume that the prevalence of ergonomic-related health problems for the office workers should be higher than that of the cubicle workers. However, no significant difference has been found, which can be explained by multiple reasons. First, in evaluating the adjustability of workstation equipment, we discovered that 40% of them could be adjusted to meet individual needs for both office and cubicle workers. Second, both, the office and cubicle workers, were sitting in a posture significantly different from the neutral posture, thus causing both groups to experience similar discomfort. Additionally, when we further investigated people's behaviors regarding ergonomics, we discovered that only a small number in both groups reported that they often paid attention to their working postures; and roughly 30-50% of them made efforts to adjust their working environment to attain physical comfort. It is well known that knowledge, attitudes, and beliefs are determinants of an individual's behavior.[18] However, we found that only 10.1% of all participants stated that they knew a lot about ergonomics.

Therefore, there is a trade-off relationship between each of the assessed factors associated with ergonomic health problems. In other words, although the prevalence of ergonomic-related health problems between office and cubicle workers is the same, and both experience discomfort after working at the computer for some period of time, it is difficult to evaluate exactly what specific factors are the causes of these similarities between groups.

Fortunately, 64.2% of the study participants expressed their willingness to learn more about ergonomics, thereby granting effectiveness to our intervention, which targeted people's ergonomics knowledge. Due to the limitations of time and money, the simple intervention we conducted was proven to be effective, as 95% of the study participants agreed or somewhat agreed they knew more about ergonomics; and 85% of them felt confident to detect the ergonomic hazards in their workstation and fix them in the future.

The above results also imply some interesting findings. 52.5% of all participants agreed that they were exposed to some ergonomic hazards. Compared to the cubicle workers, the office workers had better office equipment that would allow them to develop a healthier working environment with fewer ergonomic hazards. However, most did not take advantage of this benefit, and some of those who tried, did so the wrong way, which can be indicated by their actual working postures.

Because in this study, we evaluated each group, the office workers and cubicles, separately and together, there are some other explanations to our findings. For instance, in comparison to the cubicle workers, the office workers were more likely to have chronic health problems. This could be attributed to the older average age than the cubicle workers, as most of the office workers consist of faculty and staff. Therefore, the exposure period is longer for them than for the cubicle workers.

**Limitations**

This project was designed as a cross-sectional field study, and due to the nature of the study design, no causative relationship between the ergonomic hazards and ergonomic-related health problems can be assessed. Ergonomic problems could be associated with multiple factors; therefore it is difficult for us to detect the specific factors responsible for the discomfort experienced by employees. To identify the specific culprits causing the pain, we would need to conduct a controlled experiment and tailor it to individual workstations.

Another limitation may be associated with the working posture evaluation. In evaluating an individual's working posture, an array of numbers derived from the 1988 Anthropometric Survey of the U.S. Army Personnel databases used to define the neutral working position, with which we compared the actual values measured during this project. In reality, no one can precisely sit in the neutral posture for an extended period of time. Therefore, our results could overestimate the problem in relation to the ergonomic-pains resulting from working postures. An operational range of values for each working posture indicator should be developed in future studies.

The intervention we provided was the same for all the participants. It might be more effective if we could tailor the intervention to fit each individual's specific knowledge level of ergonomics, as some participants may not have read the brochure carefully if they already had some ergonomic knowledge. If this is the case, they might have responded that the brochure did not help them learn more.

Some individuals indicated in the post-intervention survey that they do not feel strongly about changing the ergonomic hazards in their computer workstations. However, a number of these individuals made point to personally explain this response was due to the fact that they do not have the resources to make the necessary changes.

Finally, computer workstations vary in characteristics and components. Because of these differences, the generalization of our study is limited to only similar workstations.

**Conclusions**

This study and our findings confirm that employees working in the computer workstations at Saint Louis University's School of Public Health are exposed to some ergonomic hazards, which are associated with multiple factors. Although no specific causative relationship has been verified, the results provide us with a general picture about the current exposure situation and some health problems of concern at the Salus Center. This could be a beneficial panel study for any further future investigations looking at health-related ergonomic problems in our university.

**Acknowledgements**

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