Upper Extremities Musculoskeletal Disorder Related to Use of Computer and Mobile Phone Technology

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Abstract*—The main objective of this study is to determine the possible upper extremities affected by musculoskeletal disorder among engineering students in selected CALABARZON schools. Results show that majority of the respondents are male, 20 years old, taking Industrial and Civil Engineering programs. In terms of computer-related factors, most of the respondents have used both laptop and desktop since elementary, consume it for four or more hours, type moderately fast, consider doing a hunt and peck typing skill on both hands, and sit on chair. For mobile phone-related factors, majority of the respondents have used smart phones since elementary, consume it for four or more hours, and type fast using the thumb finger of both hands. There is a significant relationship between computer and mobile phone factors and the physical discomforts around the neck, shoulder, upper arm and wrist, hand and finger. As a result, the top three upper body parts where musculoskeletal disorders mostly occur are neck, shoulder, and wrist, hand, and fingers.

Keywords*—Upper extremities, musculoskeletal, disorders, technology, nordic musculoskeletal questionnaire

INTRODUCTION

Ergonomics is simply defined as the study of work and is about designing the task to fit the person rather than the person's body fitting to the task [1]. Ergonomics plays an important role in a person's productivity. It aims to eliminate physical stress as well as to lessen physical injuries or disorders due to improper postures and being overindulged to activities [2]. The goal of ergonomics is to optimize and modify the relationship of people's work and their capabilities. In line with this, a decrease on the risk of injury or illness, an improved performance and the quality of work can take place [3].

Musculoskeletal disorders (MSDs) are injuries that affect the human body's movement or system such as muscles, tendons, ligaments, nerves, discs, blood vessels, and more [4]. Students use technologies during their free time to stay connected but gradually complain about the pain they encounter after working on a computer. A study shows that university students attached to computers have been experiencing musculoskeletal discomforts while others experience MSDs after working on a computer for an hour. One of the reasons why students feel discomfort is that workstations are not setup correctly; thus, producing awkward positions rather than a relaxed one [5].

Few researches had been conducted on MSDs among engineering students in the Philippines compared to working populations. Thus, this study aims to investigate and determine various risk factors and upper body parts affected by musculoskeletal disorders among engineering students since they are prone to develop MSD while using computers and mobile phones.

Conceptual framework

A research paradigm was used by the researchers to show the relationship between the independent variables and the dependent variable of the study.

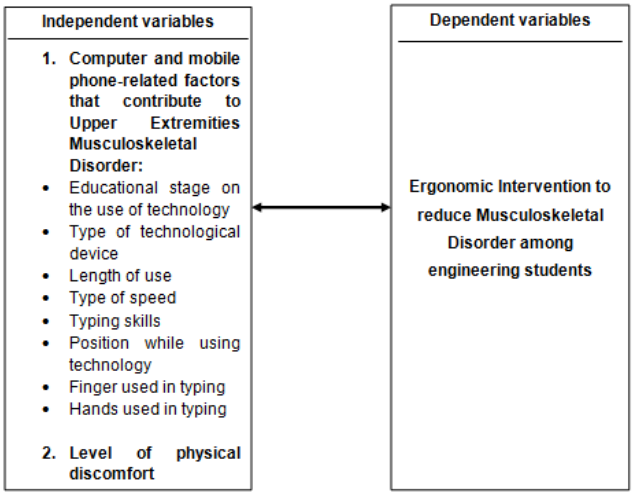

Figure 1. Research paradigm

Objectives of the study

The main objective of the study is to determine the possible part of the upper extremities affected by musculoskeletal disorder among engineering students in selected CALABARZON schools. Specifically, the study aims to achieve the following objectives:

1. Determine the demographic profile of the respondents in terms of age, gender, and Engineering program;
2. Determine the factors that contribute to upper extremities musculoskeletal disorder in terms of educational stage on the use of technology, type of technological device, length of use, type of speed, typing skills, position while using technology, finger/s used in typing, and hands used in typing;
3. Identify the level of physical discomfort of the respondents on upper body parts;
4. Determine the significant relationship between the level of physical discomfort and the factors that contributes to upper extremities musculoskeletal disorder; and
5. Recommend an ergonomic intervention strategy to reduce musculoskeletal disorder among engineering students based on the findings of the study.

METHODOLOGY

A quantitative descriptive method of research was used by the proponents of the study. It is a method that requires data gathering and data collection of the present condition of engineering students. A quantitative research concentrates on the numerical analysis of collected data through the use of surveys, questionnaires, and other types of data collection. This research used survey type of method in order to collect the necessary information needed in the study.

The data collected by the proponents were analyzed through the use of statistical treatments. These were used for the analysis and interpretation of the data from the survey. The statistical tools used were: frequency and percentage to interpret the demographic profile of the respondents and computer and mobile phone-related factors that contribute to upper extremities musculoskeletal disorder; weighted mean to assess the level of physical discomforts of the respondents; and Pearson's chi-square or chi-square test of independence to test the relationship of the level of physical discomforts and the factors that contribute to upper extremities musculoskeletal disorder.

Design constraints

Economic:
- Available budget for the new design
- Prices of current design for computers and mobile phones
- The taxes collected for having a new design
- Medical care cost once new design is implemented
- The costs of having training program to prevent musculoskeletal disease

Social:
- Creating a dependency and the limit of learning about computers and mobile phones.
- Human beings deflect aptitude in society
- How consumers use technologies for social considerations

Ethical:
- The explanations on the way technology works and gives impact on the values of a consumer
- The limitations of having access to technologies
- How the product affects the personal private

life of a consumer

Health and safety:
- The evaluation of musculoskeletal diseases to occur while using technological devices
- Product materials of the technological devices used may be toxic
- The standard vibration of devices that could give musculoskeletal diseases
- The security and safety of the consumer while using devices

Manufacturability:
- The consumption of a student in front of the technology
- The comfortability of the design for the user
- How the design would help the user prevent musculoskeletal diseases
- The design with highly accurate measurements.
- Design and methods with impossibly high constraints

Sustainability:
- The design of technologies should be appropriate every year.
- The anthropometric measurements of a person should be considered for designs
- The design of mobile phones and computers would match the varieties of an individual person.

RESULTS AND DISCUSSION

Ergonomic Intervention	
Category	**Computer/Laptop Factor**
A. Educational Stage (College Students)	• They should always prepare the computer workstation that is suited for the type of work and equipment to use. • They should make the laptop similar with the desktop workstation that will allow shoulders and hands to relax and be at the elbow level. • If they suffer from tingling or loss of sensation, get immediate medical attention. • If they suffer from pain while using computer, try to work on other activities where there will be no association with keyboard and mouse. • In order to rest the wrist, they should use one with a broad, flat, firm surface design of computer or laptop.
B. Length of use	• They should make sure to take enough intervals of rest of at least every 30 minutes. • They should not use computers/laptops for a long period of time. • When using computer for a long time, they should stretch their wrist, shoulders and neck to reduce muscle tension. • For prolonged use, it is best to add a separate monitor and keyboard. • They should keep elbows at a 90° angle. They should also keep wrists straight, supported by a foam pad or chair armrests.
C. Typing speed	• They should follow the acceptable standard in typing of 33-40 words per minute or 10000-12000 keystrokes per hour. • Be sure not to bang while using the keyboard. • They should use a regular keyboard but on a neutral position to avoid musculoskeletal discomforts. • They should keep hard copy documents at eye level by using a document holder to avoid pains due to improper placing of documents. • They should position monitor at eye level, directly in front of your body, about an arm's length from the eyes (at least 18").
D. Typing skill	• They should type with the tips of the fingers. • They should use shortcut keys as much as possible. • They should avoid lazy wrists. • Same for typing speed, they should use a regular keyboard on any typing skill used but on a neutral position to avoid musculoskeletal discomforts. • They should use keyboard arm. It is a movable piece allowing them to maintain the correct posture when using keyboard to prevent muscular pain and numbness.

Category	**Mobile Phone Factor**
A. Educational Stage (College Students)	• They should maintain the phone at the chest, chin or eye level. When phone is below eye level, they should look down with their eyes and not with their neck. • They should always observe proper handling of devices. • For neck posture, they should avoid excessive looking down when using mobile phones. • They should change their grip posture to ensure load rotation. • They should be aware of the different designs and features of the phone that will comfort their hands and other upper body parts.
B. Type of technology use	• When purchasing a mobile phone, they should choose the one that has full keyboard that would not require them to tap 2-3 times on selecting a letter, thus, reduces the repetitive motion done. • They should use voice recognition software as hand-free options. • If possible, they should use Bluetooth headset or devices so that they would not hold their phone for long period of time. • Find a phone that their thumb can reach the other side of the phone comfortably. • They should be able to touch their overall phone with their middle finger and thumb.
C. Length of use	• They should limit duration and frequency of mobile phone use or take frequent intervals of rest of at least 15-30 minutes. • They should reduce keystrokes if possible to reduce the amount of time they spend using their mobile phone. • As much as possible, they should use auto complete tools to reduce the amount of time required to type words or sentences. • When they show heavy phone use, try to stay within the easy range or the nearest range of reach. • Avoid excessive looking down as this bends the neck. If their phone is below eye level, they should look down with their eyes rather than their neck. • Those using smartphone for a long period of time, they should use tactile keyboard for smartphones for optimum use of either fingers.
D. Fingers used in typing	• They should alternately use thumbs and other fingers in typing. • They should alternately use fingers when using touch screen phones. • They should use both thumbs. • If using the thumb when typing, they should use the pad of their thumb. • They should avoid excessive gripping on the phone. A standard average grip would be 51.8 mm.

The basis of the proponents for the ergonomic intervention strategy comes from several studies, namely: *Ergonomic Guide to Computer-based Workstations*, *Ergonomics Guidelines for Mobile Devices (Stanford University)*, *Arranging a Computer Workstation: Recommendations (University of Pittsburgh)*, *Princeton University: University Health Services*, *Mobile Phones and Tablets Accounting for Touch (University of California)*, and *Computer Workstations: An Ergonomic Guide (National Safety Council)*. One of these articles states, "do not wait until you feel pain or discomfort. Learn to change the way you work. If you understand your body posture in relationship to your computer equipment and furniture, you may, in fact, be able to prevent this kind of injury."

CONCLUSION

Out of 190 engineering students from selected universities, majority of the respondents are 20 years old, male, and taking Industrial and Civil Engineering. Musculoskeletal disorder mostly occurs to programs that require repetitive movement.

In terms of computer-related factors, most of the respondents have used both laptop and desktop since elementary, consume it for four or more hours, type moderately fast, consider doing a hunt and peck typing skill on both hands, and sit on a chair. For mobile phone-related factors, majority of the respondents have used smart phones since elementary, consume if for four or more hours, and type fast using the thumb finger of both hands.

Engineering students tend to develop mild to moderate pain on both upper left and right body parts due to the factors that affect the development of physical discomfort. The top three upper body parts on both left and right regions of the body are the neck, shoulder, and wrist, hand, and fingers.

There is a significant relationship between the level of physical discomfort and the factors that contribute to upper extremities musculoskeletal disorder. Overall, the main body parts with physical discomfort are the neck, shoulder, upper arm, forearm, and wrist, hand, and fingers in terms of the respondents' educational stage, length of consumption, typing speed, typing skills, type of technological device, and finger used in typing,

Results also show that respondents are at risk of having upper extremities musculoskeletal disorder due to improper posture in using technological devices. Therefore, the proponents suggested some measures or ergonomic intervention strategies in terms of computer and mobile phone-related factors. A good working station and proper posture help reduce/minimize the risk of developing an injury.

RECOMMENDATION

For the respondents, learn the basic ergonomic principle and strategy in preventing upper extremities musculoskeletal disorder.

For school administrations, more ergonomically-designed chairs and tables must be provided. School evaluation must also be conducted to assess whether students are at risk of upper extremities musculoskeletal disorder and the result of the evaluation may adjust some workstations for students to prevent upper extremities MSDs. The school environment can contribute to the prevention of MSDs among students.

For future researchers, proper way of using computers, laptops, and mobile phones and proper workstation design must be identified as part of an investigation which may affect MSDs among students. Future studies may also consider the anthropometric measurements, angle of neck posture, the relationship between the demographic profile and musculoskeletal disorders, history of MSDs (if possible), number of breaks from the computer, and the functions one uses on a mobile phone.

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