Effects of Computer-Based Work on the Musculoskeletal Discomfort Among College Students

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Abstract

College students have been exposed to online classes ever since the COVID-19 pandemic situation arose. Exposure to the discomfort of utilizing gadgets while attending online classes or performing tasks on work desks has been rapidly emerging and increasing. This becomes a widely known issue for most college students and must be given early treatment to decrease such musculoskeletal disorders (MSDs) and risks. Causes of these MSDs are awkward posture, repetitive tasks, and maintaining a posture for long periods. This study aims to identify a significant difference in the musculoskeletal discomfort level of respondents on several factors such as gender, age, type of gadget used, hand control, type of keyboard, screen time, and workstation setup. The musculoskeletal discomfort of users experienced on body and hand were separately analyzed using Cornell Musculoskeletal Disorder Questionnaire (CMDQ). The results of the study revealed that college students who often use computer-based work in online classes experience discomfort on the lower back, neck, upper back, and right wrist while specific hand parts that have a high prevalence of discomfort are the wrist, ring, middle, index fingers, and thenar region. The result of ANOVA also revealed that students who used laptops (x=709.8) have higher body discomfort compared to users of desktops (x=199.7). It was also proved that students who use computers for more than 7 hours have higher body discomfort (x=285.2) than students who use computers for 3-6 hrs a day (x=172). Similarly, for hand discomfort, it was identified that laptop keyboard users (x=166.2) have higher discomfort than mechanical keyboard users (x=86.6), the same goes with screen time. Students who use computers for more than 7 hours per day (x=153.7) have significantly higher hand discomfort than those who use them for 3-6 hrs (x=59). Given this condition, we have proposed recommendations and prevention attributes to minimize the risk of MSD of students.

Keywords
Discomfort, CMDQ, computer-based work, musculoskeletal disorders (MSD), college students,

1. Introduction
1.1 Background of the Study
Online classes started ever since the COVID-19 pandemic began. Students around the world, such as the Philippines, are being forced to stay at home and enroll in their respective universities or schools to conduct online classes with classroom settings where professors and teachers are involved. A little background of this is that there are children ages 9-11 located in 186 countries experiencing school lockdowns because of the current situation. With the abrupt turn away from the classroom in many parts of the world, some individuals are curious whether online learning adoption would continue post-pandemic, and how such a shift will affect the global education industry. (Li, 2020). Classes are specifically being done with the use of the Zoom application, Blackboard, CANVAS, and the like. Since students are imposed to set up their cameras and laptops in a manner where professors and teachers should be able to witness, many students could not afford this which adds up stress to their mental health and the loss of interest in learning. Not only that, with the minimum amount of students who can financially manage to supply their work set up. It is not unusual for students to struggle with their work environment, which causes pain to different body parts due to hours of sitting on their monobloc chairs, on the floor, or a shortage of ergonomic facilities to maintain their productivity at its peak.

One of the main causes of muscle pains and discomfort is the lack of ergonomic equipment. As students, expect that there would be more workload for them because of the online setting which reveals more hours of sitting on their desks and having an average of almost 7 hours a day of working on their laptops or desktops. Without proper early mitigation of feelings of discomfort and risks in their musculoskeletal systems, this can cause great damage to our muscles, worst-case scenario would be the inability to move or control your muscles.

1.2 Review of Related Literature

In the latest educational trend, laptop computers are projected to become the working standard for students. Laptops are efficient, but functional, devices that are easy to handle due to their size and portability. Most teens now use laptop computers daily, and they can be classified as heavy users due to their increased usage. Users often assume uncomfortable postures as a result of the laptop's inherent portability, putting the laptop user in unpleasant or unsafe postures that may trigger pain or injury (Rafael et.al 2007).

This overlooks the impact of laptop usages on college students that leads to musculoskeletal disorders. The study looked into the prevalence of MSDs in girls and found that mild users had a higher rate of pain than other user groups. Musculoskeletal symptoms were prevalent in various anatomic regions such as the neck, shoulders, upper back, and lower back. Various studies state that most discomfort pains for college students are originally or coming from the usage of the laptop. Some studies indicate that awkward postures are more prominent in contributing to MSDs rather than the screen time of laptop usages. This study focuses on the use of RULA assessment and it states that respondents' pain was caused by the various incorrect postures they adopted when using their laptops. Karen et al (2009) also discovered that often adopting an uncomfortable pose was correlated with recurrent discomfort. The incidence of pain was also linked to users' uncomfortable positions rather than the amount of time they spent on their laptops, according to the findings. This is in line with a study conducted by Karen et al. (2009) on college students who indicated persistent musculoskeletal pain associated with computer use. The current laptop usage practice was not ergonomically proper. Long-term use of a bad posture has resulted in a variety of musculoskeletal issues among college students. There was a strong association between the respondents' stance and the rate of pain in the current research. Musculoskeletal symptoms were prevalent in various anatomic regions such as the neck, shoulders, upper back, and lower back, all of which are directly related to local physical demands. (Al-Eisa, et al., 2012).

The human body is astonishing as it is composed of different systems with complex and particular functions enabling a human to survive and perform his/her daily activities. Naturally, 11 human body systems work collaboratively to keep a person alive or in other worst cases, deteriorate his/her existence. These systems are composed of different organs, muscles, and tissues that work simultaneously in a human's body. According to McLaughlin (2020), some organs can be a part of more than one body system as it serves other functions. Alongside, some organs and tissues only serve a function in a particular system. Moving forward, these systems are namely: respiratory system, digestive system, cardiovascular/circulatory system, urinary system, endocrine system, nervous system, musculoskeletal system, integumentary/exocrine system, lymphatic/immune system, and reproductive system—theses systems, altogether work for a human's survival.

The musculoskeletal system, also known as the 'locomotor system' according to Villa-Forte (2019) provides the human body its shape, form, stability, support, and movement. This system is composed of the body's bones (which comprises the skeleton), cartilage, muscles, tendons, ligaments, and connective tissues. The body's skeleton provides a structure for the muscles and other soft tissues. Collectively, these organs support an individual's body weight, maintain his/her posture and aid human movement. Naturally, the musculoskeletal system is subdivided into two broad systems, namely: Muscular system—this comprises all types of muscles in the body. Specifically, the skeletal muscles are the ones that work on the body joints to generate human movements. In addition to that, the muscular system includes the tendons—responsible for the attachment of muscles to the bones. The skeletal system, on the other hand, which's largely constituent is the bone in which it is structured altogether, forming the joints, providing a human with a stable, yet moveable skeleton. According to Sendic (2021), the musculoskeletal system is not only limited to its main function, rather it also performs other functions such as the storage of minerals (e.g., calcium) in the skeletal parts, and storing a great number of the body's carbohydrates—in the form of glycogen—on its muscular system division. In general, the muscles aid in movement production, stabilizing joints, maintaining a human's posture, and creation of body heat. On the other hand, bones provide a framework for the body, a mechanical foundation for movement, protection for vital organs, production of blood cells, and storage of minerals (Sendic, 2021).

In an office environment, employees tend to just use tables and chairs to perform their tasks, however, according to studies, this setup causes discomfort to employees, particularly in the upper extremities. According to McBride and Harcombe (2012), the significant origin of morbidity is the work-related musculoskeletal pain and discomfort of employees—caused by ill-match among the physiological and physical factors of tissue load and tissue tolerance that causes conjunction of structural damage and the piled-up metabolic waste. It has been known that some of the strains and sprains the employees are experiencing are called acute overexertion—wherein there might be direct damage to their tendons, ligaments, muscle fibers—serious structural damages. Through direct chemical or mechanical action, this overexertion could lead to a stimulation of peripheral nociceptors (type II and IV pain fibers). Moreover, a sub-acute mechanism may also transpire through which there's a slow commencement of tissue damage over time. It has been known that chronic MSDs are also connected with pain syndromes or the 'overuse' syndromes. Furthermore, there are social and cultural connotations with these chronic pain syndromes which have caused in 'epidemics' of non-specific musculoskeletal symptoms--—some patients may be under the extremes of this range of disorder, some have acute pathology that's amendable through interventions while others become disabled. Several individuals lie among these extremes—thus, there's a further universal understanding that work-related MSDs have a multifactorial etiology (McBride and Harcombe, 2012). With the current study being conducted, as this online setup of college students continues for quite a time, a possibility of instigating a severe MSD risk could occur—this is not helpful to the students. Thus, students must invest in practicing proper posture and support their comfortability.

For the past decades, it isn't new to a lot of people's knowledge that awkward postures, extreme muscular load, and repetitive movements can cause work-related musculoskeletal disorders, also known as MSD. Despite knowing this, the risks still come across to different disciplines such as the manufacturing industry, office environment, cleaning, etc. After years of extensive research and efforts by different organizations and occupational health services, the arising number of people experiencing severe work-related MSD is still not given to a conclusion. (Arvidsson et. al., 2021). Although there are quite a few recognized risk factors for work-related musculoskeletal discomforts and disorders (MSD), there are still numerous people who are still working in damaging conditions—risking their posture and comfortability. According to Arvidsson et. al (2021), the lack of occupational exposure limits (OELs) for physical jobs obstructs both observation and precautionary work. Based on the data obtained and conclusions made in this study, the researchers have proposed action levels that concern work postures, movement velocities, and muscular loads documented by wearable equipment as prevention to various MSD such as myalgia, tendon disorders, and nerve entrapments in the upper musculoskeletal system. (Arvidsson et. al., 2021). Furthermore, as an example, the researchers have suggested that wrist velocity should not outstrip 20°/s as a median over a working day—this could reduce by 93% the occurrence of carpal tunnel syndrome (CTS) is highly unprotected male occupational units. In addition to that, the occurrence of noticeable neck/shoulder myalgia and tension neck syndrome could be lessened by 22% if the proposed action level of 60% would be done to female groups. The researchers hoped that quantitative measurements, linked with activity levels, would be significant in future studies and efforts to prevent severe work-related MSDs. (Arvidsson et. al., 2021).

The computer plays a vital role in almost every aspect of life. They assist us in a variety of areas. For example, they are used in nursing, manufacturing processes, the aviation industry, producing presentation slides in application software for taking notes and giving lectures in colleges and universities, and many other fields. According to del Lavaro (2009), Students in the fourth year were slightly more exposed to risk factors such as frequent screen use, time spent at the computer without rests, length of mouse use, and lousy workstation ergonomics. The most frequent symptom was neck pain (69 %), which was followed by hand/wrist (53 %), shoulder (49 %), and arm (8%). (Borhany, T. et. al., 2018).

Generally, musculoskeletal disorders (MSD) and their association with awkward postural alignment in work-related activities are very high. Poor seated postures had odds in terms of experiencing discomfort in the upper back. In their study, it stated that the neck and shoulders were the most frequently recorded symptomatic regions, followed by the lower and upper back. In the study that James et. al., conducted in 2018, it is evident that people who attended workstation ergonomics training or those that seek ergonomic assessment were not associated in terms of having discomfort. Their findings showed a high prevalence of staff reported musculoskeletal discomfort in the areas of the neck (60%), shoulder (53%), and lower back discomfort (47%) being the most common. It is also evident that the working postures at the workstation were more prone to upper back pain when not well assisted. (James et al., 2018). They also stated that the high uptake of health services for musculoskeletal discomfort indicates that the reliance on treatment, rather than prevention. (James et. al., 2018).

In the study conducted by Devesh and Al-Bimani (2012), as computer technology is becoming an integral part of the education curriculum, concerns regarding the health effects of it have been raised as the usage of computers by teenagers has increased. This may generate musculoskeletal disorders and excessive fatigue that can cause pain, numbness, and tingling sensations that affect the upper limbs. The health effects have a close association to the body posture and static load on the muscles of the shoulders and neck.

Heavy workloads and frequent requirements for completion of work before deadlines are evident and have been the main reasons that a person spends long hours in front of the computers. Also, the study mentioned that there is a need to educate people by conducting workshops and seminars on how to prevent and lessen the health hazards of extensive computer use. Being unable to have a better understanding and the inability to come up with strategies on how to deal with the health hazards will put them at risk. Lastly, they stated that these health problems can be reduced through an ergonomic approach and education. (Devesh & Al-Bimani, 2012)

At this point, many ergonomists were not able to deliver such adequate and sufficient systems under the occupational health and safety risk (OHS) management. It is considered to be under strain and its burden changes to more complex illnesses and injuries from chronic disease. It is substantially the reason for rapid cases of occupational health problems that are severely out of the normal issues. The best example would be musculoskeletal disorders (MSDs) and mental health disorders. MSDs are one of the most serious occupational health and safety (OHS) issues, but existing evidence about their work-related triggers isn't reflected in workplace risk management procedures. The traditional risk management approach is based too closely on risk from individual hazards rather than embracing the more systemic approach required to handle the cumulative effects of all related hazards, and inadequate attention is paid to evaluating and managing risk from psychosocial hazards. Such changes would necessitate the creation of new MSD risk management software as well as a better alignment of the positions of OHS staff and line managers.

According to Marras (2009) and colleagues' study of data, between 11 and 80 percent of low-back injuries and 11–95 percent of extremity injuries are caused by occupational physical causes, while between 14 and 63 percent of low-back injuries and 28 to 84 percent of upper-extremity injuries are caused by psychosocial factors. Physical diseases, such as MSDs, are widely assumed to be mostly, if not entirely, triggered by hazards resulting from physical activities, while psychosocial hazards are thought to mainly impact stress-related psychological health issues. This is likely due to the continued effect of mind/body dualism on our health thought, which persists despite medical practitioners paying more attention to patient's perceptions. MSDs are not formally related to just the workplace system itself but as well as the mental stability of a person. It creates an additional effect towards the discomfort of the muscles which aggravates an individual's performance to work levels.

Similarly, the students are experiencing musculoskeletal disorders through computer-based work. Most common MSDs are found in the neck, low back, shoulder, and wrist/hand. Depending on the work set-up or the type of labor being done, some fields experience hip pain. As per this study, the hip was the body part that was least affected by injury, with less than 1% of respondents. Saudi PTs registered a prevalence rate of 33% in the low back, 29% in the neck, 13% in the knee, and 13% in the upper back. In comparison to Egyptian PTs, the elbow and ankle/foot were the least affected body parts, with less than 1% of respondents. Maintaining a posture for an extended period (21.3 percent), performing physical therapy procedures (21.3 percent), lifting (15.7 percent), bending/twisting, and repetitive tasks were the most common behaviors that induced recurrence of symptoms, according to Egyptian PTs. Lifting (21 percent), bending/twisting (18 percent), holding a posture for an extended period, and performing repetitive tasks were the top four behaviors that triggered the recurrence of symptoms in physical therapists that are exposed to a working environment.

1.3 Gap of Missing Information

One study that relates to the research paper is under Hyekyoung Shin's (2003) study titled Musculoskeletal Symptoms and Laptop Computer Use Among College Students. In a comparison of this research study, it focuses on limited gadget use which is a laptop computer, and its relationship with CMDQ in an online class setting for a college student. The researchers of this study would like to determine various work-related equipment or devices such as type of keyboard used, average screen time, hand control using the mouse of the touchpad, use of mechanical keyboard and laptop keyboard, and workstation setup. Therefore. it depicts wider ranges of devices not only concentrating on laptop computers but other types of computer-based gadgets as well.

1.4 Objectives

The main objective of this research is to identify the different computer-based work factors (e.g. type of gadget used particularly during online classes, type of keyboard used, average screen time per day, etc.) that significantly affects the musculoskeletal discomfort of college students in the Philippines—the distinguished factors will be thoroughly assessed through various related studies and articles to further the understanding. This research is very timely because most of the universities are conducting online classes throughout an academic year since the pandemic hit the country. Subsequently, this study will be able to impart awareness to the respondents concerning the risk of their workstation and class setups to their musculoskeletal system. Recommendations would be given too to alleviate the discomfort of the respondents. Moreover, the research will aid future researchers in collecting information relating to musculoskeletal systems and the discomfort of students having their online classes at home.

1.5 Significance of the Study

The primary importance of this study is to impart awareness to the respondents, as well as to the future readers, the different computer-based work factors that significantly affect an individual's musculoskeletal discomfort and the possible risk of this discomfort in the long run if not addressed immediately. For the students, since the study focused on this group, the results of the study would significantly affect them. With the current situation, every student has various workstation setups—some are using chair and table, while others are only relying on their hands and lap for support; some students have a complete set of technologies for online classes, while others have limited sources—these are just some of the factors that prompt the discomfort of these students. With the help of the study, the students will be able to assess themselves during their online classes or while doing any computer-based activities—making them understand as well the importance of investing in ergonomic appliances and technologies to alleviate their discomforts.

For future researchers, although several studies relate the musculoskeletal discomfort of individuals to different factors, the research would still be beneficial especially that the researchers based this on the current situation of everyone—making most people prone to MSD. The discoveries and findings of the study would help future researchers to distinguish the differences of the normal setup from the 'new' normal setup, and further their understanding of the topic.

1.6 Scope and Limitation

The researchers conducted a quantitative study to know and examine the effects of computer-based work in terms of musculoskeletal discomfort in their respondents. A survey questionnaire which was divided into three sections: demographic information, categorical questions, and the Cornell musculoskeletal discomfort questionnaire (CMDQ) were used. The data to be gathered are from the experiences and opinions of the participants. As mentioned above, there are multiple students at different levels that are encountering the same situation wherein they are drawn in online classes at home. To be more precise, children ages 9-10 years old and teenagers around the ages of 13 to 18 years old, including office workers that are between the ages of 20 to 45 have the same situational perspective. This states the limitations of this study for the age group. Furthermore, this research was performed in the Philippine locale with different college students that are enrolled from Luzon. Before proceeding with the survey and questionnaires, it was assured that all of the respondents complied precisely following the survey's specifications. In line with the review-related literature, it discusses how a working setup adversely affects college students and tackles the severity of such risks.

2. Methodology

To expand the knowledge about the relationship between MSD and computer-based work, a review of the related literature is mandatory to exemplify its relevance and interrelation from one another. The literature and reviews that accompany the research study state that our methods and processes are certain and definitive. It has been done by other researchers and expounding this research establishes additional information and can imbibe fellow readers to its fullest. Statistical analysis by the use of ANOVA and Regression Analysis is used to determine such trends among the different factors affecting muscle pains and MSD risks. Microsoft Excel and MINITAB are software that has been operated by the researchers to distribute accurate data as to what factors largely contribute to MSD risks.

The priority is to gather all the data to be able to interpret the results and to locate such trends among different factors. The purpose of the analysis through statistical tools is to inspect which amongst these factors such as the work-set up, student's screen time, and their hand movements--which extends to what type of keyboard used and the kind of gadget used for a work-set up-- greatly affects the CMDQ risk rating of an individual's body part. To be more specific, body parts are somewhat broad that is why it doesn't only narrow down on the upper extremities but as well as the lower extremities.

The survey questionnaire is composed of CMDQ scores for two main body parts which are the hands (upper extremities) and the body (lower extremities). For the researchers to investigate which specific body part that has the highest discomfort score when college students are working for a particular average screen, hypothesis testing and ANOVA are used. Alternative and null hypothesis basis where the null hypothesis states there are no significant differences in the hand and body discomfort score between different factors. The factors are going to be discussed under the results and discussion section. And the alternative hypothesis would be that there is a significant difference in the body and hand discomfort between different factors.

Lastly, the study raises awareness to those students exposed to this kind of phenomenon. This means that when students are experiencing this first hand, it must be early treated to avoid any risks. Recommendations and prevention of such risks, either ergonomically or medically inclined, are discussed in this research study for future purposes.

2.2 Respondents of the Study
The respondents involved in this study were college students currently enrolled and are taking online classes. The researchers narrowed down the respondents to college students because the said students can contribute to a larger sampling number inducing varied results and opinions from them. Likewise, in this kind of setup, called the new normal, college students were on the computer-based work at all times and most likely to experience musculoskeletal discomfort

2.3 Ergonomic Tools
To determine the level of ergonomic risk for this study and to recommend improvements that can help in lessening musculoskeletal risk and discomfort when doing computer-based work, the researchers used a screening tool called Cornell Musculoskeletal Disorder Questionnaire (CMDQ). CMDQ Scoring is used to compute and analyze the discomfort level of body parts should to determine if the subject has a postural problem and discomfort when doing computer-based work. The researchers determine the overall CMDQ score of each body part by getting the summation of the product of frequency score, discomfort score, and interference score of each area/body part; this is simply a method of dispersing the scores so that the more serious cases can be identified more quickly. As a result, multiplying the scores stretches the scales and makes it easier to see those with the most problems.

2.4 Statistical Treatment of Data
The statistical treatment used by the researchers is presented in this section. Researchers used weighted mean, variance, and one-way ANOVA (Analysis of Variance) to know the level of discomfort that the respondents are having when doing computer-based work.

To interpret the result of the CMDQ scores, the researchers used weighted mean and average. The sum of the product of weight and value divided by the total number of respondents is the weighted mean. It's used to figure out which of the respondents' choices was the most dominant. In addition to this, the researchers used the variance to measure the spread between the given data set. It calculates the deviation of each number in the collection from the mean. Lastly, the researchers used a one-way analysis test of variance or ANOVA to compare the means of the two independent groups to see if significant differences exist.

3. Results and Discussion
3.1 Profile of Respondents
An online survey was conducted as a means of collecting the data for this study. A total of 80 respondents were garnered—comprising 40 males and 40 females. The different computer-based factors' criteria were initially asked to identify who among the respondents are under each condition. As for the age, since the respondents are limited to college students only—the range of their ages are 19-22 years old only, however, it was divided into two criteria—those that are 19-20 years old, and 21-22 years old—this would be considered in performing the analysis. In the gathered data, among the 80 respondents, the majority of them lie on 19-20 years old criteria—having 70 in the count of its respondents. Moreover, having a part-time job was asked to further understand if it's also a significant factor to the students' musculoskeletal discomfort, however, there are only 6 out of 80 students that have a part-time job—re not utilized in the analysis. Another factor identified is the type of gadget they use during online classes—69 of the

respondents use laptops as their means of attending classes, while 9 students use desktop, and only 2 are using their cellular phones. Gadget used for hand control was also considered as a factor affecting their MSD, in which 49 students use a separate mouse, 29 of them use the touchpad of their respective laptops, and only 2 students use phone keypad. Next, the majority of the students—59 in the count, uses their laptop keyboard, 18 have a mechanical keyboard, and only 3 uses touchscreen keypad. Average screen time is the next computer-based factor considered, wherein 66 of the students answered 7 hours and above, and 14 of them responded 3 – 6 hours. Lastly, the workstation setup was taken into account, wherein the majority of the respondents, 65 in the count, have a table and chair setup, and 15 are having a laptop on lap setup. These data are vital to identifying which computer-based work factors are significant and not to the MSD risk of the students. The summary of the respondent's profile is shown in Table 1.

Table 1. Summary Statistics of Respondents' Profile

Respondent's Profile	Category	N	%
Gender	Male	40	50
	Female	40	50
Age	19-20	70	87.5
	21-22	10	12.5
With part-time job	Yes	6	7.5
	No	74	92.5
Type of gadget used	Desktop	9	11.25
	Laptop	69	86.25
	Cellphone	2	2.5
Gadget used for hand control	Mouse	49	61.25
	Touchpad	29	36.25
	Phone Keypad	2	2.5
Type of keyboard use	Touchscreen Keypad	3	3.75
	Laptop Keyboard	59	73.75
	Mechanical Keyboard	18	22.5
Average screen time per day	3-6 hours	14	17.5
	7 hours and above	66	82.5
Workstation setup	Table and chair setup	65	81.25
	Laptop on lap	15	18.75

3.2. Result of Musculoskeletal Discomfort Analysis

Using the established scoring for CMDQ, the cumulative scores of respondents per body part was calculated. Below is the table and graph of the summary of the CMDQ rating for the body as shown in Figure 1.

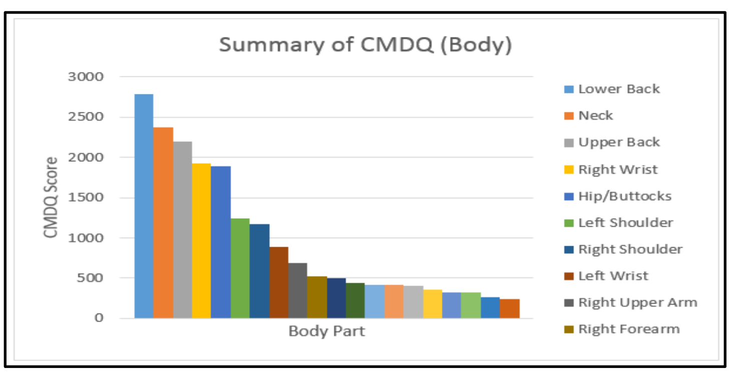

Figure 1. Summary of CMDQ Score (Body)

As seen in the result, a towering score of 2780.5 was calculated for the Lower Back—this means that the majority of the students experience severe discomfort on their lower backs during and after hours of doing computer-based work.

Next, a score of 2370.5 was calculated for the neck which means that frequent discomfort is also felt on that body part by the students. The upper back is the next body part in which discomfort is felt by the students, obtaining a cumulative 2201 CMDQ score. Next, discomfort in the right wrist garnered a 1930.5 CMDQ score, followed by the hip/buttocks with a score of 1894. The succeeding parts are then listed and summarized in the table. As observed, the majority of the discomfort is in the upper extremities, rather than the body parts that are prone to awkward positions such as the back, neck, and wrist—this could be because of their setups and repetitive use of the body parts. Furthermore, hips/buttocks ranked 5th for this body part majorly support the weight of the body—which is tiresome for the part. Moreover, a lower CMDQ score is calculated on some body parts that are not usually used and commonly supported by external factors such as the forearms, legs, and foot. In general, as the students repetitively use a body part and are not properly supported—it is more prone to severe discomfort.

Table 2 summarizes the risk rating of all the respondents. Each participant's CMDQ score was rated based on the established grading in CMDQ, wherein it ranges from no discomfort—CMDQ score of 0, to very severe—CMDQ score of 60 or more. As seen in the table, among the 80 respondents, 66.25% or 53 of them are rated to a very severe case of discomfort; 21 experienced severe cases, 4 are moderate, and both mild and no discomfort cases got 1 respondent each. In general, the majority of the participants lie in a very severe condition of discomfort.

Table 2. Summary of Risk Rating of CMDQ Score (Body)

Risk Rating	Frequency	Percentage
No Discomfort	1	1.25
Mild	1	1.25
Moderate	4	5
Severe	21	26.25
Very Severe	53	66.25

Using the established scoring for CMDQ as well, the cumulative scores of respondents per body part - right hand was also calculated. Shown in Figure 2 is the graph of the summary of the CMDQ rating for the right hand.

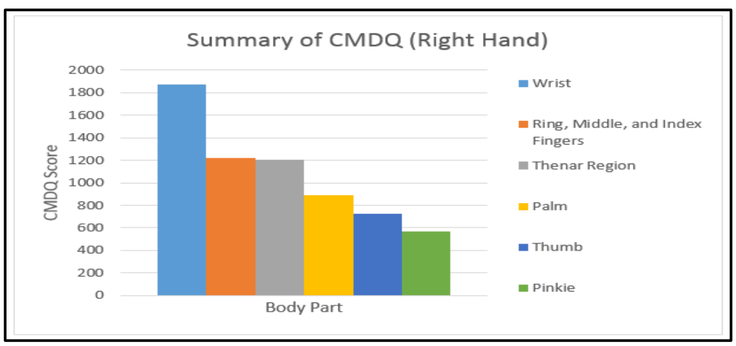

Figure 1. Summary of CMDQ Score (Right Hand)

As seen in the result, the highest CMDQ score of 1876 was calculated for the respondents' wrist. Thus, discomfort on their right hand is commonly felt in the right wrist due to its repetitive usage for activities such as typing and controlling the mouse/touchpad. Next, fingers, specifically the ring, middle, and index fingers are the second parts where discomfort is felt because again, of the repetitive activities such as typing and clicking of mouse/touchpad, having a CMDQ score of 1218. Subsequently, not so far from the previous parts is the thenar region—region below the thumb, accumulating a CMDQ score of 1205.5. The succeeding parts are the areas in the hand that is not usually used such as the thumb, palm—mostly rested in the mouse, and the pinkie finger. Thus, for these parts, a little discomfort is only felt by the respondents.

Table 3. Summary of Risk Rating of CMDQ Score (Right Hand)

Risk Rating	Frequency	Percentage
No Discomfort	14	17.5
Mild	4	5
Moderate	9	11.25
Severe	18	22.5
Very Severe	35	43.75

3.3. Result of Statistical Analysis

Table 4. Summary of ANOVA Result (CMDQ Score - Body)

Factors	Category	Mean	Std. Dev.	p-value	Remarks
Gender	Male	196.7	259.1	0.103	Not significant
	Female	287.2	23.09		
Age	19-20	628.5	178	0.029	Significant
	21-22	270	444		
Type of gadgets used	Desktop	199.7	124.4	0.000	Significant
	Laptop	709.8	291		
Average screen time	3-6 hours	172	192.5	0.000	Significant
	> 7 hours	630	285.2		
Workstation setup	Chair and table	262.9	380.7	0.92	Not significant
	Laptop on lap	251.6	204		

One-way ANOVA was performed to identify the significance between the different computer-based factors concerning the CMDQ score for the body of the respondents. As seen in Table 4, a significant difference is obvious in the CMDQ scores of respondents based on several factors. First is the gender, the null hypothesis for gender is no significant difference in the body discomfort score among male and female respondents, and an alternative hypothesis is having a significant difference between the two variables, a result of 0.103 was calculated for its p-value—indicating that the null hypothesis must be accepted suing alpha of 0.05. The age of the respondents was also considered as a factor affecting their discomfort wherein it resulted in a 0.029 p-value stipulating that there's a moderate significance in the body discomfort score among the age group of 19-20 and 21-22. Next, the type of gadget used during online classes resulted in respondents' body discomfort who's using a desktop as significantly different to the discomfort of those that are using their laptops. Further observation indicated that this significance is majorly caused by the angle of the screen of a monitor and laptop. Subsequently, the average screen time of the respondents was also considered, and based on the result, there's a significant difference in the body discomfort of students who are using their desktop/laptop for 3 - 6 hours and those whose average screen time is 7 hours and above. This is mainly because of the static position, and probably the awkward position they hold during those hours. However, on the last computer-based factor, the workstation setup resulted in no significance to body discomfort among those that have a chair and table set up to those that use their laptop having their lap supported. This only means that the severity of discomfort the respondents are experiencing in these setups are just fairly the same. In general, the factors age, type of gadget used and average screen time greatly affect the body discomfort of the respondents.

Table 5. Summary of ANOVA Result (CMDQ Score - Hand)

Factors	Category	Mean	Std. Dev.	p-value	Remarks
Hand control	Mouse	79.9	116	0.77	Not significant
	Touchpad	87.8	95.2		
Type of keyboard use	Laptop Keyboard	166.2	117	0.026	Significant
	Mechanical Keyboard	86.6	105.7		
Type of gadget used	Desktop	69.3	104.5	0.156	Not significant
	Laptop	140.2	120.6		
Average screen time	3 - 6 hours	59	118.4	0.028	Significant
	> 7 hours	153.7	96.6		

One-way ANOVA was also performed to distinguish the significance of hand discomforts between the computer-based factors identified. For hand control, having the p-value of 0.77, it signifies that for the hand discomfort, there's no significant difference among the respondents that use a mouse, to those that use the touchpad of their respective laptops. Next, for the type of keyboard use, it has been identified that there's a significance to the hand discomfort among laptop keyboard users to mechanical keyboard users. Through further investigation, the angle of the keyboard is a factor to this—some brands of the mechanical keyboard allow their consumers to adjust the angle of their keyboards that best fit their comfortability, while most laptop users' keyboard-only lay flat, 90°—which tends to tire the hands when typing for hours or so. Following, for the type of gadget used, the calculated p-value of 0.156 indicated that the hand discomfort of the desktop users is not significant to the hand discomfort of the laptop users. Lastly, there's a significant difference in the hand discomfort score based on their screen time, since the screen time of respondents indicates that they're also using their hands from time to time, thus the overuse of the body part. In general, the factors type of keyboard and screen time of respondents significantly affect the hand discomfort of the respondents.

4. Conclusion

In conclusion, the study proved that there are significant differences among the different factors shown above versus the discomfort of students when having their online classes in a computer-based work setting. This means that the researchers have inspected whether these different factors are attributed to the discomfort of college students. However, there were only some factors that were significantly different from the discomfort feeling of students. From that speculation, it suggests that not at all factors are linked to the discomfort and MSD risks of the samples. This was thoroughly investigated by the researchers which among these factors has the highest CMDQ score rating. Then, it was rated based on the risk rating of the CMDQ which among these factors highly contributes to the discomfort of college students when in a computer-based work set up. The researchers considered the gender difference of each college student since they have unequal height differences. Not all work set-ups are originally made for a particular student considering its height and the length of each body part. But with the help of ANOVA, this doesn't affect the discomfort of students. Therefore, it is considered not significant. As expected, its average screen time and hand control play a big role in the discomfort of particularly the hands. As per the body parts, the only factors that are greatly affected by the discomfort of students are their age, type of gadget used, and average screen time. Both categories (body and hand) have significant remarks on the average screen time. This is practically rational because students utilize their gadgets for a long period where the eyes are for visibility, hands for typing, and body to support such agendas and tasks. This works altogether and creates a connection between factor to factor. College students have a broader field compared to high-school students. As a result, they are prone to having an extended time when it comes to computer usage. This is the reason for workloads in college.

The most common areas that are affected by very severe cases of MSD are the lower back, neck, and upper back of the body. For the CMDQ hand, the most common area that's affected with MSD risks is the right wrist. There are some conditions in this research study; most of the respondents are right-handed which did not give much attention to the left wrists. But overall, the wrists, neck, lower and upper body are prone to having MSD risks and discomfort. Respondents that are identified with a very severe and severe case for the body and hand should make changes and revision of their work set-ups to avoid MSD risks. The main behaviors that cause MSDs are maintaining a posture for an extended period, repetitive tasks, and as well as awkward postures.

Work-related musculoskeletal discomforts (WMSD) and symptoms are primarily caused by psychological (stress, cognitive load, etc.) and organizational (inappropriate working-rest time, lack of work-enrichment, etc.) factors in the workplace (static and poor postures, repetition of gestures, non-ergonomic workstation arrangement, etc.). It is critical to improving working conditions, organizational design and layout, and effective ergonomic interventions in the workplace. Preventing and eliminating WMSDs requires an evaluation of the workplace, monitoring of the related risk factors, medical management, and education. (Erman, 2019).

This study spreads awareness that symptoms must be treated as early as possible. Recommendations and prevention actions are already given in this research study that can act as a starting point in attracting students, engineers, and ergonomists to take into action. According to Gautam (2017), if the discomforts and pain continue, it will become a chronic condition that will result in musculoskeletal distress and disorders. To enhance the current practice of laptop use and to reduce health issues among students, there is a need to raise ergonomics awareness. It's critical to monitor students' laptop use and postures so that musculoskeletal disorders and their effects can be managed before they become an obsession. Having a better understanding and being able to come up with strategies on how to deal with one's posture can eliminate and prevent musculoskeletal risk. Moreover, this study recommends its readers to be mindful of their working posture to prevent musculoskeletal risk and discomfort. This paper can also be published on school papers so that everyone can be aware of the health risks caused by prolonged usage of computers. Furthermore, it is recommended to seek professional help when experiencing discomfort aligned with the musculoskeletal system. Attending intervention, seminars, and workshops that tackle ergonomic approaches is advisable.

6. References

Abracero, Alexa & Therese, Rona & Alejandro, L & Joyce, Eliza & Balderrama, M & Ulysses, Gene & Beltran, Matthew & Castillo, Maria & Mago, Kristian & Sambile, Christopher & Francisco, & Francisco, Christopher. Optimizing Students' Workload and its Effects on their Mental Health during COVID-19 Pandemic. International Journal of Multidisciplinary Studies. 5. 118-122, 2021

Al-Eisa, E., Buragadda, S., Shaheen, A. A., Ibrahim, A., & Melam, G. R. (2012). Work-related musculoskeletal disorders: causes, prevalence, and response among Egyptian and Saudi physical therapists. Middle-East Journal of Scientific Research, 12(4), 523-9.

Arvidsson, I., Dahlquist, C., Enquist, H., & Nordander, C. (2021, February 2). Action Levels for the Prevention of Work-Related Musculoskeletal Disorders in the Neck and Upper Extremities: A Proposal. Lund, Sweden. Retrieved May 8, 2021, from Cleartax: https://www.researchgate.net/profile/Inger-Arvidsson-2/publication/350768040_Action_Levels_for_the_Prevention_of_Work-Related_Musculoskeletal_Disorders_in_the_Neck_and_Upper_Extremities_A_Proposal/links/60740d894585150fe99f8a57/Action-Levels-for-the-Preve

Borhany, T., Shahid, E., Siddique, W. A., & Ali, H. (2018). Musculoskeletal problems in frequent computer and internet users. Journal of family medicine and primary care, 7(2), 337–339. https://doi.org/10.4103/jfmpc.jfmpc_326_17

Devesh, S. and Al-Bimani, N. (2012). Healthy Tips Associated To Computer Use. International Journal of Ergonomics (IJEG), 2(1), 12-23.

Erman, Çakıt. (2019) Ergonomic Risk Assessment using Cornell Musculoskeletal Discomfort Questionnaire in a Grocery Store. Ergonomics Int J 2019, 3(6): 000222.

Gautam, D., & Chacko, N. (2017). Impact of laptop usage on symptoms leading to musculoskeletal disorders. Journal of Applied and Natural Science, 9(3), 1687-1690. https://doi.org/10.31018/jans.v9i3.1422

James, C., James, D., Nie, V., Schumacher, T., Guest, M., Tessier, J., Marley, J., Bohatko-Naismith, J., and Snodgrass, S. (2018). Musculoskeletal discomfort and use of computers in the university environment. Applied ergonomics. 69. 128-135. 10.1016/j.apergo.2018.01.013.

Karen, L., Cooper, N., Carolyn, M., Sommerich and Gary, M. A. (2009). College students and computers: Assessment of usage patterns and musculoskeletal discomfort. Work: A Journal of P

Li, C. H. of M. The COVID-19 pandemic has changed education forever. This is how. World Economic Forum. https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning/. April 29, 2020

Macdonald, W., Oakman, J. Requirements for more effective prevention of work-related musculoskeletal disorders. BMC Musculoskelet Disord 16, 293 (2015). https://doi.org/10.1186/s12891-015-0750-8

Marras W, Cutlip R, Burt S, Waters T. National occupational research agenda (NORA) future directions in occupational musculoskeletal disorder health research. Appl Ergon. 2009;40(1):15–22.

McBride, D., & Harcombe, H. (2012, October 24). Work-Related Musculoskeletal Pain and Its Management. Retrieved from Brainkart: https://www.intechopen.com/books/pain-in-perspective/work-related-musculoskeletal-pain-and-it-s-management

McLaughlin, K. (2020, October 19). Body Systems. Retrieved May 8, 2021, from Biology Dictionary: https://biologydictionary.net/body-systems/

Musculoskeletal System. (2020, December 11). Retrieved May 8, 2021, from Cleveland Clinic: https://my.clevelandclinic.org/health/articles/12254-musculoskeletal-system-normal-structure--function

Rafael, M. and Tatiana, G. (2007). A survey of ergonomic issues associated with a university laptop program. Journal of Education and Human Development. 1 (2):1- 15.

Sendic, G. (2021, April 8). Musculoskeletal System. Retrieved May 8, 2021, from Ken Hub: https://www.kenhub.com/en/library/anatomy/the-musculoskeletal-system

Villa-Forte, A. (2019, December). Introduction to the Biology of Musculoskeletal System. Retrieved May 8, 2021, from MSD Manual: https://www.msdmanuals.com/home/bone,-joint,-and-muscle-disorders/biology-of-the-musculoskeletal-system/introduction-to-the-biology-of-the-musculoskeletal-system

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