Ergonomic Design of Computer Workstation for College Students Studying at Home

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ABSTRACT

An ergonomically designed workstation is recommended for prolonged periods of time. Having an ergonomically designed workstation is beneficial for the health of an individual; therefore, this research is for the benefit of college students currently studying at home to minimize their risk of Musculoskeletal disorders (MSD). Using the results of the survey that consisted of Rapid Upper Limb Assessment worksheet (RULA) and Corlett & Bishop Body Map worksheet, it was confirmed that the current design of the workstation they use exposed them to risks of having an MSD. Prolonged usage of an improperly designed workstation can lead to a risk of the health of an individual. To solve this, the researchers used the collected data from the surveys deployed to have a reference on which designs have the least level of discomfort to have designed an ergonomic work. In the application, we used the data of our survey to come up with an ergonomic design for the chair and table for the preferred use of the students to avoid them from the risk of MSDs.

Keywords
College, Body Map, Musculoskeletal, Rapid Upper Limb Assessment, Ergonomic workstation

1. Introduction
A workstation refers to the computer and other surroundings where the work gets done. According to Onar et al. (2016), A workstation is a working area that is designed for specific applications that includes a computer. With computer workstations being a part of the work done by humans, it must be compatible, efficient, and well-designed, which is catered to provide stable support allowing movement, and comfort. Therefore, good human posture is the foundation for good workstation ergonomics as good posture helps to avoid injuries (Asaolu 2014). This study is relevant, since the use of poorly designed workstations could lead to Musculoskeletal disorders (MSDs) and injuries. MSDs are the most common health complaints in the working population and the advancement in technology is a big contributor to these complaints (Levy 2018). Gatchel and Kishino (2011) stated that the association of bodily elements with psychological, ergonomic, and occupational factors can be the source of MSDs. A type of MSD experienced by users without properly designed workstations is the carpal tunnel syndrome, one of the most common injuries within the boundaries of computer work, it is caused by the excessive abduction and extension of muscles in the wrist and hand. Thennarasi (2015) found that there is a strong relationship between carpal tunnel syndrome and work-related tasks. Furthermore, the research of Vargas et al. (2020), revealed poorly designed workstations were indicated as a factor that decreases work efficiency and is a risk factor for the user. In line with the contribution of poorly designed workstations, a research by the National Research Council, Division of Behavioral Social Sciences Education, &

Committee on Vision (2017), states that anthropometry plays an important role in an appropriate workstation design. They also found that there was a lack of application of anthropometric measurements.

1.1 Objectives

The purpose of this study was to create an ergonomic design of a computer workstation, with a focus for college students, that follows the fundamentals of anthropometry of college students and lessens the risks of MSDs. It aims to assess and evaluate the current workstations used by college students studying at home and to identify the comfortability of the user and the factors affecting them. Furthermore, a new design of an ergonomic workstation for college students will be made according to their preferences.

2. Literature Review

2.1 Ergonomics

As of today, many people in developing countries experience some sort of problems regarding their study environment. Leading to exposure to hazards, poor health, injuries, and disabilities which in term reduces productivity and study quality then to poor academic performance. In a research conducted by the Occupational Safety and Health Administration (2012), they formulated solutions to reduce Musculoskeletal disorders with the help of ergonomics by allowing employees to learn and become aware of ergonomics and its benefits, including the information about ergonomics-related concerns in the workplace, and understanding of the importance of reporting early symptoms of MSDs. Human factors or ergonomics is the scientific discipline that explores the interaction between the elements of a system and the human, it aims to design and optimize overall system performance and human well-being by applying theories, principles, data, and methods (International Ergonomics Association 2012).

2.2 Anthropometry

Anthropometry is a field in measurement that utilizes physical geometry, mass properties, and the capabilities of human bodies. According to Del Prado (2007), anthropometry can be used differently in the workplace: to assess workflow and accessibility, separate potential hazards in the environment, pinpoint obstacles that hinder body movement, and aid biomechanical analysis of force and torque. Poor anthropometric and ergonomic design in the workstations can be the precursor of illnesses and injuries. According to Thennarasi (2015), most companies in India ignore the differences in body height around the world, and follow the European anthropometric standards. According to the National Research Council (2017), workplaces that disregard the principles of work efficiency frequently have poorly designed monitors. Basic information on fine image quality, appropriate workstation design, lightings, and organizational psychology are often ignored or misapplied, and more likely that it generates issues that involve video display terminals, it would be easy if the knowledge is applied to the design

2.3 Workstation Design

Workstations should be designed in a form that the operators can perform their work in an efficient manner, and this is where the workstation design comes in. As per Middlesworth (2015), a workstation plan, or commonly referred to as workplace ergonomics, is the study of planning the work environment, the design of the workstation, instruments, and hardware, and their cooperation with the representatives and the undertaking, remembering the abilities and restrictions of the laborer or worker. Furthermore, there are benefits in an ergonomic workplace such as; (1) improves quality; (2) improves employee engagement; (3) reduces costs; (4) improves productivity; (5) and creates a better safety culture. Ergonomics in a workstation is significant in light of the fact that when you are carrying out responsibility and your body is stressed by doing repeated movement, extreme temperature, or awkward posture; therefore, your musculoskeletal system is certainly influenced.

2.4 Designs of Tables and Chairs

The current working environment requires employees and students to do work with furniture you may encounter in offices, such as tables and chairs at a minimum of six to eight hours per day. An individual who spends eight hours on a generic chair has a probability of experiencing negative effects in the body compared to an individual who uses a specialized ergonomic chair (Adu et al., 2014). In addition, Taposh et al. (2018) stated students spend the majority of their time in the classroom, making the appropriate tables and chairs is a very essential utility, as prolonged use of inappropriate chairs and tables can lead to musculoskeletal disorder. As the proposed implementation of research conducted by Taposh et al. (2018), the chair and table proposed, exhibits accurate dimensions to enable better comfort in learning facilities. Chairs have lumbar supports and hand rest, while tables have holders designed for pens, improved footrest, wheels for movement, and a drawer for storing and keeping things. The research also emphasized the use of additional material to block table desks and the importance of foamed chair hand rest. Office furniture exists to provide support to the body and an increase in productivity both in employees and students that is why a properly designed table and chair must be used during prolonged working hours. An optimal design for a table to be used in online classes must provide an adequate working space that includes a computer. Another factor of a well-designed workstation other than a well-designed table is a well-designed chair. A workstation is composed of both a table and a chair, without a chair the workstation would be incomplete. Alcaidinho (2011) supported the idea that proper lumbar and pelvic supports which result in less stress to your back muscles are deemed to be the feature of a well-designed chair. There are numerous designs of chairs ranging from armchairs which are common in schools to office chairs which are more common in office environments. Though office chairs differ in design and purpose, some may provide comfort, but the body will still be susceptible to MSDs. Some chairs are overly padded like the executive office chair. During this current pandemic, some students may not be able to acquire such chairs, therefore they end up using simple and common chairs found in their own homes such as stacking chairs, benches, possibly even sofas.

2.5 Musculoskeletal Disorders (MSDs)
Salvendy (2015) described musculoskeletal diseases and disorders caused by work-related casualty as work-related musculoskeletal disorders. Additionally, musculoskeletal disorders are caused by irregularities in the musculoskeletal system, while diseases are observed impairments in the configuration and function due to pathological entities. Although Work-related Upper Extremity Disorders (WUEDs) are genetically passed on, the actual state and details do not give consideration to the general description of the impact of these disorders. However, it is possible to point out a category of general risk factors, including biomechanical factors, static and dynamic conditions of the body and posture and, psychological and psychosocial factors for which there is evidence of producing WUEDs. According to Gallagher and Heberger (2012), several risk factors are known to be associated with MSDs. Examples of factors that affect risks are the accessibility, postures, psychological needs and interpersonal and psychosocial framework. Work-related Musculoskeletal Disorders (WMSDs) vary on different postures and tasks being done. According to Salvendy (2012), they are probable to converge and impact, producing cascading loops, its magnitude, and its nature which relies on the duration. It indicates that the mere existence of a risk factor does not necessarily mean that an individual is exposed to a higher risk of complication.

2.6 Evaluation Methods (RULA & Discomfort scale)
Zhang, et al. (2018) reported that ergonomic assessment rules give off coherent numerical values that are used to classify and manage postural ergonomic hazards at the worksite. Posture combinations of arms, back, and legs, and other related postures during work are classified into four categories based on the WMSD risk assessment. If a certain posture observed exceeds the average threshold, the category changes from lower to higher, suggesting necessary actions to resolve the matter and risk at hand. In addition, there are rules that specify certain angles and thresholds of body parts prone to WMSDs.

2.7 Rapid Upper Limb Assessment (RULA)
Dockrell (2012) claimed that Rapid Upper Limb Assessment (RULA) is a simple and easy method to evaluate one's posture. It is finished by giving mathematical scores dependent on the figure found in the RULA appraisal. In addition, it aims to expose risks that are found in worksites, needs minimum equipment regardless of the environment, and does not need clinical instruments. A methodical process that the RULA device uses to assess the force, the necessary body posture, and the reiteration for the activity task being assessed. To assess the required or selected body posture, muscles use recurrence, and forceful exertions, a solitary page worksheet (above) can be utilized. In the worksheet, there are two sections, Section A for the upper and lower arm position, the wrist position and its twist, and muscle use and load/force, and Section B for the neck position, the trunk position, the leg score, and the muscle use and load/force (Middlesworth, 2019).

2.8 Corlett and Bishop's Discomfort Scale
Work-related musculoskeletal disorders and other related injuries are some of the largest workplace injuries that account for the 30% cost of worker salary. According to Aghilinejad et al. (2016), working postures that are obviously different from standard positions are more likely to cause risks of musculoskeletal disorders. Corlett and Bishop's discomfort scale is administered as a questionnaire, a subjective survey tool that evaluates the respondent's direct experience of discomfort at different body areas (Aghilinejad et al 2016). As per observation, the score of seriousness

can be relegated a mathematical estimation of 0, 1, 2, 3, or 4, respectively for estimating the degree of uneasiness or discomfort, in various body parts all through various times of a shift, for example, the start of a shift, at a morning break, before lunch, after lunch, an evening break, and toward the finish of the shift simi.

3. Methods

The participants considered were college students that used workstations, such as chairs and tables, to study at home. The data were gathered from a questionnaire asking about the participant's demographics: age, gender, year level, hours of study per day, the area of study, time of day, and importantly, the type of chair and table used and their dimensions. In addition, the participants were asked to take a photo of the chair and table they were using as well as their sitting and working posture. The survey was accompanied by a Corlett & Bishop discomfort scale questionnaire that served as a guide to determine the respondents' level of body discomfort. In addition, Rapid Upper Limb Assessment (RULA) was used in order to evaluate the level of risk of musculoskeletal disorder (MSD) that the respondents experienced while using the workstation. As shown in Figure 1

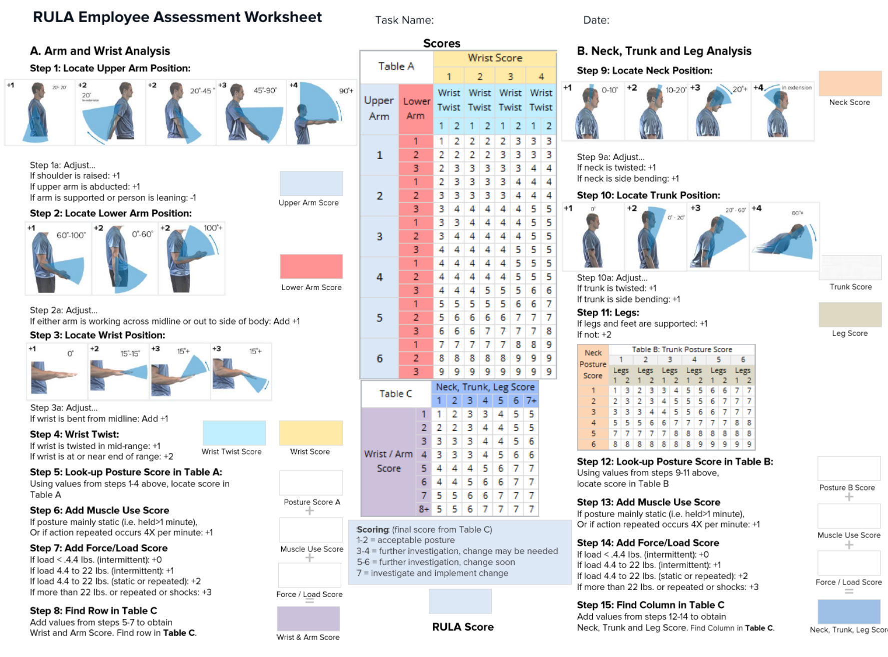

Figure 1. Rapid Upper Limb Assessment Worksheet (Middlesworth, 2019)

After taking the measurements, the respondents attended a class and answered a discomfort scale questionnaire modeled after the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) that followed the Corlett and Bishop's Body Map. This evaluated the comfortability of the college students with their current workstations. 11 body parts were assessed and rated accordingly to determine the discomfort level of each one from 1 to 5, 1 for the lowest discomfort and 5 for the highest discomfort. The numerical data are then added to acquire the overall discomfort score of each respondent.

The numerical data of discomfort obtained from the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was then inputted to Minitab. Correlation analysis identified the factors that affect the comfortability of the students, the independent variables were the dimensions of the chairs and tables, and was matched to the discomfort level of the students as the dependent variable. The results gathered from correlation analysis specified the relationship of factors to the discomfort level of the students. In addition, multiple regression analysis was also utilized in identifying significant risk factors affecting the discomfort level of students in their current use of workstations. With the identified factors, designing the new workstation will be efficient.

Lastly, the designing process of the workstation was based on the anthropometric measurements provided by a related study. The new ergonomic design will improve the comfortability of the user as it will follow the principles of anthropometry. The principles in anthropometry were used to identify the average percentiles for the minimum, average, and maximum measurements. Using that, the researcher created an ergonomic design of a table and a chair that satisfies the users. The software used was Sketch-up and V-ray, which is a 3D modeling and a rendering program.

4. Data Collection

The numerical data of discomfort obtained from Corlett & Bishop's Body Map was then inputted to Minitab, the software used for statistical analysis. Using Correlation analysis identified the factors that affect the comfortability of the students, the independent variables were the dimensions of the chairs and tables, and it was matched to the discomfort level of the students as the dependent variable. The results gathered from correlation analysis specified the relationship of factors to the discomfort level of the students. In addition, multiple regression analysis was also utilized in identifying significant risk factors affecting the discomfort level of students in their current use of workstations. With the identified factors, designing the new workstation will be efficient. Lastly, the designing process of the workstation was based on the anthropometric measurements provided by the participants. The new ergonomic design will improve the comfortability of the user as it will follow the principles of anthropometry, and product design and development. The principles in anthropometry were used to identify the average percentiles for the minimum, average, and maximum measurements. Using that, we created an ergonomic design of a workstation such as a table and a chair that satisfies the users. The software used was Sketch-up and V-ray, which is a 3D modeling and a rendering program suitable for this kind of project such as designing. The measurements of the proposed workstation were applied and were rendered to make it realistic

5. Result and Discussion

5.1 Numerical Result

The chosen demographic were college students who were studying from home and were using a table and chair as a part of their computer workstation. The accumulated respondents were a minimum of 30 respondents. The number of respondents resulted due to the ongoing COVID-19 pandemic. A summary of the respondent's demographics is presented in Table 1.

Table 1. Table Summary of Respondent Demographics

Age	Gender	Year Level	Course	Time of Day (Study)	Duration of Study (hours)	Area of Study	Type of Chair Used	Type of Table Used
20	Male	2	Hotel Management	Evening	2 - 4	Bedroom	Plastic	Wooden
20	Female	1	Medicine	Evening	2 - 4	Living room	Lounge	Wooden
21	Male	3	Education	Evening	2 - 4	Bedroom	Plastic	Wooden
21	Male	3	Engineering	Morning	6 - 8	Bedroom	Metal	Wooden
20	Male	3	Hotel Management	Evening	2 - 4	Bedroom	Plastic	Wooden
19	Male	1	Engineering	Evening	2 - 4	Bedroom	Plastic	Metal
18	Male	1	Engineering	Morning	Less than 2	Bedroom	Office	Metal
19	Male	1	Engineering	Evening	Less than 2	Living room	Office	Metal
17	Male	3	Medicine	Evening	2 - 4	Bedroom	Wooden	Wooden
21	Male	3	Agriculture	Morning	6 - 8	Dining area	Plastic	Wooden
19	Male	1	Engineering	Afternoon	Less than 2	Bedroom	Wooden	Wooden
20	Female	3	Medicine	Evening	More than 8	Bedroom	Office	Wooden
21	Female	3	Medicine	Afternoon	6 - 8 hours	Bedroom	Office	Metal
19	Female	2	Philosophy	Afternoon	6 - 8 hours	Living room	Wooden	Wooden
21	Male	1	Engineering	Evening	2 - 4 hours	Bedroom	Office	Metal
19	Female	1	Medicine	Morning	6 - 8 hours	Bedroom	Office	Wooden
19	Female	1	Business	Afternoon	6 - 8 hours	Bedroom	Office	Wooden
20	Male	2	Engineering	Morning	6 - 8 hours	Living room	Plastic	Wooden
20	Male	2	Engineering	Evening	2 - 4 hours	Bedroom	Office	Wooden
20	Male	1	Media	Evening	More than 8	Dining area	Office	Wooden
20	Female	2	Business	Morning	4 - 6	Living room	Plastic	Wooden
18	Male	1	Media	Afternoon	Less than 2	Bedroom	Office	Metal
19	male	2	Engineering	Afternoon	4 - 6	Bedroom	Wooden	Metal
19	Male	1	Engineering	Evening	2 - 4	Living room	Office	Wooden
18	Male	1	Medicine	Morning	2 - 4	Bedroom	Wooden	Plastic
18	Female	1	Architecture	Evening	2 - 4	Bedroom	Plastic	Metal
19	Male	2	Mathematics	Afternoon	2 - 4	Bedroom	Plastic	Wooden
19	Male	1	Engineering	Morning	More than 8	Bedroom	Metal	Wooden
18	Male	1	Engineering	Evening	2 - 4	Bedroom	Office	Wooden
21	Male	3	Business	Afternoon	4 - 6	Bedroom	Office	Plastic

The respondents of the survey varied in age, 17 being the youngest, and 22 being the oldest. The 60% of the respondents ranged from nineteen to twenty years old, while the remaining were split to the other remaining age range. The 73.3% of the respondents were males and 50% of the 30 respondents were college freshmen. 40% of the courses were under the discipline of mathematics. 46.7% of the respondents studied in the evening with 73.3% preferring to study at their bedrooms with a common duration of 2 to 4 hours a day. 43.3% of the respondents used Office chairs while 66.7% used wooden tables. Below is the table summary of the overall discomfort level of respondents, this shows the majority of the respondents have a high discomfort level in the middle of their back.

Table 2. Table Summary of CMDQ Scores

Areas of Discomfort	Neck	Shoulders	Upper Arm	Upper Back	Mid Back	Lower Arm	Lower Back	Upper buttocks	Left Thigh	Right Thigh	Left Leg
Average Discomfort Scores	2.57	2.3	2.23	3.00	3.23	2.10	2.97	2.67	1.87	1.93	1.77

The table 3 shows the correlation results of the factors that have a significant relationship to the discomfort scores of an individual. The value of the Pearson correlation that corresponds to each factor determines the percentage of relationship it has with the discomfort score. Regression analysis was performed due to its effectiveness in determining the relationship between two variables. Based on the result, sitting posture, table height and seat height have a significant impact on the discomfort score. Since the R value of the table height and sitting posture are 0.808 and 0.89, it shows that the relationship of the two variables have a direct positive relationship to the discomfort score. In other words, as the value of the discomfort score increases, the sitting posture index also increases. On the other hand, since the R value of seat height is -0.744, this proves that there is a negative correlation between the discomfort score and seat.

Table 3. Table of Correlation Analysis Data

Independent Variable	Pearson Correlation Value	P - Value
Age	0.392	0.032
RULA	0.890	0.000
Seat Height	-0.744	0.000
Seat Width	0.081	0.671
Seat Depth	0.192	0.309
Backrest Height	0.312	0.093
Table Height	0.808	0.000
Table Width	0.242	0.198
Table Depth	0.302	0.105

In the analysis using Regression, the result of the analysis led the researchers to the conclusion that the RULA, seat width, and backrest height are the variables that significantly affect the discomfort level of the respondents as shown in Table 4.

Table 4. Summary of Dimensions of Different Respondents' Chairs.

Workstation Dimension	Recommended Dimensions	Plastic Chair		Within range	Wooden Chair		Within range	Office Chair		Within range	Lounge Chair		Within range
		Max	Min	(yes/no)	Max	Min	(yes/no)	Max	Min	(yes/no)	Max	Min	(yes/no)
Seat Height	36.57	61	26	Yes	71	41	no	52	30	yes	53	53	no
Seat Depth	39.07	34.33	30	no	61	39.5	no	58	19.3	yes	39.5	39.5	yes
Seat Width	44.34	35.44	26	no	48.5	36.5	yes	62	22	yes	39	39	no
Backrest Height	35.48	77	16	yes	70	43.5	no	80.5	30	yes	54	54	no

Table 5. Summary of Dimensions of Different Respondents' Table.

Workstation Dimension	Recommended Dimensions	Wooden Table		Within range	Plastic Table		Within range	Metal Table		Within range (yes/no)
		Max	Min		Max	Min		Max	Min	
Table Height	51.73	100	60	no	73.4	70	no	83	28	yes
Table Depth	58.4	102	20	yes	61	56	yes	70	30	yes

The table 5 describe the current workstation dimensions of the respondents. As seen, there are a few sections of their workstation which do not meet the recommended range. The data collected also indicated that the majority of the respondents prefer to study in the evening with an average study time lasting for two to four hours. According to an article by PSB Academy (2020), learning is most effective between the hours of 10 am to 2 pm and 4 pm to 10 pm, it also states that some people gain more energy later in the day. Therefore, studying in the evening is much more preferable for some. On the other hand, an article about how long an individual should study by Hatch (n.d.), an undergraduate in the University of Florida is required to study for three hours minimum for each hour of class time. This means that the majority of the respondents meet the range of recommended hours of studying, some exceed. Taking into consideration that there are students who exceed the recommended duration of study, it is essential to use a workstation that is both comfortable and lessens risk of Musculoskeletal disorders.

5.2 Graphical Result

Anthropometric measurement for sitting

Anthropometric measurement (cm) sitting height	Male ($n = 843$)					Female (962)				
	Mean	5th Percentile	Median	95th Percentile	Std. Dev	Mean	5th Percentile	Median	95th Percentile	Std. Dev
Sitting height	84.84	78.00	85.00	92.00	5.81	79.92	73.00	80.00	87.00	4.50
Eye height	73.36	67.00	73.00	80.00	3.83	68.38	62.00	69.00	74.00	4.85
Elbow height	22.23	17.00	22.00	27.00	4.21	21.89	17.00	22.00	26.43	4.09
Waist height, sitting	19.44	15.00	19.00	24.00	6.15	22.41	18.00	22.00	27.00	3.21
Hip height	13.28	10.00	13.00	18.00	4.06	15.29	11.00	15.00	20.00	6.71
Hip breadth, sitting	35.60	31.00	35.00	41.00	4.19	36.39	31.00	36.00	42.43	4.83
Thigh clearance height	13.49	10.50	13.00	16.50	4.45	12.82	10.00	12.00	16.00	6.97
Buttock knee length	54.80	49.00	55.00	61.90	5.21	52.73	47.00	53.00	59.00	4.56
Buttock popliteal length	46.40	41.00	46.00	52.00	3.72	45.14	40.00	45.00	51.00	3.69
Knee height, sitting	50.03	45.00	50.00	55.90	3.99	46.98	42.15	47.00	52.00	4.43
Popliteal height	43.33	39.00	43.00	47.00	2.57	40.34	36.00	40.50	44.00	2.90
Buttock width	48.45	35.10	48.00	59.00	7.40	47.66	35.00	48.25	58.00	6.85
Length of upper leg	36.80	29.20	36.00	46.50	6.12	35.96	28.00	36.00	45.00	5.25
Length of lower leg and foot	45.27	38.00	46.00	52.00	4.53	42.14	35.00	42.50	48.00	4.31
Thumbtip reach	71.30	61.00	72.00	79.00	7.12	65.44	56.00	66.00	74.00	7.63
Overhead fingertip reach, sitting	127.92	117.00	128.00	138.00	7.81	116.87	108.00	117.00	128.00	9.77

Figure 2. Anthropometric measurements of Manufacturing Workers for Sitting. (Del Prado-Lu, 2007)

The figure 2 shows the anthropometric measurement for sitting of manufacturing workers in the Philippines. This served as the basis for the recommended dimensions of the table and chair for the design of an ergonomic workstation. The particular reason for using this as the basis of anthropometric measurements of the respondents was due to the lack of proper measuring tools in order to accurately measure their anthropometric measurements as well as due to the research being conducted remotely. This is applicable due to the demographic of the participants of del Prado-Lu's study in 2007, who were men and women 30 years old and below.

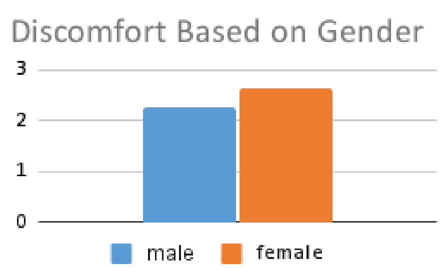

Figure 3. Bar graph of CMDQ Scores Based on Gender

Figure 3 shows the bar graph of the average discomfort scores between male and female respondents obtained from the discomfort questionnaire. According to the bar graph females have the higher discomfort average. To confirm this, we used Welch's T-test, which compensates for the unequal sample size between the two groups, to determine that gender does not affect the discomfort level of respondents.

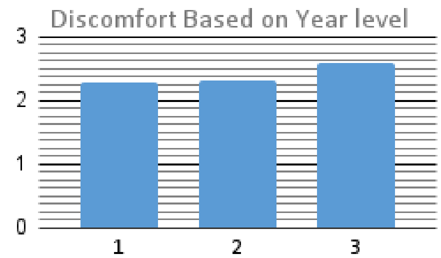

Figure 4. Bar graph of CMDQ scores Based on Year Level

Proceeding on to figure 4, which shows the bar graph of the average discomfort scores between year levels 1, 2, and 3 obtained from the administered discomfort questionnaire, which shows that third years have the highest discomfort score among the year levels. Through the use of One-Way ANOVA, the researchers confirmed that the year level of the respondents does not affect their discomfort score.

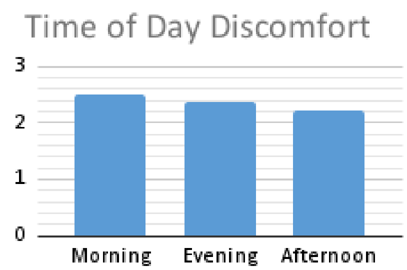

Figure 5. Bar graph of CMDQ scores Based on Time of Day

Figure 5 shows the bar graph of average discomfort scores between the times of day the respondent study, and according to this bar graph it shows that respondents who study in the evening have the highest discomfort score. Through the use of One-Way ANOVA, the researchers confirmed that the time of day the respondents study have no effect on the discomfort score.

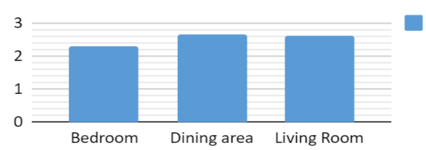

Figure 6. Bar graph of CMDQ scores Based on Area of Study

Figure 6 illustrates that the area with the highest average discomfort score is the dining area followed by the living room, and lastly the bedroom. With average scores of 2.67, 2.60, and 2.28 respectively. By analyzing the data using One-way ANOVA the researchers confirmed that regardless of the location of the study, the discomfort score will remain the same.

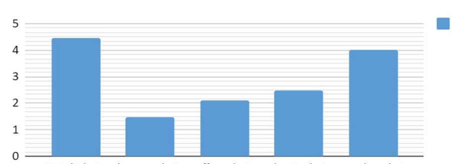

Figure 7. Bar graph of CMDQ scores Based on The Type of Chair

Figure 7 shows that metal chairs have the highest average discomfort score, followed by the wooden chair, plastic chair, office chair, and, lastly, the lounge chair with an average score of 4.46, 4.00, 2.50, 2.10, and 1.47. The researchers analyzed the scores using One-way ANOVA. The results showed that the metal chair had a significantly different score than the lounge chair and the office chair. It also shows that the wooden chair does share an average discomfort score with the lounge, office, and plastic-type of chairs

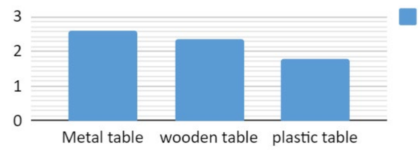

Figure 8. Bar Graph of CMDQ Scores Based on The Type of Table

Figure 8 illustrates that the type of table that has the highest average discomfort score is the metal table followed by the wooden table, and lastly, the plastic table with average scores of 2.58, 2.35, and 1.79 respectively. The researchers used One-way ANOVA to analyze the mean scores of the respondents. The analysis of the scores results in a P-value greater than the alpha value. Therefore, the researchers accepted their hypothesis that there is no significant difference in the average discomfort scores of the respondents on the type of table they use to study.

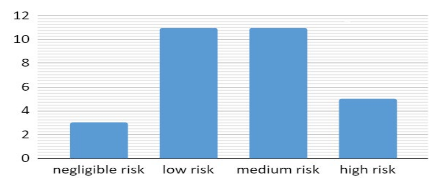

Figure 9. Bar Graph of RULA Risk Index Scores

Figure 9 illustrates the number of respondents with RULA scores that have been categorized into having negligible risk, low risk, medium risk, and high risk based on the workstation they are using. It shows that low and medium risk are at an equally high number followed by high risk, and negligible risk with numbers of 11, 11, 5, and 3 respectively.

5.3 Proposed Improvement

To further improve this particular research, the researchers recommend to perform the process of measuring the dimensions of tables and chairs of the respondents in person, and measure the anthropometric measurements using proper measuring tools. Based on the analysis, the following dimensions for the design of ergonomic chairs and tables are proposed. The dimensions for the recommended design is based on the computed anthropometric measurements are percentiles obtained from the respondents as shown in Table 6.

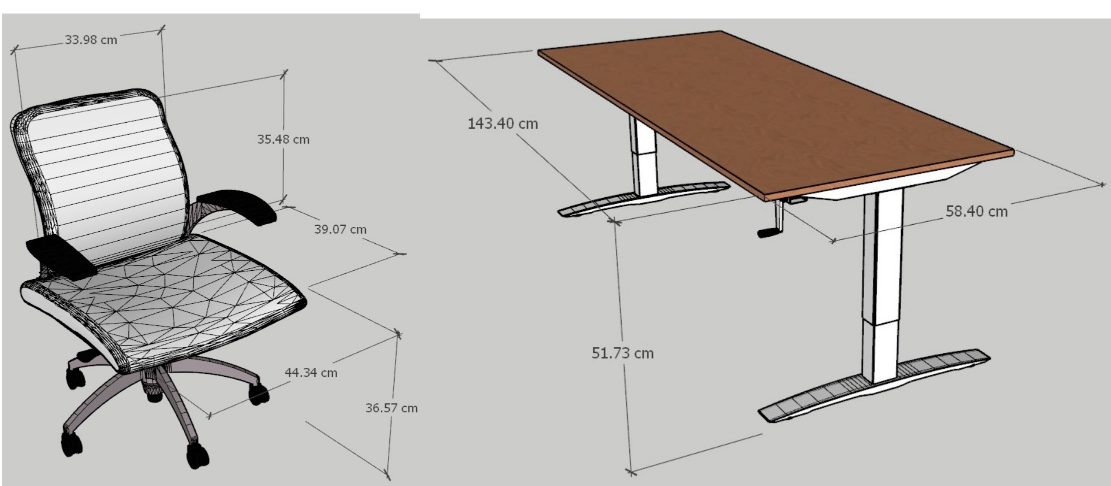

Figure 10. Design of Ergonomic Chair and Table

Table 10. Recommended Anthropometric Dimensions

Workstation Dimension	Body Reference	Percentiles	Gender	Anthropometric Measurements (cm)
Seat Height	Popliteal height + 1cm shoe allowance	5th % (min)	Female	**36.57**
Seat Depth	Buttock popliteal depth	5th % (min)	Female	**39.07**
Seat Width	Hip breadth	95th % (max)	Female	**44.34**
Backrest Height	Sitting shoulder height	5th % (min)	Female	**35.48**
Backrest Width	Elbow to elbow breadth	95th % (max)	Male	**33.98**
Table Height	Popliteal height + 1 cm shoe allowance+ Sitting elbow height	5th % (min)	Female	**51.73**
Table Depth	Functional forward Reach	5th % (min)	Female	**58.4**
Table Width	Functional forward reach + shoulder breadth + functional forward reach	5th % (min)	Female	**143.4**

6. Conclusion

To conclude, each of the respondents have their own preference in the time they study, the duration in which they study, and the area in which they study. Moreover, the significance of this study was to provide a design that considers the user of a workstation to be able to work comfortably for long periods of time, therefore the focus of the design was to be able to work for long periods of time without having discomfort and a great risk of exposure to MSDs. Both type of chair and duration of study greatly contributes to the discomfort of students while the other factors do not have any effect on the students' discomfort. The ideal type of chair to be used are lounge chairs to reduce discomfort and the duration of study should be up to 6 hours a day. In correlation analysis, seat and table height, and the seating posture have a significant relation to the discomfort score. In regression analysis, seating posture, seat width, and backrest height significantly affect the discomfort scores.

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Biographies

Randolf Cabugawan is currently a graduating senior highschool student from Mapúa University. He completed his junior highschool in Cavite School of Life Dasmariñas Campus.Where he learned about the essentials of mathematics, science, and multiple uses of AutoCAD. His mother is currently a government employee and his father is a retired seaman. Mr. Cabugawan is an only child, with interests in becoming a mechanical engineer in the future he gained a passion for automotive engineering after learning about the different motorsports that currently exist. With this knowledge, Mr. Cabugawan chose Mechanical engineering as the primary course he will be taking in college. His research interests include aerodynamics, fuel efficiency, and safety.

Homer Laguador is currently a graduating senior highschool student from Mapua University. He accomplished junior high school at Lucban Academy achieving multiple academic awards. His father is an architect, and his mother is a midwife. Mr. Laguador follows the path of his father and will take architecture as his primary choice in college. He also has his passion in sports, especially in cycling, he is an official of a local cycling group, Team Lagaslas. Besides sports, he also practices music production, and practices the use of AutoCAD and Sketchup. It is in his interest to pursue architecture including his research interest on efficiency, stability, development, artistic designs, and contemporary architecture.

Kelly Lim is currently a graduating senior highschool student from Mapua University. Mr. Lim finished junior highschool Lucban Academy and was granted an honor award. While finishing elementary in New Jerusalem School. He also studied highschool mathematics and learned various Microsoft Office applications at the Personage Institute. His parents are Entrepreneurs working in a family company. He is the son of the owner of Kenlyn General Merchandise and a brother to three siblings. He is a bike enthusiast and mechanic earning different participation awards in cycling events and a former member of Team Lagaslas. An aspiring Civil engineer and Entrepreneur, Mr. Lim research interests include structural development and innovation, structural durability, reliability, and computational mechanics.

Ma. Janice J. Gumasing is a Professor of the School of Industrial Engineering and Engineering Management at Mapua University, Philippines. She has earned her B.S. degree in Industrial Engineering and a Master of Engineering degree from Mapua University. She is a Professional Industrial Engineer (PIE) with over 15 years of experience. She is also a professional consultant of Kaizen Management Systems, Inc. She has taught courses in Ergonomics and Human Factors, Cognitive Engineering, Methods Engineering, Occupational Safety and Health, and Lean Manufacturing. She has numerous international research publications in Human Factors and Ergonomics.