DEVELOPMENT OF AN ERGONOMICALLY DESIGNED DRAFTING TABLE AND CHAIR FOR ENGINEERING STUDENTS OF LPU-LAGUNA BASED ON ANTHROPOMETRIC MEASUREMENT

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ABSTRACT

This paper presents the ergonomically designed drafting table and chair for engineering students of LPU-Laguna based on anthropometric measurement. Anthropometric data were collated from 42 first year engineering students consisting 21 females and 21 males. The NORDIC Musculoskeletal Form was used to ascertain the current status of workstation which shows severe pains in the arms, upper back, middle back, lower back and buttocks and mild pain in other anatomical parts. The RULA or Rapid upper limb assessment was used to evaluate the posture of the respondents. The analysis of anthropometric data, NORDIC questionnaire and RULA were used in designing for the drafting table and chair to alleviate the intensity of musculoskeletal disorder in the affected parts of the body. The recommended dimensions were the following: the table height is 65.74cm ± 8.88cm, table length is 85cm, table width is 51.82 cm and adjustable desktop angle is 30º - 45º and for the height of chair is 42.25cm ± 5.87 and with lumbar support at the back.

Keywords: *RULA, musculoskeletal, ergonomics, workstation, anthropometric.*

INTRODUCTION

In the design of work and everyday-life situations, the focus of ergonomics is man. According to Frevalds (2012), ergonomics is derived from the Greek words for work (erg) and laws (nomos). Hence, ergonomics is a science that focuses on the study of human fit, decrease in fatigue and discomfort through proper product design, work spaces and workstations. Ergonomics played an extraordinary consideration in body positioning in order to prevent physical discomfort that occur from bad posture during work and it is vital part of modern design, manufacturing and use of products. According to Dul and Weerdmester (2008), A number of principles of importance to the ergonomics of posture and movement derive from a range of specialist fields, namely biomechanics, physiology and anthropometrics.

Anthropometry has an exceptional significance due to the rise of complex work system where information of the physical measurements of man with accuracy is essential. One application of anthropometrical measurement in ergonomics is the design of working space and the improvement of industrialized products. The study of body sizes and other associated characteristics is generally referred to as anthropometric. The anthropometric data are often collated, analyze and used in ergonomics to specify the physical dimension of workspace, workstation and equipment as well as to product design.

Figure 1. Posture of student

Posture is often imposed by the task or the workplace. Prolonged postures can in time lead to complaints of the muscles and joints. The need to protect the body from musculoskeletal disorder, cumulative trauma disorder and reduce fatigue, increase productivity and efficiency of the workers requires proper anthropometric measurement data collection and analysis for designing of workspace, workstation and product. The study was conducted to evaluate the design of the drafting tables and chair and to improve the posture of the students while performing activities.

Literature Review

Ergonomics is concerned with making the workplace as efficient, safe and comfortable as possible. Effective application of ergonomics in work system design can achieve a balance between worker characteristics and task demands. This can help improve the performance of the workers, including safety, physical and mental well being. Neglect of ergonomic principles brings inefficiency and pain to workforce. The goal for the design of workplaces is to design for as many people as possible and to have an understanding of the Ergonomic principles of posture and movement which play a central role in the provision of a safe, healthy and comfortable work environment (http://www.hsa.ie).

Frevalds (2012), stated that anthropometric design principle typically used for equipment or facilities that can be adjusted to fit a wider range of individuals. The true design should have used the body dimensions for a combined male and female population. Lethod and Buck (2008) cited that anthropometry provides a scientific basis for analyzing and designing elements of the workplace so that they fit people of different sizes. Furthermore, the field of applied anthropometry relates basic measures of human size, strength, and bodily motion to very helpful design criteria used by designers interested in creating things that fit or otherwise better match the size or other aspect of the human body.

According to International Labor Organization (2012), suggested the following ergonomics guidelines for sitting work: (1) The person needs to be able to reach the entire work area without stretching or twisting necessary. (2) The good sitting position means that the individual is sitting straight in front of and close to the work. (3) The work table and chair should be designed so that the work surface is approximately at the same level as the elbows. (4) If possible, there should be some form of adjustable support for the elbows, forearms or hands.

According to Jung (2014), The average physical dimensions of students have increased due to changes in living standards and dietary habits. Moreover, students' anthropometric measurements also vary widely across different age groups, within the same age groups, and between genders and different cultures. Thus, it is unlikely that current school furniture with fixed dimensions would be compatible with the majority of students. In order to ensure proper posture and comfortableness while students are learning, the development and distribution of adjustable tables and chairs are essential. The market demand for such adjustable furniture is expected to grow rapidly.

Statement of the Problem

The main objective of the study is to develop an ergonomically designed tables and chair for engineering students based on anthropometric measurement, specifically sought to answer the following questions.

1. What anthropometric measurement of the respondents in terms of sitting position?

2. How do respondents rate level of physical discomfort experienced while performing drafting activity?
3. What is the assessment on the posture of respondents using RULA (Rapid Upper Limb Assessment) while performing drafting activity?
4. Based on the result, what are the proposed ergonomically designed tables and chairs?

Conceptual Framework

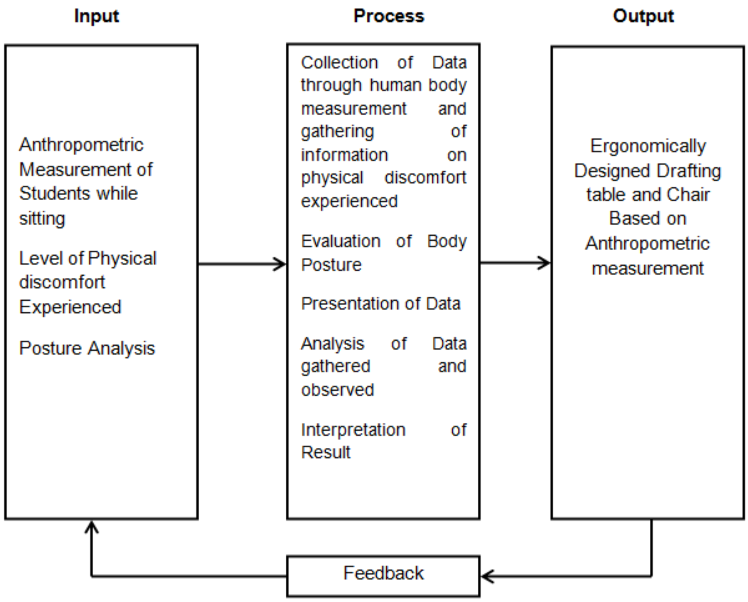

Figure 2. Research Paradigm of the Study

Figure 2 shows how the researcher came up with the study. The inputs are knowledge about anthropometric measurement, physical discomfort and posture analysis. The process includes the collection of data by human body measurements, gathering of information about physical discomfort experienced, evaluation of body posture, presentation of data, analysis of data gathered and observed and interpretation of result. The output of the study is ergonomically designed table and chair based on anthropometric measurement.

METHOD

Research Design

The study used the developmental and descriptive method of research. The developmental research was used to develop a proposed ergonomically designed drafting tables and chairs based on the anthropometric measurements. The descriptive method was used to analyze the anthropometric measurement, posture analysis and the physical discomfort experienced while performing drawing activity.

Respondents of the Study

The respondents of the study were from first year engineering students who were enrolled in the subject Engineering Drawing 1 last first semester 2014-2015. Purposive non-random sampling was used to determine the samples of the study. There were six respondents from each section, three males and three females and with different height were chosen as respondents of the study. A total of 42 students were selected.

Procedure

The ergonomics laboratory instruments like large and small anthropometer were used in the study to measure the human body parts specifically the (a) Popliteal height, (b) Buttocks knee length (c) Elbow rest height (d) Knee height (e) Hip breath and (f) thigh clearance height for design of the chair while the related anthropometry for design of drafting tables are (a) Sitting elbow height; (b) Upper arm length; (c) and Lower arm length. The survey questionnaire adapted from Nordic Musculoskeletal Form was used to evaluate the physical discomfort in the affected parts of the body and other anatomical parts of the body such as neck, shoulder, elbows, wrist/hand, upper back, lower back, hips, thigh, buttocks, knees and ankle/feet). The respondents were answered the survey questionnaire based on the rate according to (4) four points Likert scale.

The weighted mean were verbally interpreted using the following scale.

Rate	Range	Verbal Interpretation
4	3.26 – 4.00	Extreme Pain
3	2.51 – 3.25	Severe Pain
2	1.76 - 2.50	Mild Pain
1	1.00 – 1.75	No Pain

RULA (Rapid Upper Limb Assessment) was used to analyze the posture of the respondents while performing the drawing activity.

Action level	RULA score	Interpretation
1	1-2	The person is working in the best posture with no risk of injury from their work posture.
2	3-4	The person is working in a posture that could present some risk of injury from their work posture, and this score most likely is the result of one part of the body being in a deviated and awkward position, so this should be investigated and corrected.
3	5-6	The person is working in a poor posture with a risk of injury from their work posture, and the reasons for this need to be investigated and changed in the near future to prevent an injury

4	7+	The person is working in the worst posture with an immediate risk of injury from their work posture, and the reasons for this need to be investigated and changed immediately to prevent an injury.

The mean was used to sum up all the measurements and divided by the number of measurements; the standard deviation was used to calculate the difference between each individual and the mean, and the 5th percentile, 50th percentile and 95th percentile values represents the percentage population with the body dimension of a certain size for design purposes.

RESULTS AND DISCUSSIONS

The design work considered the eight anthropometric data measured from the 42 first year engineering students.

Table 1. Anthropometric measurement of the respondents in terms of sitting

	5th Percentile	50th Percentile	95th Percentile	Standard Deviation
Elbow Height (cm)	18.46	22.85	27.24	2.67
Buttocks (cm)	47.85	52.72	57.58	2.96
Popliteal Height (cm)	36.38	42.25	48.12	3.57
Knee Height (cm)	45.47	49.83	54.19	2.65
Hip Breath (cm)	27.96	34.38	40.79	3.90
Upper Arm Length (cm)	20.00	25.99	31.10	4.54
Lower Arm Length (cm)	21.10	25.83	30.00	4.41
Thigh Clearance Height (cm)	10.50	13.49	16.50	4.45

Table 1 shows the anthropometric measurement of the respondents. The researcher computed the 5th percentile and 95th to determine the minimum and maximum design parameters. The designs that are specified must accommodate the majority of users, typically those within a range from the 5th percentile to the 95th percentile of the population. An old rule of thumb is to design large enough for a large man and small enough for a small woman. (Letho and Buck, 2008)

Table 2. Level of physical discomfort in relation to sitting position

Body Parts	Weighted Mean	Verbal Interpretation	Portion of the Body		
			Left	Right	Both
Neck	2.38	Mild Pain	7	10	22
Shoulder	2.45	Mild Pain	8	9	22
Elbows	2.19	Mild Pain	8	9	17
Arms	2.79	Severe Pain	8	15	17
Hip	2.48	Mild Pain	3	7	27
Upper Back	2.71	Severe Pain	2	2	31
Middle Back	3.00	Severe Pain	2	2	36
Lower Back	3.19	Severe Pain	3	3	35
Leg	2.45	Mild Pain	3	6	25
Buttocks	2.83	Severe Pain	3	7	31
Knee	2.29	Mild Pain	5	9	25

Table 2 shows that the respondents experienced severe pain on different parts of body such as arm (μ = 2.79), upper back (μ = 2.71), middle back (μ = 3.00) lower back (μ =3.19) and buttocks (μ = 2.29). Other respondent's experienced mild pain in the neck (μ= 2.38), shoulder (μ = 2.45), elbows (μ =2.19), hip (μ = 2.48), leg (μ = 2.45) and knee μ = (2.29). The results indicated that most of the respondents experienced severe pain at lower back part of the body while performing drawing activity. According to Letho and Buck (2008), the chair should provide support in the lumbar region of the sitter's back to prevent lower back pain experienced during a long period of sitting.

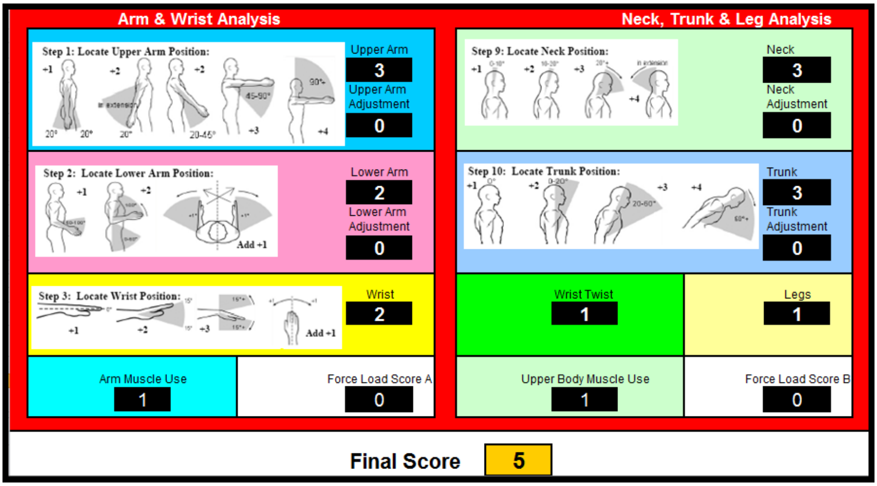

Figure 3. Rapid Upper Limb Assessment (RULA)

Figure 3 shows the assessment of the respondent's posture. It indicates that the final score is 5. This means that the person is working in a poor posture with a risk of injury from their work posture, and the reasons for this need to be investigated and changed in the near future to prevent an injury. According to Dul and Weerdmester (2008), Posture is often imposed by the task or the workplace. Prolonged postures can in time lead to complaints of the muscles and joints. A person should be able to maintain an upright and forward facing posture during work. All work activities shall permit the operator to adopt several different natural, healthy, and safe postures without reducing capability to perform the work. These two principles both focus on postural freedom. The first principle stresses the importance of eye-hand coordination in many jobs, both for safety and efficiency. When people cannot directly face the work at hand, coordination is impaired. A person who is not directly facing their work must twist their body to do the job. The body will have to counterbalance twisting movements or twisted postures. This will result in extra stress and strain on the body. This situation not only forces a person to do more physical work, but also prevents the person from balancing the work over the body. (Letho and Buck, 2008)

CONCLUSIONS AND RECOMMENDATIONS

The anthropometric data of 42 first year engineering students have been determined for the design of drafting table and chair. The measured anthropometric data are; popliteal height, elbow height, buttocks, knee height, thigh clearance height, hip breath for the design of chair while the related anthropometry measurement for drafting table are; upper arm length, lower arm length, and sitting elbow height. The Nordic Musculoskeletal form was used to determine the parts of body experienced discomfort and fatigue due to incorrect posture as a result of the current workstation design. Most of the respondents experienced discomfort and fatigue at lower back of the body. The rapid upper limb assessment was used to evaluate the posture of the respondents while performing the task and base on the posture analysis it indicates that the person is working in the worst posture with an immediate risk of injury from their work posture. The researcher proposed the new design of drawing table and chair for engineering students based on their anthropometric measurement. The table height is 65.74cm ± 8.88cm, table length is 85cm, table width is 51.82 cm and adjustable desktop angle is 30º - 45º and for the height of chair is 42.25cm ± 5.87 and with lumbar support at the back.

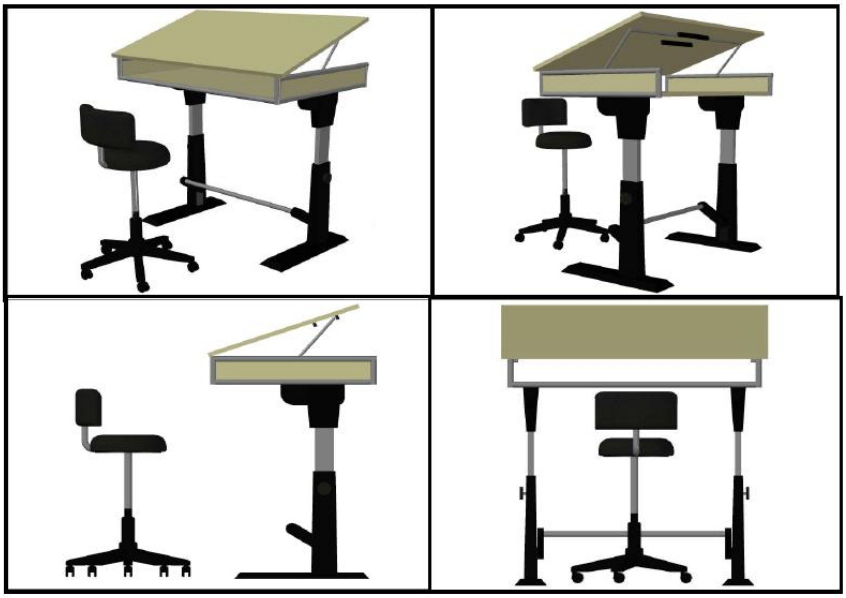

Figure 4. Proposed ergonomic design of drafting table and chair

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