CHAPTER 5

INFLATABLE POSTURE CARE CUSHION USING ANTHROPOMETRIC MEASUREMENT

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5.1 INTRODUCTION

Students spend most of their time sitting in their classroom during lecture, workshop or seminar, as it is provided by the institution using the normal class chair [1]. Sitting in most common positions puts greater pressure on the lumbar discs compared to standing [2]. Malaysia students have different body sizes and shapes, including variations between genders. This diversity makes it difficult to find suitable ergonomic chairs in classrooms. Furthermore, the lack of comprehensive anthropometric data and the prevalence of ready-made chairs contribute to the absence of ergonomic seating options. Here, a lumbar depth of between 0.6” (1.524 cm) to 2” (5.08 cm) work well for most people, which means that the lumbar support should be adjusted according to your body shape, size, and comfort [3]. As this work is to develop an ergonomic chair that is able to fit different body sizes, the risk factors in static sitting position need to be investigated. In addition, the performance of the developed inflated air cushion which is part of the ergonomic chair also essential to be evaluated as the way to convince the quality and satisfactory of users.

5.2 METHODOLOGY

5.2.1 ANTHROPOMETRIC DATA COLLECTION FROM FACULTY STUDENT

Anthropometric data collection using a consent form as shown in Figure 5.1 for Faculty of Electrical and Electronic Engineering (FKEE) students involves measuring their physical characteristics, such as height, weight, popliteal height, sitting shoulder height, and buttock to popliteal length. These data parameters are analyzed to create an Inflatable Posture Care Cushion, ensuring comfort and safety. In detail, the chair designing needs the measurement of sitting shoulder height, buttock-popliteal length and the height. The measurements were taken using a standardized protocol and stored securely for analysis, respecting participant privacy and informed consent. Furthermore, the size, shape and strength of the human body including mass, volumes, mobility, proportions, center of gravity and inertial properties are analyzed as additional dataset to develop the smart ergonomics chair with memory size type. Collecting this data is crucial for establishing a safe and comfortable working environment for the students.

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ANTHROPOMETRIC MEASUREMENT

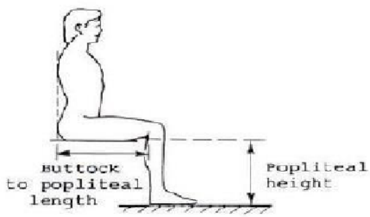
Name: ______________________________

Age: _____

Gender: (M / F)

Programme: ______________________________

ANTROPOMETRY DATA	MEASUREMENT
Height	(cm)
Weight	(kg)
Popliteal Height	(cm)
Sitting Shoulder Height	(cm)
Buttock to Popliteal Length	(cm)



I have agreed to participate in procedure to give my Anthropometric Data to Muhammad Izzat Izzulhaq for his Final Year Project.

____
(name)

Figure 5.1: Consent form on Anthropometric data

5.2.2 WORKFLOW SYSTEM OF DEVELOPED INFLATABLE POSTURE CARE CUSHION

Figure 5.2 shows the work system for the inflatable cushion, which includes two inputs for the Arduino Uno R3: a keypad to enter the weight and height, and a pressure sensor to provide feedback pressure from the inflatable cushion. Arduino Uno and Arduino Nano are being connected using the pin at Table 5.1. The output signal to turn on the Micro Pump 12V to inflate the cushion.

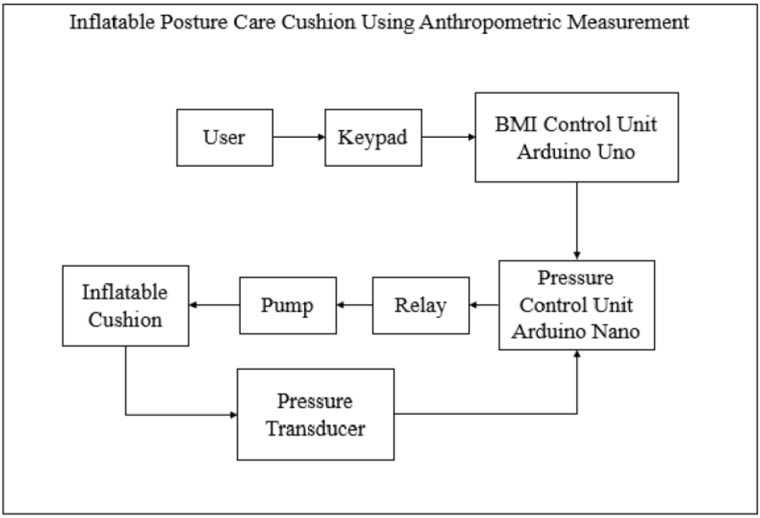


Figure 5.2: Block Diagram System of the Developed Cushion

Table 5.1: Connection pin from Arduino Uno and Arduino Nano

Arduino Uno	Arduino Nano
3	3
9	5
5	7
6	9
10	11
11	13

Figure 5.3 shows the flowchart for operating an Arduino Uno-based BMI control unit. The user provides height, weight, and gender inputs. After a 30-second countdown, the BMI is calculated and displayed on the screen. Depending on the BMI and gender, specific pins on the Arduino Uno are activated to

trigger corresponding conditions. The user is prompted to press a switch to inflate an air cushion, with options for automated or manual reset. The trigger pin connects to the pressure control unit as an input.

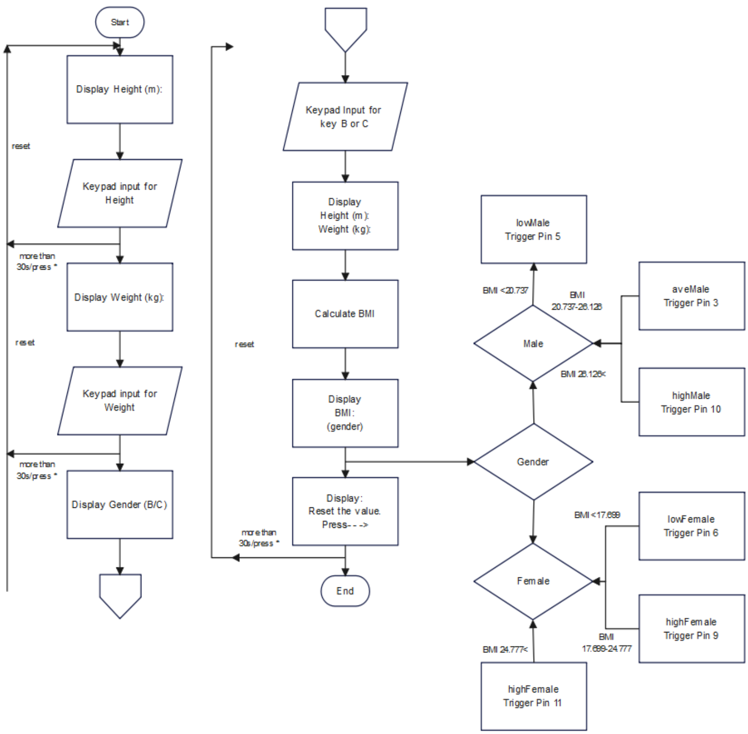


Figure 5.3: Flowchart for the BMI Control Unit at Arduino Uno

Meanwhile, Figure 5.4 depicts the flowchart for the pressure control unit using Arduino Nano. The flowchart outlines the functionality of the pressure control unit and its interaction with the input signals. The relay controlling the pump is activated, initiating the system. The pressure transducer measures the air cushion pressure with a 0.5-second delay, providing readings in kPa. The system operates based on six conditions. If pin 3 or pin 5 is HIGH, the pressure limit is set at 96 psi, causing the relay to turn LOW.

When pin 7 or pin 9 is HIGH, the pressure limit is set at 86 psi. Similarly, if pin 11 or pin 13 is HIGH, the program sets the pressure limit at 106 psi.

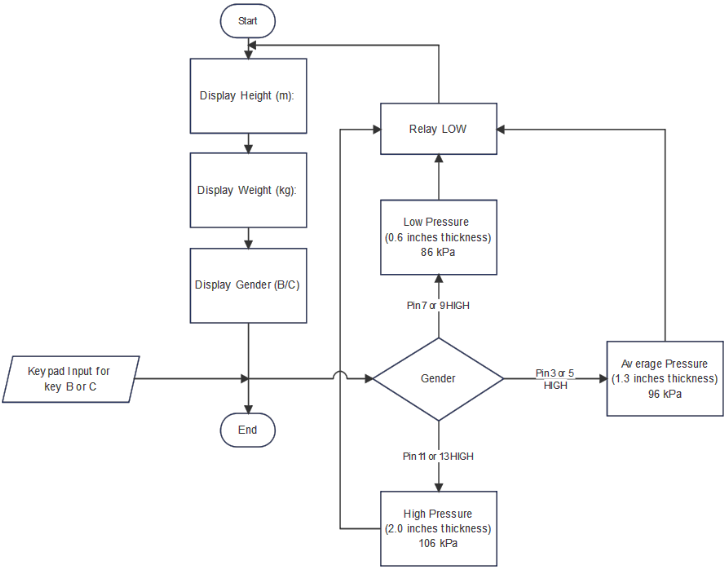


Figure 5.4: Flowchart for the Pressure Control Unit at Arduino Nano

5.2.3 EQUATIONS

Below are the equations applied to calculate and analyze the data. The body mass index (BMI) is calculated using the Eq. (1) that used the height and weight of the student. Eq. (2) shows the formula to calculate the Standard Deviation for every factor in the data. Meanwhile, Eq. (3) and Eq. (4) are used to calculate the 5 percentiles and 95 percentiles, respectively. Both of the equations are used to differentiate the highest and lowest possibility for the data.

$$BMI = \frac{weight}{(height)^2} \tag{1}$$

$$STD = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}} \qquad (2)$$

where,

x = value in data
$\bar{x}$ = mean
n = total number of observations

$$5\ percentile = \left(\frac{5}{100}\right) * n \qquad (3)$$

where,

n = total number of observations

$$95\ percentile = \left(\frac{95}{100}\right) * n \qquad (4)$$

where,

n = total number of observations

5.3 RESULTS

Table 5.2 displays the anthropometric measurements for the distance from the buttock to the popliteal for males and females. The average height for males is 47.433 cm, with a standard deviation of 4.091. The 5th percentile measurement is 40.704 cm, indicating that 5% of males have a shorter height than this value. The 95th percentile measurement is 54.162 cm, indicating that 95% of males have a shorter height than this value. Females have an average height of 45.806 cm, with a standard deviation of 4.055. The 5th percentile measurement is 39.136 cm, indicating that 5% of females have a shorter height than this value. The 95th percentile measurement is 52.475 cm, indicating that 95% of females have a shorter height than this value.

Table 5.2: Buttock to Popliteal Height

Gender	Mean (cm)	Std	5th percentiles (cm)	95th percentiles (cm)
Male	47.433	4.091	40.704	54.162
Female	45.806	4.055	39.136	52.475

Table 5.3 presents the anthropometric measurements of sitting shoulder height for men and women. For men, the mean measurement is 56.571 cm, with a standard deviation of 3.628. The 5th percentile measurement is 50.603 cm, indicating that 5% of men have a shorter sitting shoulder height than this value. The 95th percentile measurement is 62.540 cm, indicating that 95% of men have a shorter sitting shoulder height than this value. For women, the mean measurement is 54.294 cm, with a standard deviation of 4.479. The 5th percentile measurement is 46.926 cm, indicating that 5% of women have a shorter sitting shoulder height than this value. The 95th percentile measurement is 61.662 cm, indicating that 95% of women have a shorter sitting shoulder height than this value. Thus, it is important to note that there is significant variation among individuals, and these values represent averages.

Table 5.3: Sitting Shoulder Height Measurement

Gender	Mean (cm)	Std	5th percentiles (cm)	95th percentile s (cm)
Male	56.571	3.628	50.603	62.540
Female	54.294	4.479	46.926	61.662

Table 5.4 displays anthropometric measurements of popliteal height for males and females. For males, the average height is 43.976 cm, with a standard deviation of 2.308. The 5th percentile measurement is 40.179 cm, indicating that 5% of males have a shorter popliteal height than this value. The 95th percentile measurement is 47.773 cm, indicating that 95% of males have a shorter popliteal height than this value. For females, the mean measurement is 44.865 cm, with a standard deviation of 5.163. The 5th percentile measurement is 36.371 cm, indicating that 5%

of females have a shorter popliteal height than this value. The 95th percentile measurement is 53.358 cm, indicating that 95% of females have a shorter popliteal height than this value. It is important to note that there is variability among individuals, and these measurements represent averages.

Table 5.4: Popliteal Height Measurement

Gender	Mean	Std	5th percentiles (cm)	95th percentiles (cm)
Male	43.976	2.308	40.179	47.773
Female	44.865	5.163	36.371	53.358

Table 5.5: BMI Measurement

Gender	Mean	Std	5th percentiles	95th percentiles
Male	23.43	3.276	18.043	28.821
Female	21.24	4.304	14.157	28.314

Table 5.5 is the analysis of Body Mass Index (BMI) data for males and females based on anthropometric measurements yielded the following results. For males, the mean BMI measurement is 23.43, with a standard deviation of 3.276. The 5th percentile measurement is 18.043, indicating that 5% of males have a BMI lower than this value. The 95th percentile measurement is 28.821, indicating that 95% of males have a BMI lower than this value. For females, the mean BMI measurement is 21.24, with a standard deviation of 4.304. The 5th percentile measurement is 18.043, indicating that 5% of females have a BMI lower than this value. The 95th percentile measurement is 28.314, indicating that 95% of females have a BMI lower than this value.

In this work, conditions are categorized by gender (male/female) that includes Low, Average, and High based on BMI ranges. "LowMale" is BMI below 20.737 for males. Average is 20.737 to 26.126, and High is above 26.126. For females, Low is 17.699, Average is 17.699 to 24.777, and High is above 24.777 (Table 5.6).

Table 5.6: Male and Female Anthropometric Condition

Gender	Low	Average	High
Male	20.737	20.737 - 26.126	26.126
Female	17.699	17.699 – 24.777	24.777

(a) (b) (c)

Figure 5.5: The thickness of inflatable cushion with (a) 86 kPa, (b) 96 kPa, and (c) 106 kPa.

Figure 5.5 shows the level of thickness of developed inflatable cushion for three conditions. Figure 5.5 (a) condition when the pressure is 86 kPa with the thickness is 0.6 inches. Figure 5.5 (b) condition when the pressure is 96 kPa with the thickness is 1.3 inches. Figure 5.5 (c) condition when the pressure is 106 kPa with the thickness is 2 inches.

The evaluation involved 35 respondents who participated by filling out a Google Form. The Google Form required the respondents to provide their gender, height, and weight. Additionally, the respondents were asked to indicate whether they found the inflatable cushion suitable for classroom use and whether they felt comfortable while using it. Figure 5.6 shows the result survey of testing feedback from the classroom students.

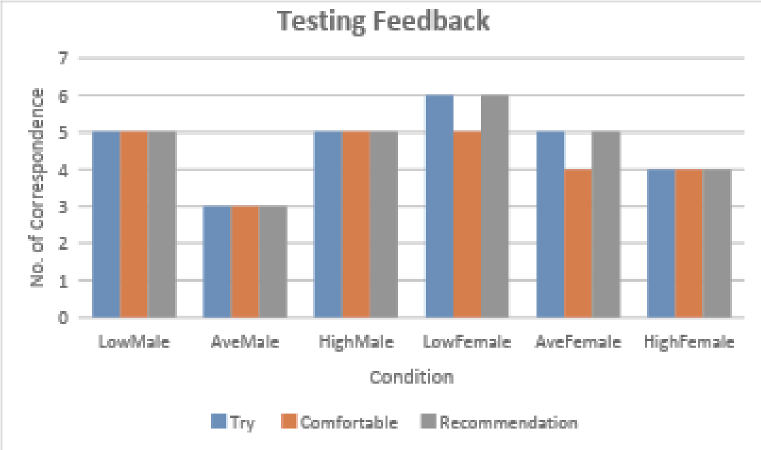


Figure 5.6: Testing Feedback Chart

5.4 CONCLUSION

This project aims to develop a customizable inflatable posture care cushion using anthropometric measurements. Parameters such as height, weight, and body dimensions were analyzed to create an optimum assessment for a comfortable learning chair. Data was collected from FKEE students of both genders, aged between 23 and 25 years. The results categorized anthropometric measurements into six distinct ranges, considering factors like BMI mean, 5th percentile, and 95th percentile. This work also utilizes Arduino Uno and Arduino Nano for the BMI control unit and pressure control unit, respectively. By incorporating a 12 VDC power supply and a pressure transducer, the cushion's inflation is regulated. In summary, the goals to design a healthcare chair that prioritizes user comfort and ergonomic conditions were achieved and practicable.

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