Ergonomical Evaluation for the Design of EMU Library and Proposing a Better Design

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ABSTRACT

The objective of thesis is to propose better design of EMU Library by assessing its furniture and its impact on the understudy stance, execution and consideration. We discovered that the EMU library furniture (Chairs and Tables) are not suitable for students' health.

One hundred and fifty seven undergraduate and postgraduate were used as a subject. They were between 16 to 45 years old. Twelve measurements of anthropometry of the students were measured including: Shoulder Height (SDH), Stature, Shoulder Elbow Height, Popliteal Height, Knee Height, Forearm Length, Buttock-to-Popliteal Length, Elbow Sitting Height(EH), Hip Width, Sitting Height, Sitting, Overhead Stretch Height, and Eye Height. Standard deviation, mean, percentiles, least and greatest estimation of measurements were figured.

Arrangement of the present light of the library was assessed by recording the illumination level on every table on second floor of library. The present light system was found to neglect to consent to ergonomic configuration criteria.

Another configuration of furniture and recommendation of light system proposed to enhance the level of solace for students.

Keywords: Ergonomic design criteria, Anthropometric data, Mismatch, Percentile

ÖZ

Bu çalışmanın amacı, DAÜ Kütüphanesi mobilya ve öğrenci duruş, performans ve dikkat üzerindeki etkisini değerlendirmek.

Yüz elli yedi öğrenci denek olarak kullanıldı. Yaşları 16 ile 45 yıl arasında değişmektedir. konuların Oniki antropometrik veriler de dahil olmak üzere önlemler vardı: boyu, Omuz Yüksekliği, Omuz Dirsek yüksekliği, Kalça-Popliteal uzunluğu, Popliteal yüksekliği, Diz Yüksekliği, Önkol Uzunluğu, Kalça genişliği, Dirsek oturma Yüksekliği, Oturma Yüksekliği, Oturma Göz Yüksekliği ve Tepegöz streç yüksekliği. ortalama, standart sapma, yüzdelik, minimum ve antropometrik boyutlar maksimum değeri hesaplandı.

Kütüphanenin mevcut ışık sistemi kütüphanenin ikinci katta her masada aydınlatma seviyesini gözlemleyerek değerlendirildi. Geçerli ışık sistemi ergonomik tasarım kriterlerine uymayan bulunmuştur.

mobilya ve ışık sistemi önerisi yeni bir tasarım öğrencilerin için konfor düzeyini artırmak için önerildi.

Anahtar Kelimeler: Ergonomi tasarım kriterleri, Antropometrik veriler, Uyuşmazlığı, Yüzdelik

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Chapter 1

INTRODUCTION

The scholastic library was, and dependably will be a basic piece of learning. Indeed, even in this advanced age, the library has a considerable measure to offer by overseeing online information, weaving and sorting electronic sources, and giving backing to clients who are always shelled by electronic data. While beyond any doubt understudies live, breath, mingle and associate in the computerized environment regardless they require the library's backing to help them arrange, structure and organize electronic data. The library can in any case capacity under its conventional setting it is apparent that there must be a movement of the library's needs from putting resources into physical and simple things to hardware ones. Therefor; it is important to center in workstation region and configuration of college library where a great deal of understudies spend an extensive piece of their everyday life, utilizing library furniture; of course, because of absence of legitimate anthropometric database, these items have ordinarily been not well fitted for the planned client populaces.

We know all bodies of students are confronting numerous critical anxieties, without being aware of them, from augmenting their wrists; or slumping, or there is no arm-support chair to take a gander at ineffectively put screen.

Some situations, affecting to the health of human and can cause pain, or muscle fatigue, or may cause poor focus and may lead to cumulative trauma disorder or injuries which comes from stress.

The decrease stress, weariness, and wounds of person by enhancing an item plan and workspace game plan is the point of ergonomics science. It has dependably guaranteed an agreeable plan and loose stance. In this manner, in the library workstation plan, it is essential to utilize anthropometric measures.

In the design, we require some anthropometric measurements. In addition, we can decide the level of wellness to human body measurements that we called "mismatch ratio" to survey the level of accomplishment in item plan.

The mismatch may influence the considering procedure, and can create musculoskeletal issue, for example, low-back agony. The current library furniture at Eastern Mediterranean University, Famagusta, Turkish Republic of Northern Cyprus had altered measurements for every students and served as a kind of perspective. We estimated that would give uncomfortable and tiring sitting positions to dominant students' part. The primary target of my thesis was to play out an anthropometric study then to characterize the ideal measurements and attributes of library furniture through the utilization of approved and significant anthropometric criteria.

In this proposal we firstly, in chapter two we will display a literature review about configuration of furniture. Besides, to accumulate the anthropometric estimations from students at Eastern Mediterranean University (EMU) we proposed the methodology which is introduced in chapter three. Furthermore, the design of

experiment is considered in chapter four. After that, our analysis and results will be discussed in chapter five. At long last, chapter six gives a recommendation and future work and conclusion.

Chapter 2

LITERATURE REVIEW

Universities have enormous libraries to bolster the instructive procedure and help students to read, study and research. Subsequently, libraries played a noteworthy base in many Universities on the planet to construct students' learning.

Many universities are using libraries to help students to find books and references easily, read, study and research in comfortable and quite area.

As we probably am aware, students spend numerous hours every day in library either before PC screen or just reading or studying by sitting on seat with table without pondering the wellbeing effect of the related human stance. In this thesis we concentrate on the best possible furniture outline to lessen visual and musculoskeletal distress.

2.1 Design of Workstation

In the design of workstation regarding to the following subjects were concerned; screen situation, console, work surface customizability, seat plan, footstools, and lighting. Furniture outline of these subjects may bring about physical issue which are known as musculoskeletal issue that may appear as (Sweere, 2002):

- Strain on eyes and Headache.
- Back-fatigue or neck.
- Shoulder-disease and wrist.

(Timoteo and Afininda, 2010) examined the workstation of Filipino clients. Their contemplations were wellbeing issues due rate fitting of current outline, present configuration, and the stances of the specialists. The present workstation plan does not fit the normal Filipino clients were their decision. Furthermore, the expansion in the quantity of wounds amid work because of the wrong measurements and poor workspace outline may prompt unacceptable motivational needs. In addition, the utilization of uncomfortable workstation created the expansion of the likelihood of mistakes at work and lessened the execution of laborers. In this manner, they suggested some prompt arrangements as putting the back pad for lower back backing to stay away from back agonies and when the seats utilized were made from wood the seat and back pad ought to be utilized. Additionally, at a distance of 50 cm the monitor must be placed.

at Chulalongkorn University the assessments of a work area chair set were utilized. By utilizing connected insights with advancement, it was found subsequently that 9% of clients are coordinating with seat tallness and 36.3% of clients are coordinating for work area stature. Also, the conclusion was that the best statures for seat and work area were (40.5cm and 62cm) rather than (47.7cm and 75cm) which were presently utilized. The rate of coordinating was expanded by proposing these new measurements to 63.4% for seat tallness and 98% for work area stature (Angusmalin, 2010).

2.2 Sitting

(Callahan, 2004) broke down the advantage of seat arms is to help with emptying the spine as the body weight movements to the aspect joints and bringing on a stretching

of stature, when contrasted with the standard situated position, and hence the plates would be emptied.

(Dowler, 1998) said "when clients are sitting, tilting forward on a seat, a higher stacking of the intervertebral happened. This was happening because of diminishing of the hip point and would impact the breathing capacity and blood dissemination".

(EOHSS, 2008) recommended that backrests ought to be movable in tilting no less than 85 degrees to 100 degrees while still it is conceivable to keep up no less than a 90° sitting edge and the flexibility for stature between 16to20 inches from the seat dish. Also, it ought to be no less than 13 creeps wide.

(Callahan, 2004) said "whatever is left of laborers feet on the floor or on a stool ought to be permitted by the seat stature. Furthermore, the seat height ought to permit the laborer to utilize a reasonable console while keeping his/her lower arm parallel to the floor and his/her wrists at the same plane of the lower arm, and his/her legs ought to have enough leeway". (Healthcare Ergonomics, 2012) recommended that the ideal adjustability range for seat stature be 37cm to 55cm.

2.3 Library Furniture and Anthropometric Measures Mismatch

The contrarily between understudy's body measurements and the measurements of library furniture is the mismatch.

A confound between seat-height and popliteal-height when the flow seat stature is not exactly cos30° or more noteworthy than cos5° level of height of popliteal. The jumble between width of hip and width of seat happens when the width of seat is under1.1 or more prominent than 1.3 of width of hip, and the height of backrest as

prescribed to keep scapula stature more than the backrest. Consequently, the crisscross shows up if backrest is more prominent than0.8 or under0.6 of sitting shoulder tallness (Gouvali, 2006). the crisscross between seat profundity and butt cheek to-popliteal length when the seat profundity is under 80% or more noteworthy than 95% of butt cheek to-popliteal length (Parcells, 1999).

(Parcells, 1999) prescribed the table freedom ought to be no less than 20mm: the knees will be more agreeable under the table when this space exist. The table stature ought to be intended to elbow stature (Parcells, 1999). Hence when shoulders are not in flexion or snatching, we will get the most reduced table stature. At the point when 20°snatching and 25°flexion of shoulders happen, greatest height will be exist, figure (2-1) show us the degrees of abduction and flexion.

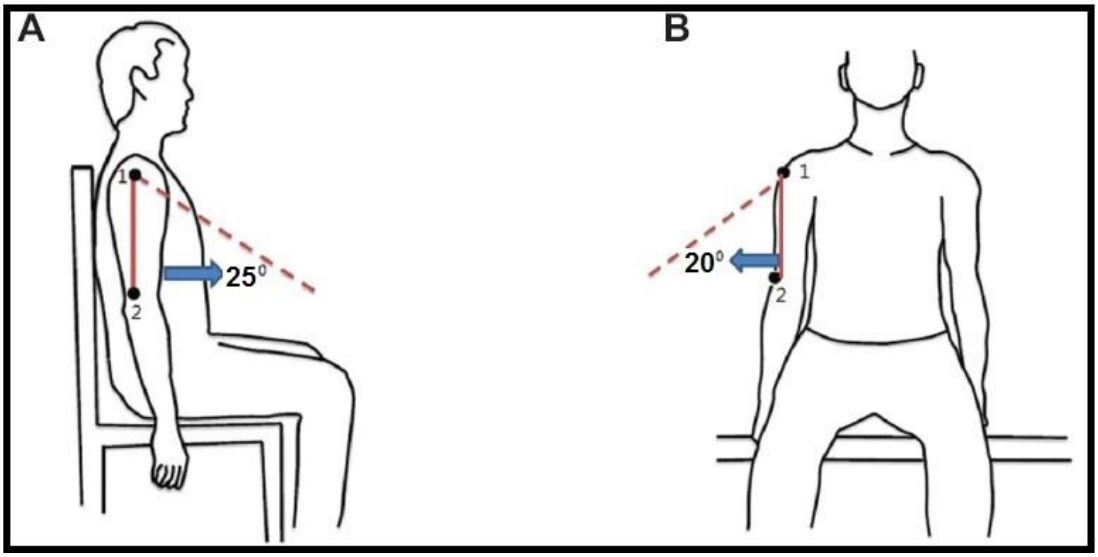

Figure 2.1: The Shoulder at 25° Flexion and 20° Abduction

(Pheasant S, Haslegrave CM, 2006) assessed nine measures of anthropometric of the members which were produced using the half of their bodies, by embracing legitimate historic point definitions and standard measuring procedures. Amid

estimations, the members were barefooted, wearing light fabrics, and educated to sit in a manner that their thighs were in full contact with the seat, their lower and up-per legs were at right points (knee bowed at 90°), their feet were set on the floor, and the storage compartment was upright. The anthropometric measurements were (Stature (S), Sitting Elbow Height (EH), Sitting Shoulder Height (SSH), Knee Height (KH), Popliteal Height (PH), Sitting Height (SH), Buttock-Popliteal Length (BPL), Hip Width (HW)).

In addition, the following Table (2.1) shows the dimensions measured on the library furniture.

Table 2.1: Dimension of Library Furniture with formula of combination

Dimension Combination	**Formula**
Popliteal Height (PH) and Chair Height (CH)	$(\mathrm{PH}+2)*\cos 30° \leq \mathrm{CH} \leq (\mathrm{PH}+2)*\cos 5°$
Buttock-Popliteal Length (BPL) and Chair Depth (CD)	$0.80\ \mathrm{BPL} \leq \mathrm{CD} \leq\ 0.99\ \mathrm{BPL}$
Hip Width (HB) and Chair Width (CW)	$1.1\mathrm{HB} \leq \mathrm{CW} \leq 1.3\mathrm{HW}$
Shoulder Height (SDH) and Backrest Height (BH)	$0.60\ \mathrm{SDH} \leq \mathrm{BH} \leq 0.80\ \mathrm{SDH}$
Elbow-Height (EH) and Table Height (TH)	$(\mathrm{PH}+2)\cos 30° + \mathrm{EH} \leq \mathrm{TH} \leq (\mathrm{PH}+2)\cos 30° + 0.85\ \mathrm{EH} + 0.14\ \mathrm{SH}$
Underneath Table Height (UTH)	$(\mathrm{KH}+2)+2 \leq \mathrm{UTH} \leq (\mathrm{PH}+2)\cos 5 + 0.85\ \mathrm{EH} + 0.14\ \mathrm{SH}$

Along these lines, We can finish up the most reduced table height:

Minimum Table Height (TH) = EH + LSH

Minimum TB = EH+ cos 30° PH (2.1)

The maximum table height calculated from

Maximum TH = Maximum SH + Maximum EH

Maximum Table Height = cos5°Popliteal Height+ Maximum Elbow Height (2.2)

If AL is the length of

AL = SDH – EH (2.3)

Maximum of Elbow Height = Elbow Height + 0.0605 Arm Length + 0.0881 Arm Length (2.4)

From (2.2) and (2.4)

Maximum of Table Height = cos5° Popliteal Height + 0.852 Elbow Height + 0.148 Shoulder Height (2.5)

Therefore, from (2.1) and (2.5), Table Height will be

Elbow Height + cos30° Popliteal Height < Table Height < cos5° Popliteal Height+ 0.852 Elbow Height + 0.148 Shoulder Height (2.6)

2.4 Level of Illumination

We require wellspring of light in numerous fields of our lives which it comes from the sun from simulated source, for example, lamp light. The measures of lighting we have to finish our jobs rely on upon kind of jobs. (McCormick, 1992) recommended

that it is important to give person with some wellspring of enlightenment whether from regular sunlight or from manufactured source when he/she works a few exercises on indoor or around evening time.

The Students for the most part seating in library for over one hour and this may have some impact on their vision if the measure of light is insufficient or surpassing the point of confinement. They regularly concentrate on their perusing or contemplating for drawn out stretches of time, in any case, this may bring about the strain in muscles of their eyes and potentially they may feel cerebral pain and weakness.

(Jago and Tanner, 1999) said "Learning places enlightening assumes a particularly basic part due to the immediate relationship that great lighting and student's execution".

(Pulay, 2010) said "Students must read a wide range of surfaces, similar to papers or they ought to look on PC screens". So they regularly need to move their look from "heads up" to "heads down, subsequently, proper an astounding brightening is extremely basic and critical. Lighting in schools environment must be considered as an extremely indispensable, basic and element component of the entire instructive environment (Dunn, 1985). Numerous components have specifically impact on understudy execution from environment places of learning however the light impact is more than different components. (Jago, and Tanner, 1999) recommended that there are some components can affect to students' study and focus, and one of those components is the light which unequivocally impacted.

There are six human classifications prerequisites tended to by lighting: errand execution, correspondence and social conduct, wellbeing and security, state of mind and solace, tasteful, and judgments (Veitch, 2010). since changing the light is achievable surely profitability and expansion execution by means of the accompanying instrument is conceivable:

- Visual execution: When individuals can see the undertaking clear certainly they work and play out that better. Visual execution doesn't have clear worship and significance in all assignments. Some assignments needn't bother with much light keeping in mind the end goal to be performed well outwardly.
- Visual solace: By evacuate or decrease uneasiness glaring the execution will increment since fixation will upgrade.
- Interpersonal relationship: when individuals can see each other better they can have better correspondence and more collaboration.

Since expanding the lighting quality will upgrade prosperity and inspiration among individuals they will have better execution. Hence, tackling existing lighting issue is vital on the grounds that it will build work fulfillment in work environments and energize understudies in learning places for better execution and learn better.

Inadmissible lighting can be the reason for some issues, for example, eye fatigue to different graves musculoskeletal wounds. Light touching base in human eyes has a fundamental non-visual natural impact on the human body, sways human wellbeing, prosperity and productivity (Oneworkpalce, 1999). Poor lighting has basic show on understudies or other individuals and: red or ragged looking eyes in the wake of perusing, be uncomfortable and squirming amid perusing or close work exercises,

skipping words or lines while perusing or composing (Johnson, 2011). Very much outlined lighting environment can alleviate strain of eyes, and expansion visual security or toughness.

(Rice, 2010) said "there is a kind of stress on people's body that can lead to disease or slow breakdown of biological function. The important point is that the human body wishes to be healthy, and for having a very great physical and mental power it is necessary to have appropriate environment. Each cell in human body is separately able to sense and respond correctly to both positive and negative influences in environments". (Rice, 2010) said "As a result, Activation, arousal, and stress are three mental reactions that consider to lighting"

According to (Halliday, 2008) a great counterfeit lighting technique has productive component. It will as a rule be significant and more proficient with mix by great sunshine and appropriate shading and make errand less demanding to do. Where fake light and sunshine are joined, then lights ought to be shifted from perspective to maintain a strategic distance from glare and direct difference amongst sunlight and a reveal light.

Ecological architects and therapists have affirmed that the procurement of decisions in the physical environment will prompt satisfying outcomes for workers, for example, better execution and enhanced mind-set (Veitch and Gifford, 1996). We can see in figure 2.2 which shows the relationships between individual outcomes lighting conditions, and individual processes.

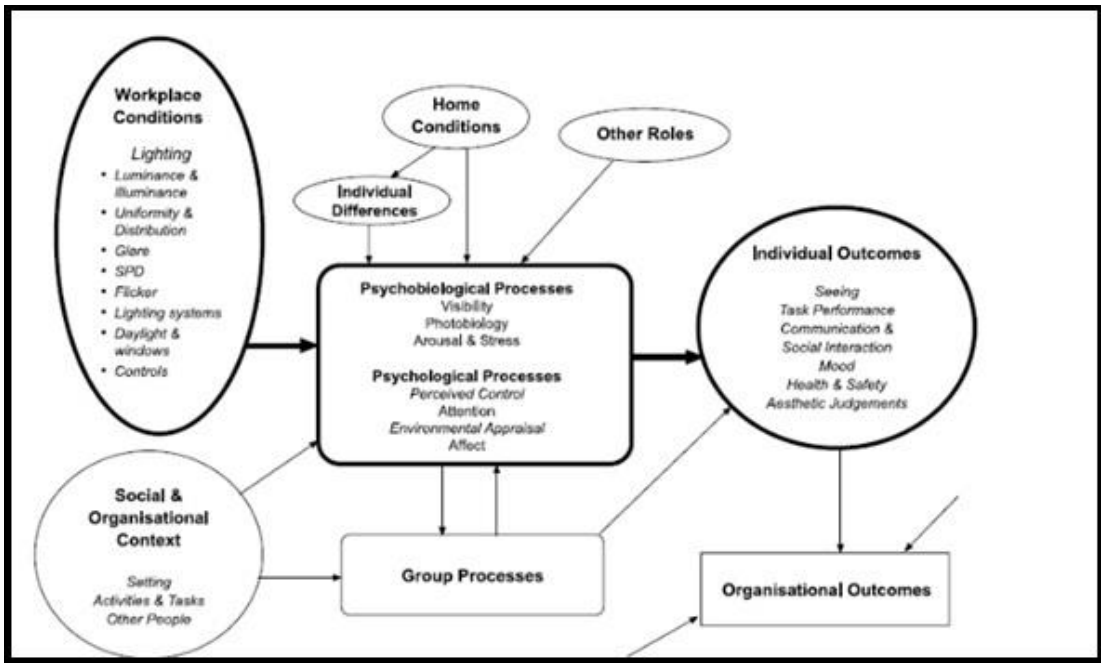

Figure 2.2: individual processes, lighting conditions, and individual outcomes.

The glare (trouble of vision because of the nearness of splendid light) and the force of light are the fundamental variables that may impact on eye strain. At the point when understudy sitting in library and perusing or writing in a poor lighting, he/she will feel weakness in his/her eyes. Case in point, the understudies may tilt forward in low light framework environment to see unmistakably, or tilt in reverse to stay away from the glare originating from brilliant light overhead. Enhancing the lighting and conformity of the stature of workstation will take care of numerous vision issues (EOHSS, 2008).

(U.S. General Services Administration, 2015) recommended that Lighting should be designed to enhance both the overall building architecture as well as the effect of individual spaces within the building. Interior Lighting Consideration should be given to the options offered by direct lighting, indirect lighting, down lighting, up lighting and lighting from wall- or floor-mounted fixtures. Illumination Levels For lighting levels for interior spaces see the values indicated in Table (2-2).

Table 2.2: Interior Illumination Levels (Average)

Area	**Nominal Illumination Level in Lumens/Square Meter (lux)**
Office Space	
Normal work station space, open or closed offices	500
ADP Areas	500
Conference Rooms	300
Training Rooms	500

Chapter 3

METHODOLOGY

3.1 Subjects

An aggregate one hundred-fifty-four undergrad and postgraduate students, ninety-seven males and fifty-seven females were taken part in this study. Their ages went from sixteen to forty-five years of age. All subjects were students from Eastern Mediterranean University (EMU).

3.2 Anthropometric Method

Anthropometric measurements are therefore an important consideration in designing ergonomically appropriate furniture for students, ergonomics and architecture where statistical data about the distribution of body dimensions in the population are used to improve products. The distribution of body dimensions would change when life style (nutrition and physical) change from person to person. There require general overhauling of anthropometric information accumulations.

In this research, twelve anthropometry measurements were measured and straightforwardly utilized as a part of outlining seats and tables for understudies' library furniture. Every single anthropometric estimation were gathered utilizing the understudies of Eastern Mediterranean University. Amid estimation every understudy was requested that keep two distinctive stances; standing erect without shoes and sitting correctly where elbow bowed 90° and knees, we can see it in figure (3-1).

The twelve anthropometric dimensions were stature, shoulder elbow height, forearm hand length, shoulder height, popliteal height, sitting height, buttock-to-popliteal length, hip width, eye sitting height elbow sitting height, and overhead stretch figure (3-2) demonstrates all these measurements. On the normal, 12 minutes was enough to finish required measures per student.

The depictions of anthropometric measurements which are taken in this experiment are showed in figure (3-3) below

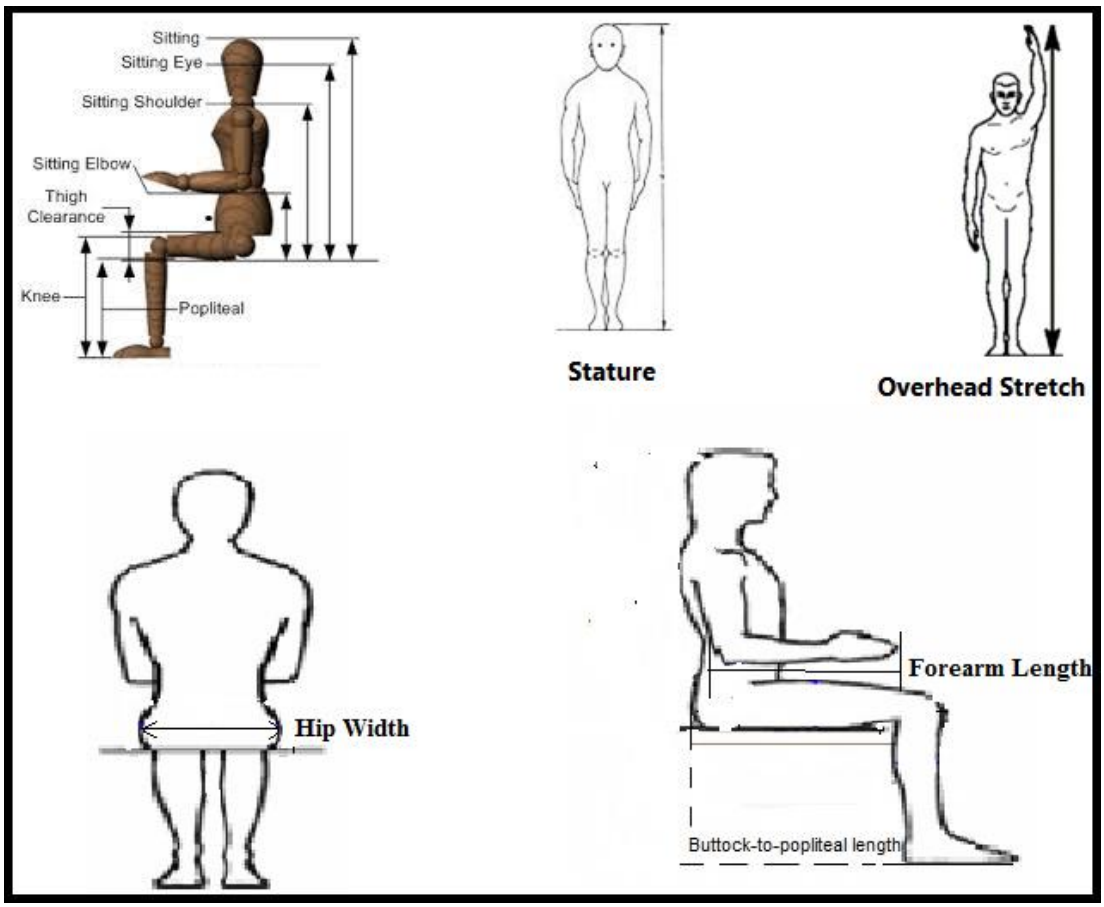

Figure 3.3: Measured Anthropometric Dimensions

3.3 Illumination

Measure the light & the lux levels are important in every workplace. If the light system is bad, it will affect to our business. Low levels of illumination can be the reason of fatigue and muscle eye strain. The same is true for high levels of illumination. Glare and reflected light can distract an individual and impair his or her vision. We know the reading or studying requires the student's full attention, so, this will be dangerous for students. Using a light or lux meter to measure light levels in library can help us to avoid these issues. It is important to protect our students in library by providing appropriate lighting. Regulation no.8 of the Workplace Regulations Act 1992 states that employers must ensure that:

- Sufficient lighting and every workplace has suitable.
- Natural light should be used, so far as is reasonably practicable.
- Sufficient emergency lighting and Suitable must be provided.

3.4 The Equipment Used in this Study

1. Balance.
2. Metal tape.
3. Anthropometric ruler
4. Lux meter.
5. Angle finder

Figure 3.4: Equipment Used to Measure Students

3.5 Gathering of Data

The measurement measured ought to be recorded in a structure, which incorporates some individual data, for example, name, age, sexual orientation and understudy number. Every understudy must fill his/her very own data before the estimation procedure began. Table 3-1 demonstrates plainly the careful area for every one of the twelve anthropometric measurements, which is essential to guarantee the estimation procedure for every understudy is done effectively and precisely and to minimize the blunders in the information accumulation process.

Small questionnaire was distributed to students in library randomly. 100 participant answered for it, to analyze if chairs and tables were comfortable or no. Table (3-2) shows the sample of distributed questionnaire.

Table 3.1: Sample Form for Students' Measurement

Number	
Name	
Student Number	
Gender	
Age	
Weight (kg)	
Height	
Forearm Length	
Knee Height(KH)	
Hip Width(HW)	
Popliteal Height(PH)	
Shoulder Elbow Height(SHE)	
Shoulder Height(SDH)	
Buttock-to-Popliteal Length(BPL)	
Sitting Eye Height	
Sitting Height	
Elbow Sitting Height(EH)	
Overhead Stretch Height	

Table 3.2: Sample Questionnaire Form for Students

Name :

Student Number (ID) :

For each of the following categories, please rate your satisfaction level with your workplace:

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Table height					
Table surface width					
Chair height					
Chair width					
Bookshelf height					
Lighting					
comfort					

- **Do you have any pain when you were staying long time in library?**

  Yes ( ) **No ( )**

- **Do you prefer chair with arm-supports?**

  Yes ( ) **No ( )**

- **Do you like adjustable Chairs?**

  Yes ( ) **No ( )**

Chapter 4

DESIGN OF EXPERIMENT

4.1 The Design of Experiment

It is a factual system used to enhance forms, and the experimenter can see from results which are the most critical or irrelevant variables.

A test was planned and executed as takes after. Initial, 154 students were arbitrarily chosen. At that point we utilize anthropometric set to gauge the measurements of students' body. Subjects were haphazardly planned to the collection of measurements. Furthermore, the request of measurement of particular measurements were randomized.

A totally randomized configuration was utilized as a part of this examination. The normal of every anthropometric estimation, male and female was ascertained.

4.2 The Assumption of Normality

Before applying measurable technique that assumes typicality, it is important to perform ordinariness test on anthropometric body measurements. The typicality suppositions are anything but difficult to check by utilizing an ordinary likelihood plot. For the most part, we used Minitab16 to perform it rapidly. We got P-value from Minitab16 then; we can see whether and our alpha level (equivalent to 0.05) is larger or smaller than the value was given.

The null hypothesis states that, the anthropometric data of male and female students follows a normal distribution. We will reject the null hypothesis when the p-value is less than alpha level. As can be seen from Minitab output, the p-value is larger than 0.05, this implies there is no sufficient evidence to reject the null hypothesis and it is concluded the data distribution is normal. Additionally, as illustrated in figure (4.1) and figure (4.2) all observation are close to the straight line on the graphs. Hence, the null hypothesis about normality is verified.

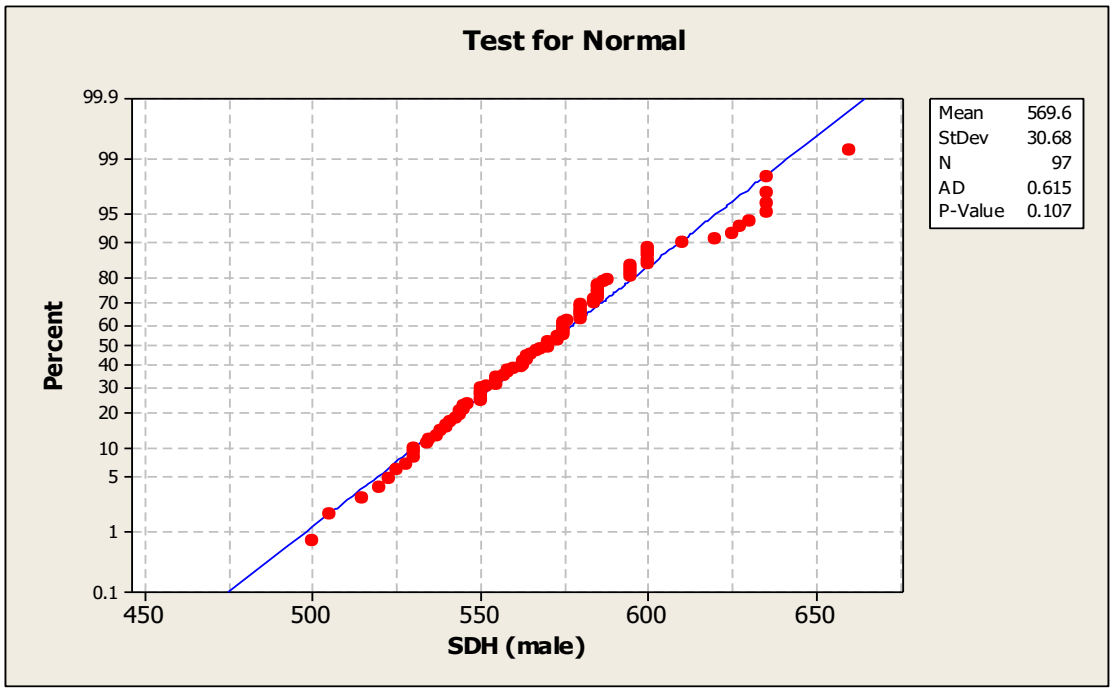

Figure 4.1a: Shoulder Height Normality Plot (male)

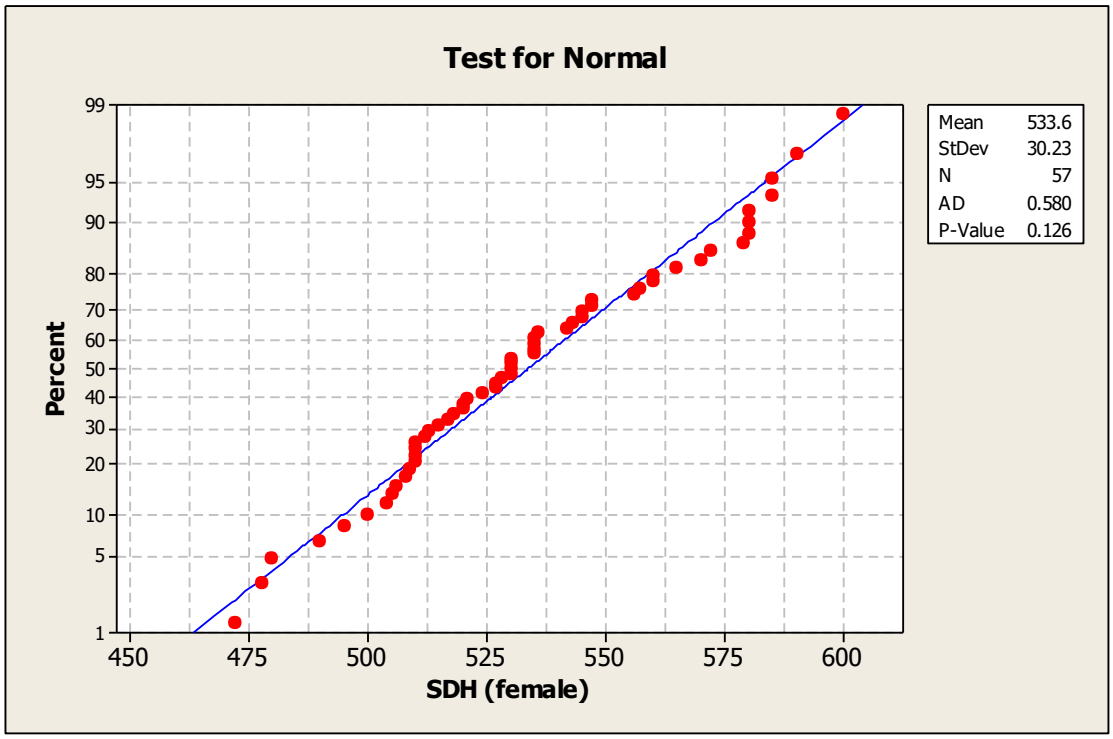

Figure 4.1b: Shoulder Height Normality Plot (female)

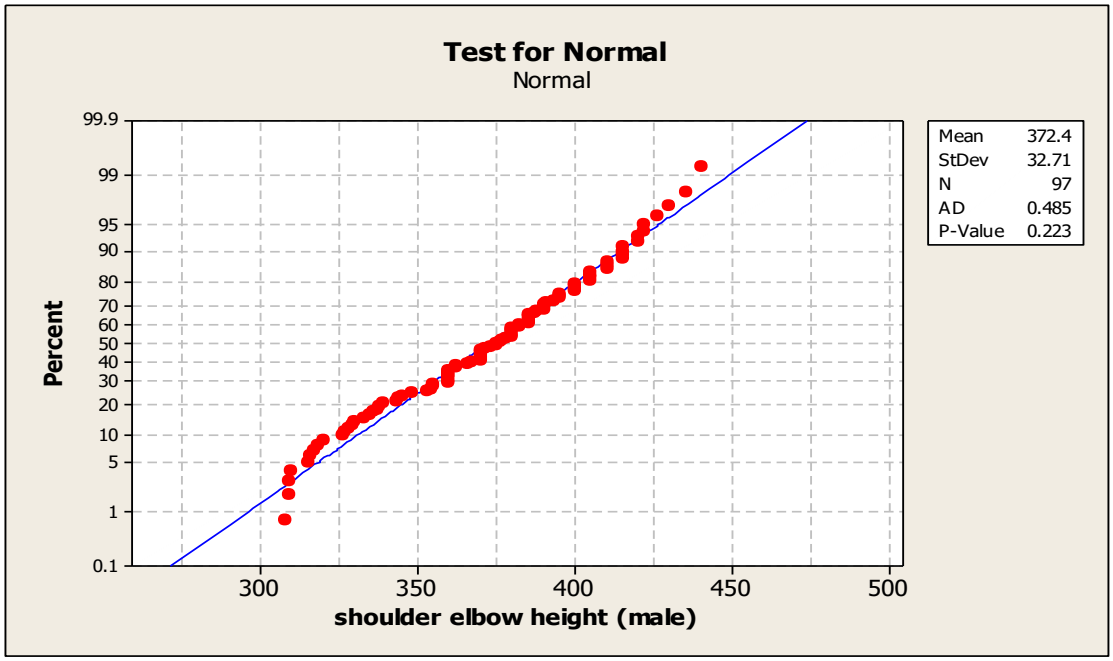

Figure 4.2a: Shoulder Elbow Height Normality Plot (male)

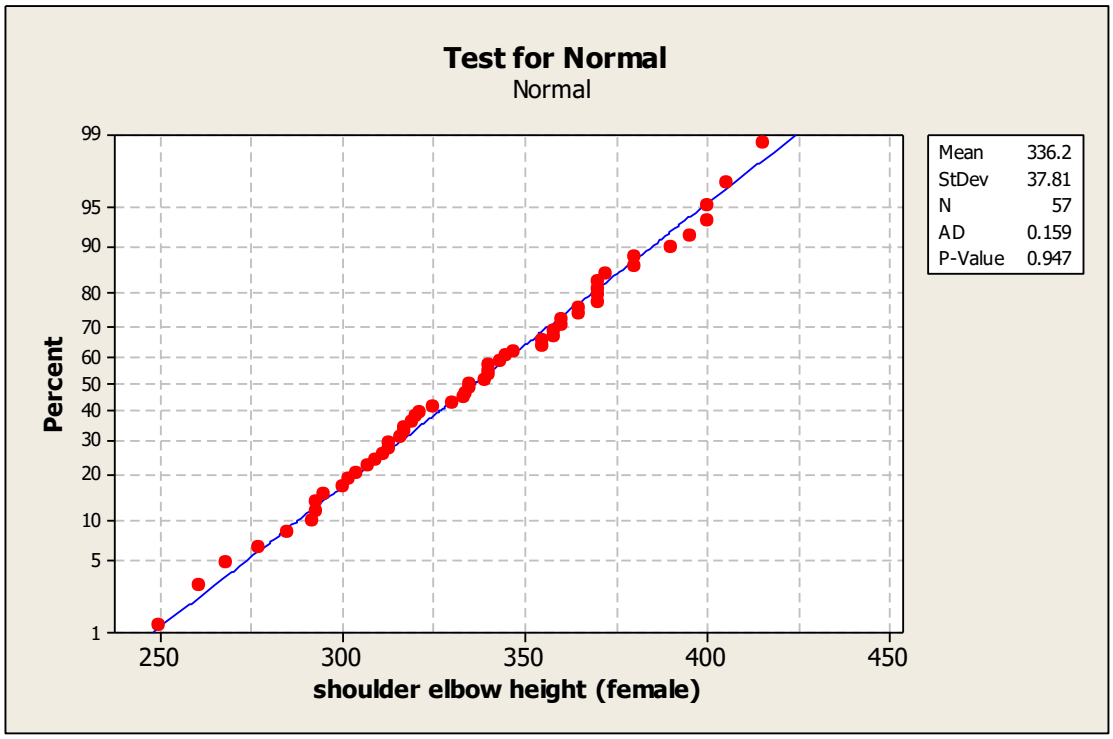

Figure 4.2b: Shoulder Elbow Height Normality Plot (female)

We can see all tests of normality in appendix C.

4.3 Calculate the Percentile

We can find the percentiles of any normal distribution by using the equation:

$$\text{Kth percentile} = \mu \pm z\,\sigma \tag{4-1}$$

Where μ is the mean of anthropometric dimensions which are (stature, shoulder height, shoulder elbow height, buttock-to-popliteal length, popliteal height, knee height, forearm hand length, hip width, elbow sitting height, sitting height and eye sitting height figure) and σ is their standard deviation and z is the value from the standard normal distribution for the wanted percentile. For example, if we consider elbow sitting height locate the 10th and 90th percentiles, it means:

10^{th} $P_{\text{sitting height}} = \mu_{\text{sitting height}} - 1.28 * \sigma_{\text{sitting height}}$

90^{th} $P_{\text{sitting height}} = \mu_{\text{sitting height}} + 1.28 * \sigma_{\text{sitting height}}$

We can see find Table (5-2) in chapter five the average (μ) and the standard deviation (σ) of students' anthropometric measurements.

Chapter 5

RESULTS AND DISCUSSION

5.1 Library Furniture

The EMU Library second floor contains about one hundred and forty one tables, three hundred and twenty four chairs and fifty nine bookshelves. Three types of tables and only one type of chairs exist in second floor of library, Table (5-1) illustrate the dimensions of library furniture.

Table 5.1: Measurements of EMU Library Furniture (Second Floor).

Dimension	**Measurement (cm)**
Seat Height	40
Seat Depth	43.5
Seat Angle	4°
Seat width	44.5
Backrest angle	10°
Maximum Height of backrest	41.5
Maximum Height to bottom of backrest	28.5
Individual Table	
Table Height	73
Table Clearance	71
Table Slop	0
Table Width	86.5
Table Length	60
Long Table	
Table Height	76
Table Clearance	67
Table Slop	0
Table Width	180
Table Length	90
Computer Table	
Table Height	74
Table Clearance	71
Table Slop	0
Table Width	80
Table Length	80

5.2 The Measurements of Anthropometric

Table 5-2 below showed us the body dimensions of students. Minitab 16 and Excel 2010 were used to investigate the information. Fundamental clear measurements were utilized to process mean, middle, standard deviation, most extreme and least esteem for anthropometric information for males and females. As should be obvious in table 5-2a and 5-2b, the greater part of the mean and medians are near each, demonstrating symmetrical appropriations.

We can calculate the 10^{th} and 90^{th} percentile by using formula (4-1). If we take any dimension form table (5-2a) and table (5-2b) such as shoulder elbow height, we can see the average for males and females are 372.4 mm and 336.2 mm with standard deviation of 32.71 mm and 37.81mm respectively, where the standard deviation value is directly proportional to the difference between each data and the mean.

Let: mean = μ and standard deviation = σ

10^{th} percentile (male) = μ- 1.29 σ = 372.4 – (1.29*32.71) = 330.2 mm.

10^{th} percentile (female) = μ- 1.29 σ = 336.2 – (1.29*37.81) = 287.4 mm.

90^{th} percentile (male) = μ+ 1.29 σ =372.4 – (1.29*32.71) = 414.6 mm.

90^{th} percentile (female) = μ+ 1.29 σ = 336.2 – (1.29*37.81) = 384.9 mm.

This distribution seems to be normally distributed for shoulder elbow heights for male and female and we can see in figure (5.1).

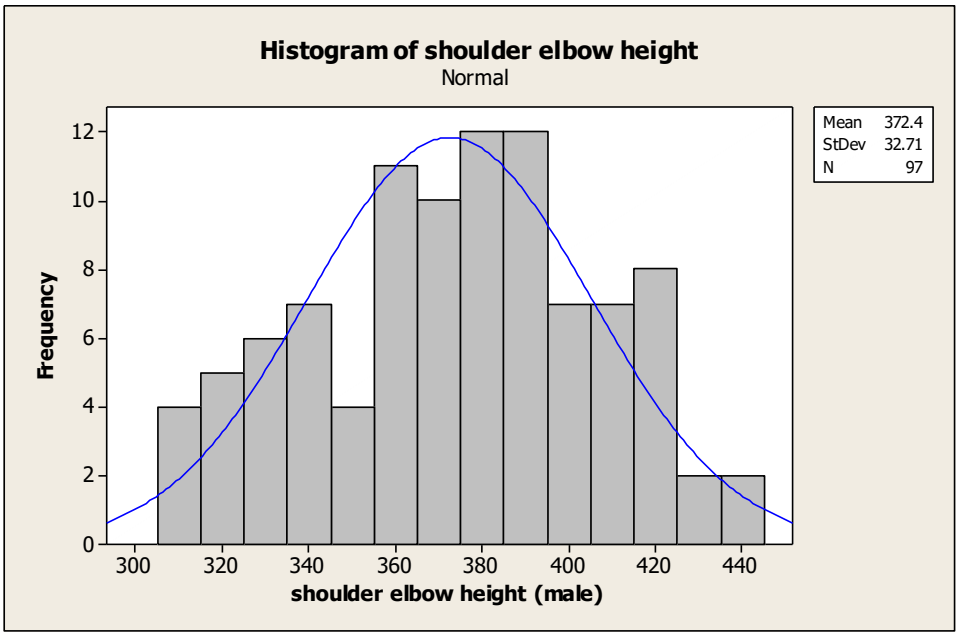

Figure 5.1a: Shoulder Elbow Height Histogram (male)

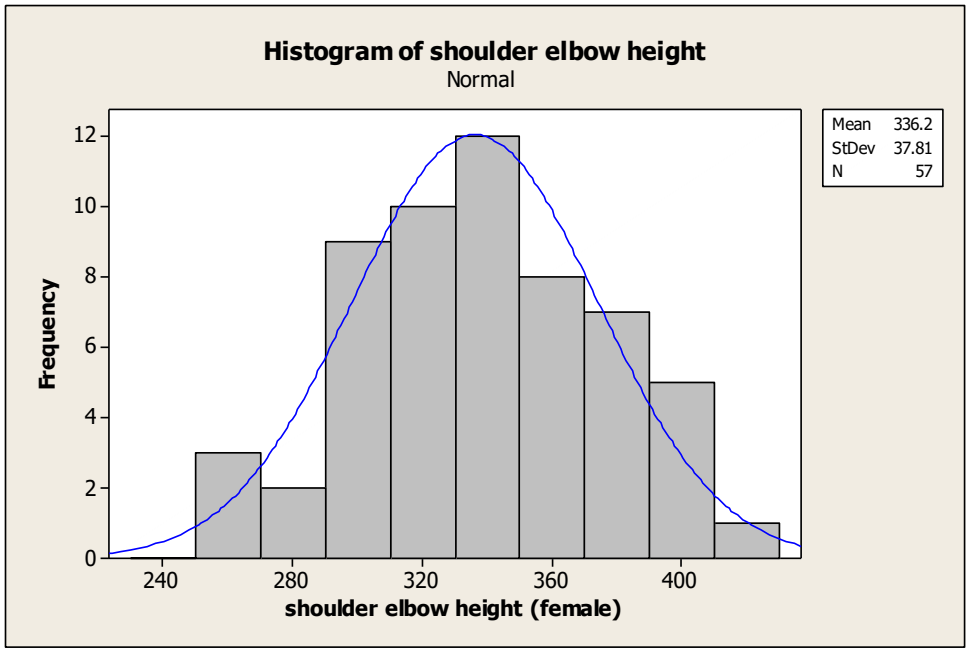

Figure 5.1b: Shoulder Elbow Height Histogram (female)

Table 5.2a: Anthropometric Data for Male Students

Item	μ	median	σ	min	max	10th	90th
Weight (kg)	76.5	75.0	12.9	55.0	115.0	59.9	93.2
Stature (cm)	176.8	176.0	5.6	160.0	194.0	169.6	184.0
Shoulder Height (mm)	569.6	570.0	30.7	500.0	660.0	530.1	609.2
Shoulder Elbow Height (mm)	372.4	375.0	32.7	308.0	440.0	330.2	414.6
Buttock-to-Popliteal Height (mm)	502.5	501.0	40.7	425.0	600.0	449.9	555.0
Popliteal Height (mm)	470.3	465.0	32.7	408.0	580.0	428.1	512.5
Knee Height (mm)	563.1	565.0	33.5	485.0	650.0	519.9	606.4
Forearm Length (mm)	492.2	492.0	29.2	420.0	570.0	454.4	529.9
Hip Width (mm)	397.6	394.0	40.9	290.0	520.0	344.8	450.4
Elbow Sitting Height (mm)	226.4	225.0	28.2	155.0	290.0	190.0	262.8
Sitting Height (mm)	839.6	840.0	38.7	720.0	930.0	789.7	889.5
Siting Eye Height (mm)	742.8	740.0	38.4	648.0	825.0	693.3	792.2
Overhead stretch (mm)	2218.1	2210.0	84.8	2000.0	2460.0	2108.7	2327.5

Table 5.2b: Anthropometric Data for Female Students

Item	μ	median	σ	min	max	10th	90th
Weight (kg)	61.23	59	11.831	35	98	45.97	76.49
Stature (cm)	163.65	163	7.359	148	182	154.16	173.14
Shoulder Height (mm)	533.56	530	30.232	472	600	494.56	572.56
Shoulder Elbow Height (mm)	336.18	335	37.808	250	415	287.40	384.95
Buttock-to-Popliteal Height (mm)	475.32	475	37.001	400	559	427.58	523.05
Popliteal Height (mm)	447.07	451	30.488	385	510	407.74	486.40
Knee Height (mm)	516.60	511	31.778	448	590	475.60	557.59
Forearm Length (mm)	451.37	450	22.559	390	500	422.27	480.47
Hip Width (mm)	404.25	400	44.513	310	505	346.82	461.67
Elbow Sitting Height (mm)	228.18	225	29.561	170	301	190.04	266.31
Sitting Height (mm)	779.91	780	41.189	680	874	726.78	833.05
Siting Eye Height (mm)	688.32	685	39.160	591	794	637.80	738.83
Overhead stretch (mm)	2004	1995	104.077	1790	2242	1869.92	2138.44

5.3 Evaluate the Current Furniture of EMU Library

For assessment and overhaul furniture of library, it is essential to consider the connected standards of ergonomics and anthropometry, and to decide the mismatch we shall use conditions to figure the restrictions of furniture measurements.

5.3.1 Seat Height (SH) and Popliteal Height

The match measure as (Gouvali, 2006) said should be:

$$PH \cos 30° < SH < PH \cos 5° \quad (5\text{-}1)$$

In this manner, the bungle happens when the momentum seat stature is under cos30° or more noteworthy than cos5° of popliteal height.

5.3.2 Seat Depth (SD) and Buttock-to-Popliteal Length (BPL)

Most originators suggested that the seat depth ought to be intended for the 10th of the popliteal buttock length circulation. The depth ought to be no less than 5cm shorter than popliteal buttock length (Poulakakis and Marmaras, 1998). (Castellucci,2010) said "the mismatch when the seat depth was ≥ 95% or ≤ 80% of buttock-to-popliteal length".

$$0.80\ BPL \leq SD \leq 0.95\ BPL \quad (5\text{-}2)$$

5.3.3 Seat Width (SW) and Hip Width (HW)

"To give settlement to users with the biggest hip so, the seat width must be sufficiently. To lessen the ratio of mismatch between seat width and hip width the seat width ought to be planned at percentile of 90th of hip width conveyance or the biggest hip" (Gouvali, 2006), we can see in the following equation.

$$1.1\ HW \leq SW \leq 1.3\ HW \quad (5\text{-}3)$$

We can see from equation (5-3) that the mismatch happens when the seat width is more prominent than 1.3 of the hip widths or under 1.1of the hip width.

5.3.4 Backrest Height (BH) and Shoulder Height (SDH)

(Gouvali, 2006) said "the backrest height as keeping the backrest lesser than the scapula stature, or the upper edge of scapula (60-80% of shoulder height)".

$$0.6\ SDH \leq BH \leq 0.8\ SDH \tag{5-4}$$

We can see from the equation above the mismatch happens when the backrest is under 0.6 of shoulder height or more prominent than 0.8.

5.3.5 Table Height (TH) and Elbow Sitting Height (EH)

One of the critical measurement is elbow sitting height which is important decide the table height so that, the analysts considered it as the real model for table height. In this manner we can say the shoulders shouldn't be in flexion or abduction for minimum table height, however, when the shoulders are at 20° abduction and 25° flexion, it means that the table height is at the greatest hence, equation (2-6) can tell us when the mismatch.

$$EH + \cos 30° PH < TH < \cos 5° PH + 0.852EH + 0.148SDH \tag{5-5}$$

5.3.6 Underneath Table Height (UT)

The space between the underneath surface of the table (UT) and the knees we call it the table clearance. "The table clearance ought to be no less than 20 mm" (Parcells, 1999). This space permits the movement of knees under the table easily.

$$UT \geq 20 + KH \tag{5-6}$$

From equations specified from (5-1) to (5-6) we can see in Table (5-3) the mismatch for all measured students.

Table 5.3a: Furniture Mismatch with Anthropometric measurements for 57 Female

Mismatch Between	Percentage %
PH and SH	40.4
BPL and SD	47.4
HW and SW	57.9
SDH and BH	35.1
EH and TH (Individual)	84.2
UT (Individual Table Clearance)	0.0
EH and TH (Long)	96.5
UT (Long Table Clearance)	0.0
EH and TH (Computer)	89.5
UT (Computer Table Clearance)	0.0

Table 5.3b: Furniture Mismatch with Anthropometric measurements for 97 Male

Mismatch Between	Percentage
PH and SH	55.7
BPL and SD	45.4
HW and SW	45.4
SDH and BH	3.1
EH and TH (Individual)	73.2
UT (Individual Table Clearance)	0.0
EH and TH (Long)	89.7
UT (Long Table Clearance)	0.0
EH and TH (Computer)	80.4
UT (Computer Table Clearance)	0.0

Our target is to assess the furniture of EMU library by utilizing the mismatch proportion. Along these lines, two methods were considered to design the furniture of workstations. In every strategy our design will be depending on the matching optimality. After that, we will look to those designs and we will choose the best model. Moreover, the light framework in EMU library will be assessed and we will suggest how to improve it.

5.4 Statistics Optimization and Combination

This strategy is to find greatest matching for seats and tables as for by focus on populace's body measurements and the furniture set.

5.4.1 Design of Chair

The seat is the most imperative bit of furniture utilized as a part of library where the student burn through one hour or more of their time sitting, contemplating and perusing. In this way, it is important to choose a legitimately planned seat to empower the student to sit serenely, work proficiently, and give appropriate backing to the human body to minimize weakness.

- **Seat Height (SH)**

After numerous years of examination various proposals and rules are offered with the goal that it can be utilized as a part of the outline of a seat. Equation (5-1) gives us:

$SH < 0.996PH, SH > 0.866PH$

So, $\frac{SH}{0.996} \leq PH \leq \frac{SH}{0.866}$

Therefore, the matching between the current seat height and students' dimension is (400mm).

$\frac{400}{0.996} \leq PH \leq \frac{400}{0.866}$ $\quad\quad$ Thus, $401.6 \leq PH \leq 461.9$

Table (5-2) showed us the value of popliteal height mean for 97 male and 57 female students is 470.3 mm and 447.07 mm and the standard deviation is 32.7 mm and 30.48 mm respectively.

Proportion match of male population = $P\left(\frac{401.6-470.3}{32.7} \leq \frac{PH-\mu}{\sigma} \leq \frac{461.9-470.3}{32.7}\right)$

Proportion match of female population = $P\left(\frac{401.6-447.07}{30.48} \leq \frac{PH-\mu}{\sigma} \leq \frac{461.9-447.07}{30.48}\right)$

Proportion match of male population match = $P(-2.1 \leq Z \leq -0.26) = 0.38$

Proportion match of male population match = $P(-1.49 \leq Z \leq 0.49) = 0.62$

Subsequently the flow seat stature is fitting for male and female students by 38% and 62% respectively.

To streamline the matching rate we can compute this extent for various heights of seat.

Table (5-4) showed us the matching proportion of different heights of seat with students' body:

$$P_{male} = \left(\frac{\left(\frac{SH}{0.996}\right) - 470.3}{32.7} \leq \frac{PH - \mu}{\sigma} \leq \frac{\left(\frac{SH}{0.866}\right) - 470.3}{32.7} \right).$$

$$P_{female} = \left(\frac{\left(\frac{SH}{0.996}\right) - 447.07}{30.48} \leq \frac{PH - \mu}{\sigma} \leq \frac{\left(\frac{SH}{0.886}\right) - 447.07}{30.48} \right).$$

Through shifting the seat range from 400 mm to the distinctive qualities somewhere around 320 and 570 mm, the extent of male match is expanded when the seat height diminished from 570 to 435 mm. At that point this extent begins diminishing and motivates more like zero when the seat height around 320 mm. likewise the extent of female match expanded when the seat height lessened from 570 to 420 mm, then it begins diminishing and motivates more like zero when the seat height around 320 mm. With the streamlining strategy, the greatest extent of match populace for male and female is found at 68% and 69% when the seat height is 440 and 420 mm individually, subsequently; the flow seat is not advantageous for the most students and ought to change it to go between 420 to 440 mm. This is evident from taking a gander at Table (5-2).

Table 5.4a: Matching Proportion of Different Seat Height with Male Students

Seat Height	Seat Height/0.996	Seat Height/0.866	Prob 1	Prob2	Probability
320	321.2851	369.515	0.00	0.00	0.00
330	331.3253	381.0624	0.00	0.00	0.00
340	341.3655	392.6097	0.00	0.01	0.01
350	351.4056	404.157	0.00	0.02	0.02
360	361.4458	415.7044	0.00	0.05	0.05
365	366.4659	421.4781	0.00	0.07	0.07
370	371.4859	427.2517	0.00	0.09	0.09
375	376.506	433.0254	0.00	0.13	0.12
380	381.5261	438.7991	0.00	0.17	0.16
385	386.5462	444.5727	0.01	0.22	0.21
390	391.5663	450.3464	0.01	0.27	0.26
400	401.6064	461.8938	0.02	0.40	0.38
410	411.6466	473.4411	0.04	0.54	0.50
420	421.6867	484.9885	0.07	0.67	0.60
425	426.7068	490.7621	0.09	0.73	0.64
430	431.7269	496.5358	0.12	0.79	0.67
435	436.747	502.3095	0.15	0.84	0.68
440	441.7671	508.0831	0.19	0.88	0.68
460	461.8474	531.1778	0.40	0.97	0.57
470	471.8876	542.7252	0.52	0.99	0.47
480	481.9277	554.2725	0.64	0.99	0.36
490	491.9679	565.8199	0.75	1.00	0.25
500	502.008	577.3672	0.83	1.00	0.17
510	512.0482	588.9145	0.90	1.00	0.10
520	522.0884	600.4619	0.94	1.00	0.06
530	532.1285	612.0092	0.97	1.00	0.03
540	542.1687	623.5566	0.99	1.00	0.01
550	552.2088	635.1039	0.99	1.00	0.01
560	562.249	646.6513	1.00	1.00	0.00
570	572.2892	658.1986	1.00	1.00	0.00

Table 5.4b : Matching Proportion of Different Seat Height with Female Students

Seat Height	Seat Height/0.996	Seat Height/0.866	Prob 1	Prob2	Probability
320	321.2851	369.515	0.00	0.01	0.01
330	331.3253	381.0624	0.00	0.02	0.02
340	341.3655	392.6097	0.00	0.04	0.04
350	351.4056	404.157	0.00	0.08	0.08
360	361.4458	415.7044	0.00	0.15	0.15
365	366.4659	421.4781	0.00	0.20	0.20
370	371.4859	427.2517	0.01	0.26	0.25
375	376.506	433.0254	0.01	0.32	0.31
380	381.5261	438.7991	0.02	0.39	0.38
385	386.5462	444.5727	0.02	0.47	0.44
390	391.5663	450.3464	0.03	0.54	0.51
400	401.6064	461.8938	0.07	0.69	0.62
410	411.6466	473.4411	0.12	0.81	0.68
420	421.6867	484.9885	0.20	0.89	0.69
425	426.7068	490.7621	0.25	0.92	0.67
430	431.7269	496.5358	0.31	0.95	0.64
435	436.747	502.3095	0.37	0.96	0.60
440	441.7671	508.0831	0.43	0.98	0.55
460	461.8474	531.1778	0.69	1.00	0.31
470	471.8876	542.7252	0.79	1.00	0.21
480	481.9277	554.2725	0.87	1.00	0.13
490	491.9679	565.8199	0.93	1.00	0.07
500	502.008	577.3672	0.96	1.00	0.04
510	512.0482	588.9145	0.98	1.00	0.02
520	522.0884	600.4619	0.99	1.00	0.01
530	532.1285	612.0092	1.00	1.00	0.00
540	542.1687	623.5566	1.00	1.00	0.00
550	552.2088	635.1039	1.00	1.00	0.00
560	562.249	646.6513	1.00	1.00	0.00
570	572.2892	658.1986	1.00	1.00	0.00

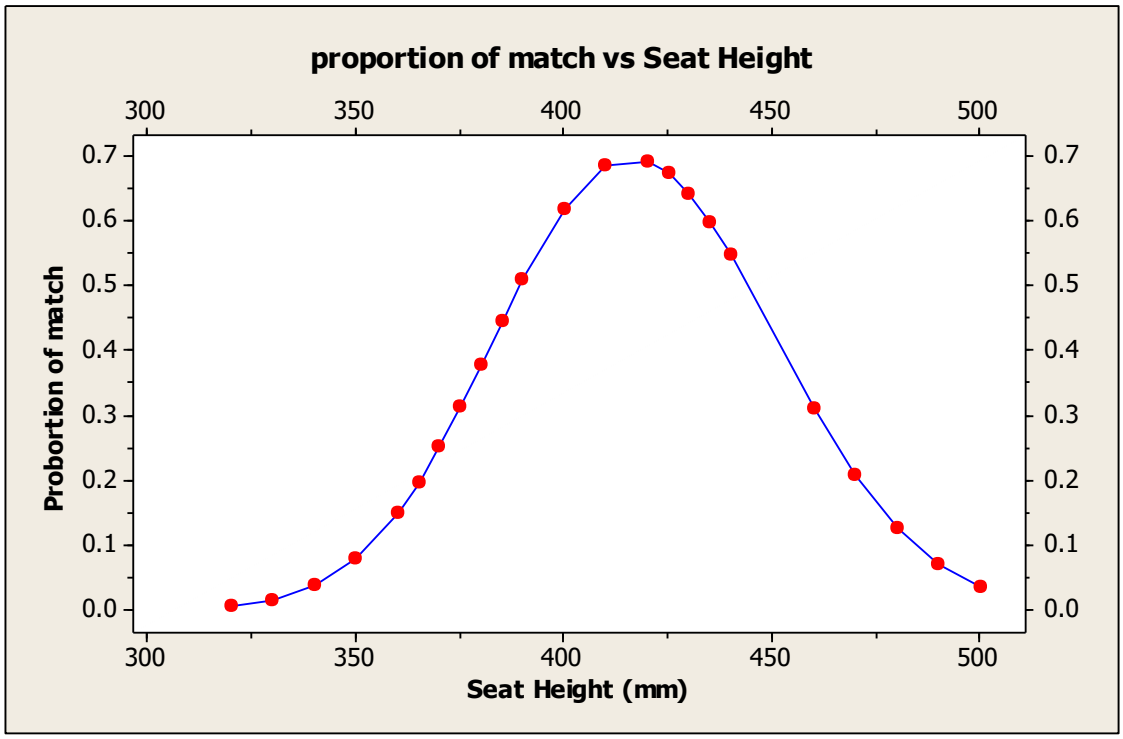

Figure 5.2a: Matching Proportion of Different Seat Height with Male Students

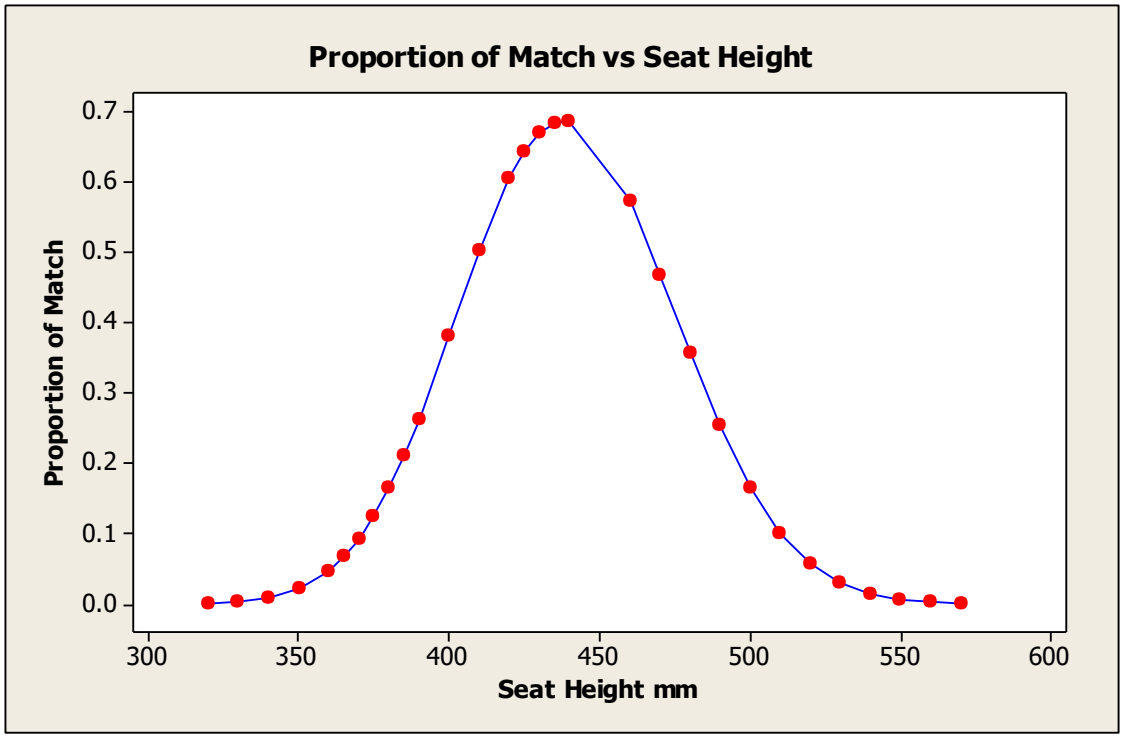

Figure 5.2b: Matching Proportion of Different Seat Height with Female Students

- **Seat Depth (SD)**

The most scientists suggested SD ought to be intended for the tenth percentile, of BPL appropriation, the shorter user was included (Gouvali, 2006). SD should not be less than 5cm shorter than BPL (Poulkakis and Marmaras, 1998). but (Parcells, 1999) suggested the mismatch for the situation when SD is between 80% and 95% of BPL, equation (5-2) gives us:

$0.80\ \text{BPL} \leq \text{SD} \leq\ 0.95\ \text{BPL}$

The matching proportion of the male and female students and SD can be calculated:

$\text{SD}\ >\ 0.8\text{BPL}\,,\text{SD}\ <\ 0.95\text{BPL}$

Then, $\frac{\text{SD}}{0.95} \leq \text{BP} \leq \frac{\text{SD}}{0.80}$

Table 5.5: Mean and Standard Deviation for Buttock-to-Popliteal Length for Students

Body Dimension	**μ (mm)**	**Ϭ (mm)**
Male Buttock-popliteal Length (BP)	502.45	40.70
Female Buttock-to-Popliteal Length(BP)	475.32	37.001

Along these lines, students whose body measurement of BP are somewhere around 457.9 and 543.8 mm they matching the ebb and flow seat depth with 70.8% of male students and 65% of female students. On the off chance that we process the extent at various seat depth as appeared in figure (5-3) and appendix table (B-6) and (B-7) we see that, the most extreme extent of match populace is 71.1% of male students when the seat depth is 440 mm and 73% of female students when the seat depth is 420 mm.

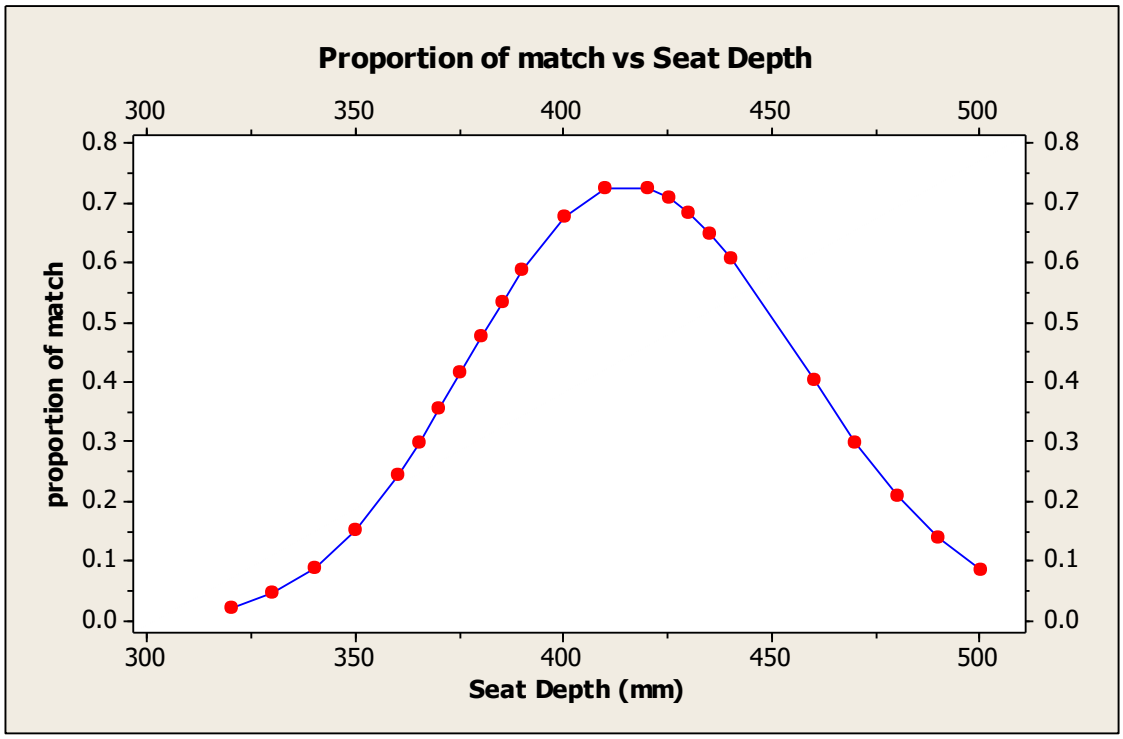

Figure 5.3a: Matching Proportion of Different Seat Depth with Male Students

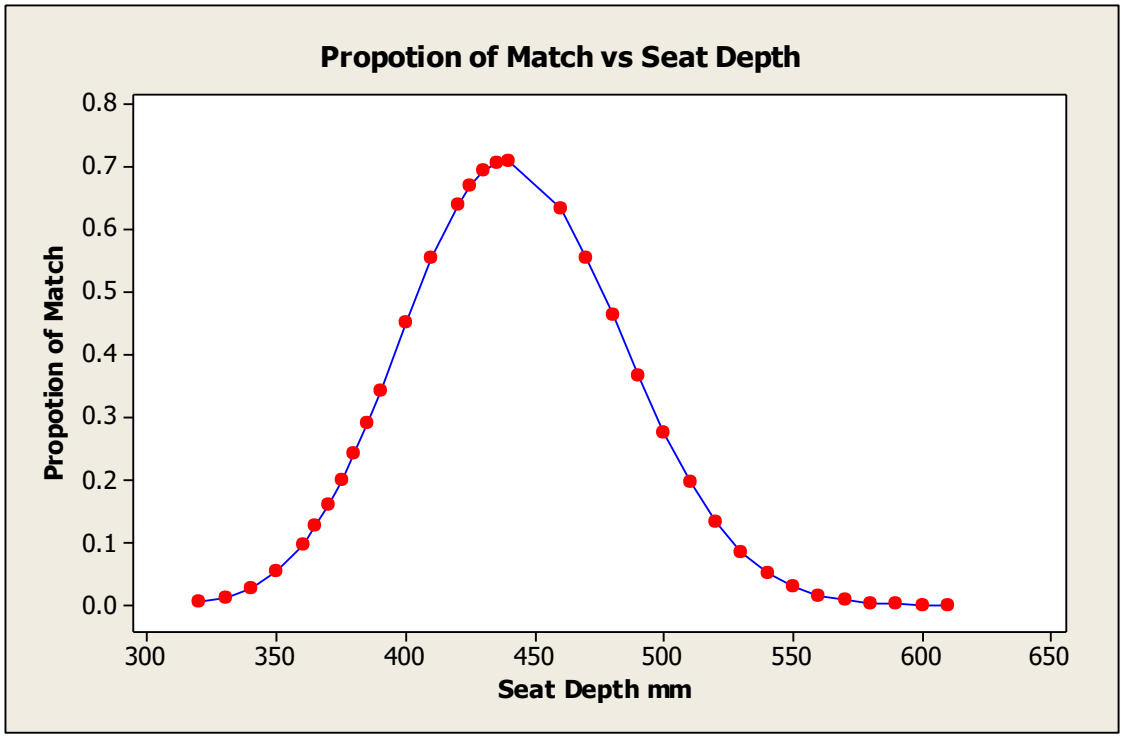

Figure 5.3b: Matching Proportion of Different Seat Depth with Female Students

- **Seat Width (SW)**

(Gouvali, 2006) said "the seat width ought to be sufficiently expansive to permit space for side development", therefore, equation (5-3) gives us:

$1.1\mathrm{HW} \leq \mathrm{SW} \leq 1.3\mathrm{HW}$

The matching proportion for any SW = $\mathrm{P}(\frac{(\frac{\mathrm{SW}}{1.3})-\mu}{\sigma} \leq \frac{\mathrm{HW}-\mu}{\sigma} \leq \frac{(\frac{\mathrm{SW}}{1.1})-\mu}{\sigma})$

By and by utilize the same systems to discover the extent of matching the seat width along these lines, with ref to the Table (B-10) and (B-11) and figure (B-4) and (B-5) in Appendix B we found the most extreme rate of matching for male is 58.4 % when SW is 480mm and greatest rate of matching for female is 55.3% when SW is 490mm.

- **Backrest Height (BH)**

(Gouvali, 2006) suggested that tha back rest height should be between 60% and 80% of shoulder height. From equation (5-4),

$0.6\,\mathrm{SDH} \leq \mathrm{BH} \leq 0.8$

Then, $\mathrm{BH} \leq 0.8\,\mathrm{SDH}$, $\mathrm{BH} \geq 0.6\,\mathrm{SDH}$

So, $\frac{\mathrm{BH}}{0.8} \leq \mathrm{SDH} \leq \frac{\mathrm{BH}}{0.6}$

from the Table(B-8) and (B-9) and figure (B-2) and (B-3) in Appendix B the most extreme extent of match populace is 99.2% when the backrest height is 390mm for male and greatest extent of match populace is 98.8% when backrest height is 365mm for female.

5.4.2 Table Height (TH) Design

As individuals with various heights perform diverse undertakings, the three sorts of table ought to be intended to minimize upsetting stance. To assess the extent of

matching of students' table height (TH), we will consider the same strategies that we utilized matching seat height with students. Table (5-1) showed us the present TH for individual table, long table, and PC table are 730,760 and 740mm separately. We can see from equation (2-6) which was for TH:

$$EH + \cos 30° PH < TH < \cos 5° PH + 0.852\ EH + 0.148 SDH$$

Then, If we let $ES = 0.853EH + 0.148\ SDH$ (5-7)

$$EH < TH - 0.866PH \quad (5\text{-}8)$$

And from (5-7) and (2-6),

$$ES > TH - 0.996PH \quad (5\text{-}9)$$

PH is SH which is 400mm.

- **Individual Table**

EH< 730 - (0.866*400)

EH< 383.6mm.

TH< 0.996PH +ES,

ES > 730 - (0.996*400)

ES > 331.6mm.

When we calculate this for the remaining types of tables then,

- **Long Table**

EH < 413.6mm.

ES > 361.6mm.

- **Computer Table**

EH < 393.6mm.

ES > 341.6mm.

The equations above showed us the matching proportion of students with current TH (individual, long, and PC) are 100% for male and female students (for sitting elbow height under 383.6, 413.6 and 393.6 mm separately, in any case, the rate of students who fit to the present table height (individual, long and PC) are 0% for all students as we see in Table (5-7) and figure (5-4).

Equations (5-8) and (5-9) gave us the matching ratio at various TH.

The proportion of the EH at different table height (male) = $p(z \leq \frac{(TH-346.4)-226.37}{28.20})$

and the proportion of ES at different table height (male) = $p(z \geq \frac{(TH-398.4)-277.4}{27.27})$.

The proportion of the EH at different table height (female) = $p(z \leq \frac{(TH-346.4)-228.18}{29.56})$

and the proportion of ES at different table height (female) = $p(z \geq \frac{(TH-398.4)-273.6}{28.28})$.

Table 5.6: EH and ES Measures for Students

Body dimension	**Mean (mm)**	**Standard Deviation(mm)**
Male Elbow Sitting Height (EH)	226.37	28.20
Male (ES)	277.4	27.27
Female Elbow Sitting Height (EH)	228.18	29.56
Female (ES)	273.6	28.28

As we find in the Table (5-7) in the event that we change the table height from 730,760mm and 740 to 630mm for male students, we will discover the extent of match is 97.9% when EH is under 283.6mm. The extent of match is 95.4% when ES is more prominent than 231.6mm. On the off chance that we change the table height from 730, 760 and 740mm to 630mm for female students, we will discover the extent

of match is 96.9% when EH is under 283.6mm. The extent of match is 93.1% when ES is more noteworthy than 231.6mm. Therefore we can get the greatest purpose matching ratio which is 99% at that comes from intersection of two bends (ES and EH) when table height is 630mm for male and female students, figure (5-4) below shows us the optimal matching proportion of TH.

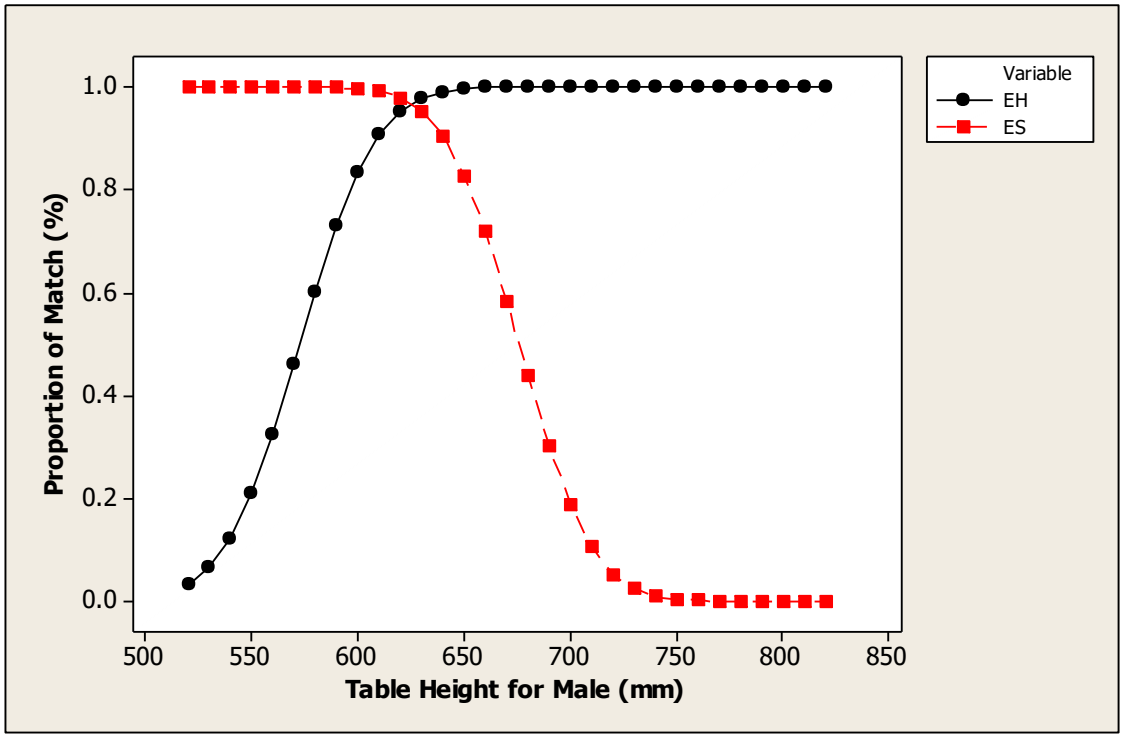

Figure 5.4a: Matching Proportion of Different Table Height with Male Students.

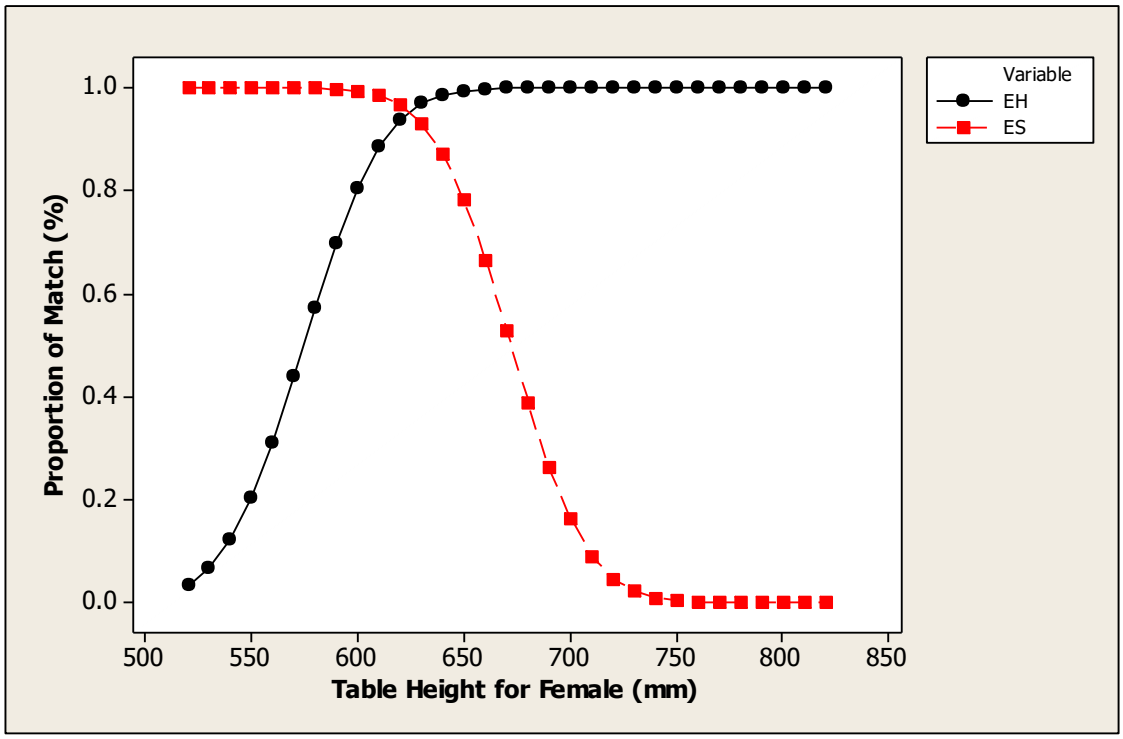

Figure 5.4b: Matching Proportion of Different Table Height with Female Students.

Table 5.7a: Different Table Height Matching Proportion of with Male Students

Table Height	EH≤TH-346.4	ES≥TH-398.4	Prob 1	Prob2	Probability
560	213.6	161.6	0.325333	1.09E-05	0.9999891
570	223.6	171.6	0.460876	5.23E-05	0.9999477
580	233.6	181.6	0.601172	0.000222	0.9997785
590	243.6	191.6	0.729398	0.000827	0.9991733
600	253.6	201.6	0.832879	0.002721	0.9972788
610	263.6	211.6	0.906618	0.007913	0.9920871
620	273.6	221.6	0.953015	0.020368	0.9796319
630	283.6	231.6	0.978793	0.046527	0.9534728
640	293.6	241.6	0.991438	0.094626	0.9053745
650	303.6	251.6	0.996915	0.17205	0.8279498
660	313.6	261.6	0.99901	0.281163	0.7188374
670	323.6	271.6	0.999717	0.415785	0.5842148
680	333.6	281.6	0.999928	0.561201	0.4387988
690	343.6	291.6	0.999984	0.698719	0.3012814
700	353.6	301.6	0.999997	0.812574	0.1874259
710	363.6	311.6	0.999999	0.895102	0.1048982
720	373.6	321.6	1	0.947473	0.0525272
730	383.6	331.6	1	0.976568	0.0234317
740	393.6	341.6	1	0.99072	0.0092804
750	403.6	351.6	1	0.996745	0.0032548
760	413.6	361.6	1	0.998991	0.0010088

Table 5.7b: Different Table Height Matching Proportion of with Female Students

Table Height	EH≤TH-346.4	ES≥TH-398.4	Prob 1	Prob2	Probability
560	213.6	161.6	0.325333	1.09E-05	0.9999891
570	223.6	171.6	0.460876	5.23E-05	0.9999477
580	233.6	181.6	0.601172	0.000222	0.9997785
590	243.6	191.6	0.729398	0.000827	0.9991733
600	253.6	201.6	0.832879	0.002721	0.9972788
610	263.6	211.6	0.906618	0.007913	0.9920871
620	273.6	221.6	0.953015	0.020368	0.9796319
630	283.6	231.6	0.978793	0.046527	0.9534728
640	293.6	241.6	0.991438	0.094626	0.9053745
650	303.6	251.6	0.996915	0.17205	0.8279498
660	313.6	261.6	0.99901	0.281163	0.7188374
670	323.6	271.6	0.999717	0.415785	0.5842148
680	333.6	281.6	0.999928	0.561201	0.4387988
690	343.6	291.6	0.999984	0.698719	0.3012814
700	353.6	301.6	0.999997	0.812574	0.1874259
710	363.6	311.6	0.999999	0.895102	0.1048982
720	373.6	321.6	1	0.947473	0.0525272
730	383.6	331.6	1	0.976568	0.0234317
740	393.6	341.6	1	0.99072	0.0092804
750	403.6	351.6	1	0.996745	0.0032548
760	413.6	361.6	1	0.998991	0.0010088

- **Underneath Table**

"The table clearance ought to be not less than 20mm"(Parcells, 1999). (Corlett and Clark, 1995) said "this space ought to be given to permit to knee of specialists intersection and feel more good". Subsequently, (Gouvali, 2006) said "the table-knee clearance should be surpassed by 20mm". Equation (5-6) showed us

$$UD \geq 20 + KH$$

Then, $$KH \leq UD - 20 \quad (5\text{-}9)$$

We can see the current clearance of table for three types (Individual, Long, and Computer) of table are 710, 670 and 710mm respectively as shown in Table (5-1).

From (5-9) then with respect the lowest clearance 670mm

Knee height ≤ 670-20 ≤650mm.

Hence, KH ≤ 650 mm.

The number of inhabitants in students (male or female) whose body measurement matches with current most minimal clearance (670mm) is the populace whose KH is under 650mm. The most extreme extent of match is found at 99.5% when the table clearance 670mm. See Table (5-8) and figure (5-5). However, the table clearance must be changed in accordance with 600mm to be lower than the new height of the table by 30mm.

Table 5.8a: Underneath Matching Proportion of Male Students with Table Height

TH	UD-20	Probability
490	470	0.002871026
500	480	0.006839218
510	490	0.015039856
520	500	0.030570166
530	510	0.057522197
540	520	0.100385257
550	530	0.162853058
560	540	0.246281009
570	550	0.348386699
580	560	0.46290419
590	570	0.580604468
600	580	0.691462461
610	590	0.787146664
620	600	0.8628294
630	610	0.917686921
640	620	0.954125172
650	630	0.976305086
660	640	0.988677146
670	650	0.995001302
680	660	0.997963676
690	670	0.999235281
700	680	0.999735474
710	690	0.999915774

Table 5.8b: Underneath Matching Proportion of Female Students with Table Height

TH	Underneath-20	Probability
490	470	0.0712665
500	480	0.124713924
510	490	0.201280241
520	500	0.300704988
530	510	0.417735179
540	520	0.542602439
550	530	0.663369009
560	540	0.769243719
570	550	0.853380258
580	560	0.913987308
590	570	0.953561003
600	580	0.976983519
610	590	0.989549667
620	600	0.99566064
630	610	0.99835438
640	620	0.999430685
650	630	0.999820489
660	640	0.999948452
670	650	0.999986528
680	660	0.999996797
690	670	0.999999308
700	680	0.999999864
710	690	0.999999976

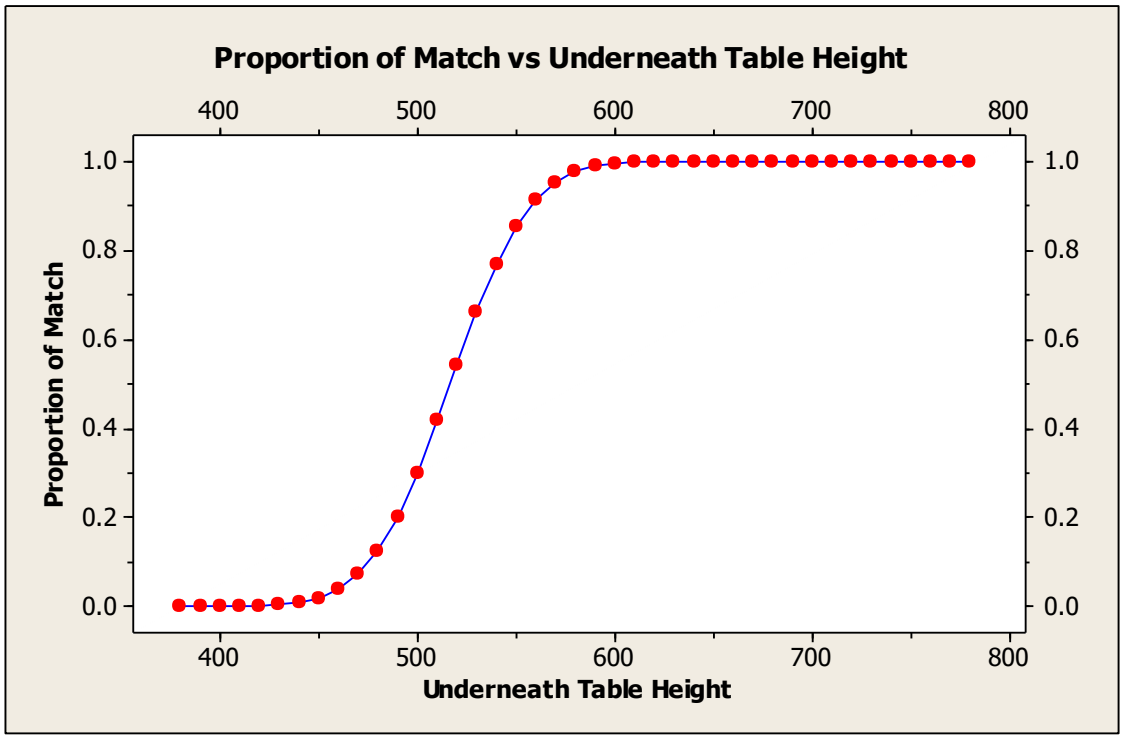

Figure 5.5a: The Optimal Proportion of Match Population Table Clearance (male).

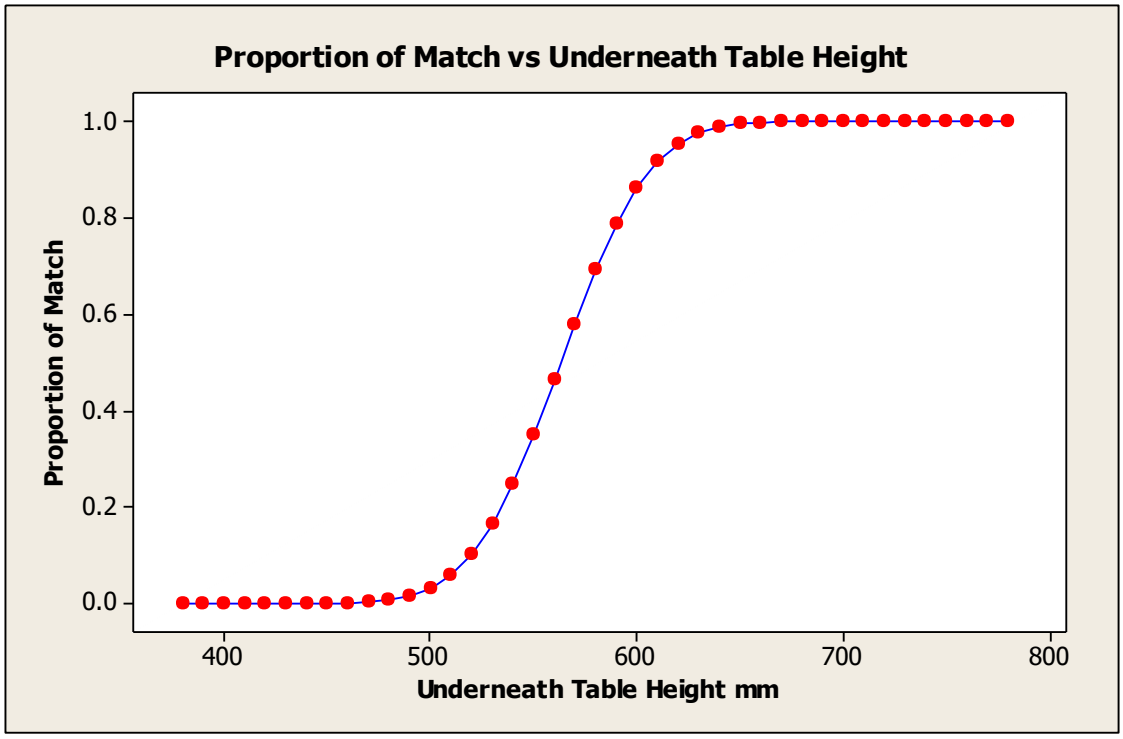

Figure 5.5b: The Optimal Proportion of Match Population Table Clearance (female).

Accordingly, the seat and table measurements for male understudies, by this strategy, ought to be as taking after Table (5-9):

Table 5.9: Optimal Dimensions of Library Furniture for Male Students

Item	**Dimension (mm)**
Seat Height	440
Seat Depth	440
Seat Width	480
Backrest Height	390
Table Height	630

On the other hand, the chair and table dimension for female students, by this technique, should be as following Table (5-10):

Table 5.10: Optimal Dimensions of Library Furniture for Female Students

Item	**Dimension (mm)**
Seat Height	420
Seat Depth	420
Seat Width	490
Backrest Height	365
Table Height	630

The mismatch for male and female students from this method was recorded as following Table (5-11):

Table 5.11: Mismatch Result after Optimization Technique

Mismatch	**Male**	**Female**
Between popliteal height and SH for old chair	35%	35%
Between buttock-to-Popliteal Length and Seat depth	32.9%	28%
Between hip width and seat width	43.3%	49%
Between sitting elbow height and table height	1%	0%

5.5 Percentage of Mismatch for New Chair (Adjustable)

I. Height of Seat

We can design the SH and customize it from range of 407.74mm to 512.55mm. We took 10th percentile of female students' PH to know about this range from Table (B-2) in appendix B and 90th percentile of male students' PH from Table (B-4) in appendix B. The students can put their feet on the floor in this SH range. The mismatch ratio of new SH will be decreased from 35% - 2% for male students and from 35% - 10% for female students; we can summarize the mismatch ratio of old and new SH in Table (5-12).

Table 5.12: Old and New SH Mismatch Ratio

Mismatch Between	**Male**	**Female**
Popliteal Height and old Seat Height	35%	35%
Popliteal Height and New Seat Height	2%	10%

II. Arm-support Seat

We can design the arm-support seat height as 227.28mm.We took the measurement from average EH of all students which were in Table (5-2) because; there is no contrast between different gender students' EH which can be seen in table (5-2).

Thus, students' wrist will be set level in plane as the lower forearm and the same on the table.

III. Seat Backrest

Figure (5-6) show us that the backrest seat height in library is very low.

Figure5.6: Sample of EMU Library chair

Equation (5-4) gives us the most extreme backrest height,

$$\text{Maximum Backrest} = 0.8 * \text{SDH} = 0.8 * 660 = 528\text{mm}.$$

We took SDH estimation value from the most extreme SDH of male students in table (5-2). The most minimal backrest was computed from the thigh clearance, we can see table (B-8) and (B-9). If we subtract 10th percentile of female PH from 90th percentile of male KH, then we found tight clearance: Thigh clearance = 606.39–475.6 = 130.79mm. The lower back will be more comfort with this clearance.

IV. Depth of Chair

We designed SD to the tenth percentile of female's BPL, to be suitable for short users. Along these lines, we took the 10th percentile of females' BPL which is

427.58mm shown in Table (B-6) and (B-7) in appendix B, then substituted it in equation (5-2).

$$\text{Maximum SD} = 0.95 * \text{BP} = 0.95 * 427.58 \text{ mm}.$$

Table 5.13: Old and New SD Mismatch ratio

Mismatch Between	**Female**	**Male**
Buttock-to-popliteal Length (BPL) and Seat Depth (SD) of current chair	28%	32.9%
Buttock-to-popliteal Length (BPL) and Seat Depth (SD) of New chair	22.8%	11.3%

Subsequently, the mismatch will be diminished from 32.9% to 11.3% for male and from 28% to 22.8% for female students. Also, we will get the same results on the off chance that we are outlined by as takes after. Consequently the best SD is 406.2mm, because of the mismatch was decrease and fit for all students.

V. Width of Chair

We took the most extreme HW for all students which is 520mm in Table (5-2) to design the width of chair, this estimation reduced the mismatch for male and female students from 49% and 43.3% to 5.2% and 4% respectively as shown in Table (5.14).

Table 5.14: HW and SW Mismatch

Mismatch Between	**Female**	**Male**
Hip Width (HW) and old Seat Width (SW)	49%	43.3%
Hip Width (HW) and new Seat Width (SW)	5.2%	4%

As a result from our small questionnaire which were distributed to the students on library we found, more than 66% of students they didn't prefer the adjustable chairs, on the other hand 80% of them prefer arm-support for chairs. Most of students they have pain when they stayed long time in Library. We found more than 45% of students they have problems with lighting (some tables have not enough light); furthermore, we need to improve the light system.

5.6 Illumination

Any work place needs a light to complete job. The light in a library must be adequate for the user to see a particular task, usually reading a book or the text on a computer screen. The first requirement is then for enough light energy, or lumens, distributed over the area of the page or the screen so that the information can be readable. In this section we want to improve the light system of EMU Library by using standard Illumination with furniture, we measured the illumination level for every table by using lux meter two times (day and night) in second floor of EMU Library. There are 141 tables; we evaluated which tables need more amount of light to avoid the strain in muscles of their eyes or headache or fatigue.

Libraries form a space for self-study and group work through both concentration and relaxation. In addition to proper task and shelf lighting, the atmosphere needs to be welcoming. Natural light and daylight create a pleasant study environment. The library is a meeting place where social zones require a cozier light setting. To mix artificial light with daylight and coordinate this with blinds is a challenging task that requires careful light management, but the effect may ensure a friendly and comfortable atmosphere for reading and working (Glamox Luxo Lighting Ltd, 2012).

Reading areas, on the other hand needs a good working light. The minimum average luminance should be 500 lux with a high uniformity and low glare. Indirect-direct luminaires create a uniform light that improve the work environment. To allow for greater flexibility and allow for individual needs, a task light for each reading station is recommended in Table (5-15).

Table 5.15: Library Lighting Requirement

Type of area, task or activity	**Lux-level**
Library: bookshelves	200
Library: reading areas	500

(U.S. General Services Administration, 2015) mentioned the standards illumination level in interior lighting, and the illumination level in average must be more than 500 lux/m^2 in any reading or conference area. Figure (5-7) show us top view for second floor of EMU Library.

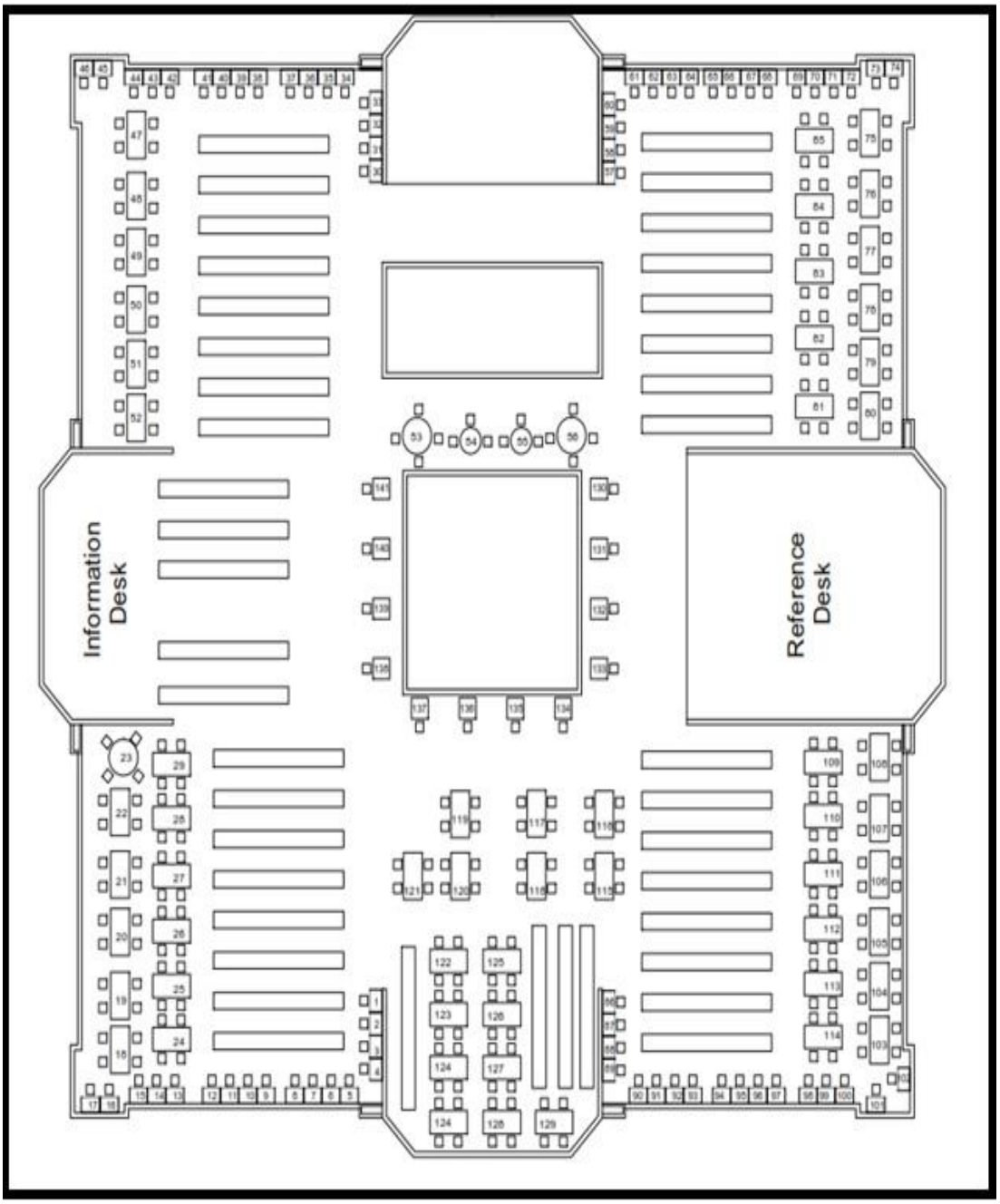

Figure 5.7: Top View for Second floor EMU Library with Table Numbering

After measuring the illumination level for all individual, long, and computer tables, Table (5-16) and Table (5-17) illustrate the illumination level in each table during (Day and Night). The first measure was at 10AM then the second was at 10PM.

Table 5.16: Illumination Level for Tables in EMU Library (Day).

Table Number	Illumination level	Table Number	Illumination level	Table Number	Illumination level	Table Number	Illumination level
1	230	37	865	73	280	109	990
2	300	38	870	74	260	110	1215
3	650	39	890	75	1420	111	1440
4	1090	40	1070	76	2200	112	1680
5	640	41	970	77	1900	113	2170
6	1065	42	1620	78	2100	114	3050
7	1240	43	1750	79	1950	115	350
8	1300	44	1780	80	1250	116	335
9	1620	45	820	81	3000	117	335
10	1580	46	630	82	5900	118	452
11	1570	47	5400	83	2130	119	400
12	1550	48	4200	84	2050	120	445
13	1980	49	2900	85	2300	121	410
14	1960	50	3850	86	300	122	250
15	1845	51	3800	87	470	123	365
16	430	52	3000	88	820	124	475
17	350	53	1500	89	1170	125	675
18	2370	54	2350	90	880	126	570
19	4500	55	2700	91	1280	127	510
20	8300	56	1500	92	1250	128	370
21	4800	57	220	93	1280	129	250
22	2900	58	390	94	1600	130	500
23	2000	59	530	95	1540	131	8050
24	4100	60	595	96	1550	132	6250
25	3370	61	560	97	1550	133	6250
26	4470	62	760	98	1753	134	5200
27	4500	63	890	99	1720	135	1440
28	3750	64	820	100	1540	136	1345
29	3410	65	965	101	500	137	1230
30	230	66	955	102	370	138	1920
31	370	67	1045	103	1750	139	1960
32	545	68	1030	104	2250	140	1885
33	820	69	985	105	2100	141	1720
34	700	70	970	106	1950		
35	820	71	855	107	1700		
36	925	72	360	108	990		

Table 5.17: Illumination Level for Tables in EMU Library (Night)

Table Number	Illumination level	Table Number	Illumination level	Table Number	Illumination level	Table Number	Illumination level
1	50	37	60	73	35	109	150
2	70	38	87	74	130	110	160
3	60	39	105	75	150	111	175
4	90	40	115	76	130	112	170
5	90	41	100	77	100	113	200
6	102	42	95	78	80	114	270
7	100	43	100	79	80	115	310
8	85	44	95	80	96	116	125
9	105	45	70	81	115	117	340
10	110	46	35	82	120	118	300
11	100	47	120	83	145	119	145
12	80	48	115	84	190	120	300
13	80	49	145	85	70	121	155
14	65	50	130	86	70	122	300
15	70	51	120	87	80	123	230
16	32	52	120	88	90	124	75
17	30	53	225	89	100	125	60
18	92	54	260	90	105	126	192
19	112	55	270	91	100	127	215
20	135	56	260	92	70	128	160
21	140	57	50	93	120	129	80
22	110	58	90	94	130	130	200
23	100	59	115	95	135	131	220
24	130	60	120	96	115	132	215
25	115	61	130	97	100	133	150
26	135	62	120	98	100	134	180
27	150	63	125	99	95	135	200
28	125	64	100	100	80	136	200
29	100	65	110	101	20	137	200
30	60	66	135	102	110	138	170
31	67	67	140	103	140	139	180
32	50	68	90	104	165	140	200
33	50	69	110	105	150	141	200
34	60	70	110	106	115		
35	55	71	100	107	110		
36	70	72	75	108	135		

From Tables above, we can tell that some tables need more light to be comfort for students. It was better for reading or studying during day shift than night shift, as we can see from Table (5-16) there are 26 out of 141 tables which have less than 500 lux and need more light during day shift, however, from Table (5-17) we can see that the Light is not suitable for students to study or reading for long time in all tables during night shift. So, we suggested improving the light system in Library to avoid any fatigue or the strain in muscles of their eyes by adding more artificial light sources above the tables.

Chapter 6

DISCUSSION AND CONCLUSION

We Can Summarize Our Work and Recommendations as Follow:

We realize that the bodies of male and female students are different. So, we determined the anthropometric measures and mismatch between their bodies and furniture separately. Along these lines, we can follow two strategies to get the best ratio of matching for both genders.

The present heights of tables in library are more than required and this can cause the strain in muscles and focus reduction during reading or studying because of the edge upper and lower arm was more than 90°.

The mismatch proportion between female's sitting elbow height and each type of tables was higher than male mismatch ratio. Therefore, we decided to design the three type of tables (individual, long, and computer) with unique height 630mm to reduce the mismatch from 84.2%, 96.5% and 89.5% to 2.1% for female students and 73.2%, 89.7% and 80.4% to 1.5% for male students. The result showed us that no need for table adjustability.

We proposed chair adjustability to get an optimal mismatch reduction, therefore, when we suggest the chair height range from 407mm to 512mm, we found the

mismatch was reduced from 40.4% and 55.7% to 10% and 2% for female and male students respectively.

It is conceivable to exploit lighting in current furniture in library since it might bring about the strain in muscles of students' eyes, headache or fatigue. Therefore we evaluate the illumination level of every table in second floor of library, and we found that we need to improve the lighting system by adding more lighting sources to some tables.

Further Study can be done

- Assessing the safety factors of fire system and electricity installation.
- A study to give the agreeable ecological conditions in library for students, and to persuade them to study and work productively. Case in point, temperature, noise, humidity and sound impacts, to build inspiration of student to focus and give careful consideration to the perusing or concentrating on, as per Ergonomic Principles of Design.
- Extending this to consider other floors and sections of EMU Library.

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APPENDICES

Appendix A: Anthropometric Measures of Eastern Mediterranean University Students

Table A.1: Anthropometric Measures of Fifty Students in mm.

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
1	F	15701089	17	85	169	535	355	485	455	533	450	400	230	780	685	1985	275
2	F	143145	19	97	176	600	415	550	502	590	500	505	290	850	740	2200	336
3	M	81793	25	73	175	545	326	451	441	510	459	372	219	858	769	2194	267
4	F	115351	31	65	148	472	358	420	385	448	390	368	215	680	610	1802	253
5	M	15700484	20	70	174	575	400	550	473	592	518	390	215	810	685	2260	268
6	M	138507	21	81	186	575	391	540	580	610	523	401	210	840	715	2390	264
7	F	139154	21	35	150	480	339	430	486	505	440	340	200	730	635	1850	242
8	M	15500360	29	91	179	567	400	500	490	585	486	470	215	850	780	2330	267
9	M	15500438	27	71	176	584	385	485	447	560	480	380	250	830	720	2200	300
10	M	143186	21	55	172	570	388	538	473	550	490	400	255	805	695	2065	302
11	F	71273	27	58	168	530	302	454	434	491	430	381	228	792	707	2060	273
12	F	47974	31	56	179	547	347	453	451	524	465	443	195	690	794	2203	247
13	M	148783	20	83	177	563	362	482	428	545	465	410	205	820	705	2311	258
14	M	117725	23	81	174	568	360	520	460	565	481	435	230	795	720	2140	280
15	F	118631	25	52	170	521	320	477	443	508	460	325	201	780	695	2086	249
16	M	147354	20	69	179	550	370	472	452	485	460	360	175	800	695	2210	231

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
17	M	148251	20	62	176	550	367	455	460	543	455	360	225	830	730	2185	273
18	F	128587	27	46	160	520	360	540	475	470	460	400	210	765	645	1975	256
19	F	140092	20	63	173	557	405	515	500	575	490	380	234	835	715	2115	282
20	F	15700836	18	59	166	536	365	505	461	549	473	400	215	800	685	2050	263
21	M	72381	26	84	177	544	336	448	431	549	487	363	208	896	804	2221	258
22	M	148565	20	65	176	585	405	520	500	585	510	386	240	870	730	2220	291
23	F	141517	22	58	162	530	370	525	497	527	450	430	210	790	690	1995	258
24	F	127365	24	65	164	585	390	530	490	535	490	465	265	725	735	2010	313
25	M	15701129	17	66	181	546	310	525	517	590	532	345	205	825	701	2250	256
26	M	137579	20	111	183	635	415	537	527	600	525	500	227	910	815	2340	288
27	F	148467	20	56	158	510	358	505	465	505	445	420	205	780	685	1940	250
28	M	148315	20	68	174	558	410	547	485	580	530	440	205	830	725	2190	257
29	M	138948	21	64	182	580	400	535	505	580	522	354	235	860	760	2300	286
30	M	105493	30	69	180	562	345	496	460	536	495	369	217	844	745	2261	268
31	F	51323	27	65	162	512	285	449	420	486	435	423	236	751	666	1983	277
32	M	145596	24	78	176	550	377	501	450	565	490	395	190	790	685	2210	243

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
33	M	143589	20	75	185	600	420	530	540	605	540	425	225	850	740	2300	281
34	M	138061	22	75	182	627	430	593	492	608	530	425	270	885	795	2280	323
35	F	115670	31	54	162	508	295	442	412	480	470	335	213	766	681	1983	257
36	F	89712	22	71	174	545	334	481	415	562	470	406	195	844	760	2138	247
37	F	72392	27	75	176	572	313	463	432	524	455	452	260	860	769	2164	306
38	F	118429	23	54	170	513	311	452	433	512	445	380	202	815	716	2086	248
39	F	15700462	17	44	155	495	370	475	470	505	452	355	190	735	635	1940	235
40	M	148535	20	75	177	585	385	480	450	570	480	407	215	840	735	2230	270
41	M	127692	21	62	176	530	360	525	475	570	520	372	195	790	700	2210	245
42	M	144883	19	90	183	570	422	593	510	620	521	445	200	845	715	2230	255
43	M	137653	21	92	170	587	362	495	465	560	480	440	270	840	725	2090	317
44	F	118610	21	56	161	490	292	435	417	502	435	357	195	758	664	1970	239
45	M	15500369	23	93	178	575	387	505	503	585	515	440	220	870	790	2270	273
46	M	128519	22	94	170	550	370	500	490	590	510	400	240	810	695	2115	286
47	M	133394	21	76	189	625	435	565	517	608	528	400	243	920	785	2385	300
48	M	137794	21	78	174	535	370	443	473	566	487	400	233	770	690	2230	278

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
49	F	147953	18	65	169	524	365	485	465	525	443	415	205	780	685	1980	252
50	M	147184	20	72	180	595	390	495	485	594	493	390	255	845	730	2180	306
51	M	147470	22	80	181	595	375	525	500	600	531	390	265	820	725	2245	314
52	M	148059	20	75	171	534	380	491	460	560	472	362	185	835	740	2160	237
53	M	71242	28	85	177	558	333	466	448	506	467	374	225	856	768	2221	275
54	M	89603	35	82	168	530	317	439	408	503	455	367	213	833	751	2099	260
55	M	147183	20	75	181	595	422	523	490	630	531	394	225	855	735	2210	280
56	M	148014	20	75	177	550	390	474	430	550	465	370	205	823	725	2251	256
57	M	138817	20	73	170	580	360	560	463	535	470	400	255	840	700	2040	303
58	F	72396	28	98	168	527	268	461	426	510	431	467	241	793	708	2060	284
59	M	139127	20	61	174	565	370	530	485	580	505	390	270	860	735	2140	314
60	F	81783	25	59	168	528	307	451	433	510	425	385	221	796	698	2060	267
61	M	144631	24	78	178	520	360	450	422	530	475	408	240	805	748	2381	282
62	F	71223	25	57	174	547	313	467	439	523	450	352	235	834	747	2138	281
63	M	115609	28	63	173	540	329	484	433	526	467	368	211	813	720	2167	260
64	F	115386	30	55	163	506	300	447	423	510	460	355	206	760	668	1996	251

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
65	M	148559	19	77	177	575	420	520	495	588	515	427	195	860	750	2270	251
66	M	148739	20	93	174	600	405	556	465	560	515	450	232	865	765	2170	287
67	M	81773	25	71	171	523	330	460	413	526	465	290	193	837	752	2140	242
68	F	116264	38	64	167	509	317	457	420	502	435	456	197	793	708	2048	243
69	M	15700119	22	61	161	505	318	425	435	520	420	380	195	790	680	2105	241
70	F	81720	28	71	182	579	333	485	461	549	470	462	246	874	772	2242	296
71	M	145074	26	95	194	660	415	543	515	615	540	440	265	930	825	2460	324
72	F	148553	19	45	152	530	360	465	470	485	455	365	180	730	645	1855	232
73	F	81724	30	64	162	517	319	443	419	494	450	412	170	758	673	1983	222
74	F	128334	23	65	153	535	370	545	484	525	475	415	256	750	640	1870	298
75	M	15700639	19	83	189	635	440	600	555	603	525	436	250	910	805	2350	307
76	F	122377	21	55	165	500	340	485	461	518	445	360	301	725	635	1870	331
77	F	115671	35	59	165	518	304	451	427	503	445	425	215	772	678	2022	260
78	M	115169	27	64	170	545	320	452	438	513	447	382	225	810	720	2126	273
79	M	15700833	16	81	177	600	405	547	475	585	505	430	227	785	685	2290	282
80	M	51338	28	90	181	564	327	511	461	528	493	354	237	838	755	2275	286

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
81	F	148505	19	87	155	535	335	475	460	510	470	490	248	760	675	1920	291
82	F	147862	19	67	172	570	400	559	510	580	480	415	210	815	700	2200	263
83	M	127748	22	62	172	580	415	550	510	570	500	440	240	810	705	2070	291
84	M	147574	21	105	171	635	366	520	473	577	520	510	288	880	765	2180	340
85	M	138113	22	72	176	600	405	563	515	600	492	410	240	720	765	2115	294
86	M	149074	26	68	178	560	382	465	440	540	465	355	212	812	725	2350	264
87	F	115532	32	62	155	504	277	429	389	471	453	356	227	732	647	1892	268
88	M	105153	30	81	181	573	343	502	463	547	488	390	230	845	768	2275	281
89	M	15702129	20	67	181	580	370	545	530	595	510	400	240	870	755	2265	291
90	F	138282	22	74	166	560	380	500	457	563	500	450	240	810	659	2130	288
91	F	72379	26	70	171	542	316	488	429	524	450	437	226	793	708	2099	273
92	F	123431	21	44	161	580	395	500	480	545	490	390	255	790	695	2005	303
93	M	15702109	19	64	168	500	335	445	428	495	425	345	155	775	671	2117	206
94	M	148829	21	67	176	610	378	487	475	581	490	405	290	880	775	2190	338
95	F	115779	31	54	151	478	293	400	407	469	410	365	185	700	591	1841	229
96	M	48232	31	72	172	525	308	458	430	527	478	363	217	837	755	2153	263

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
97	F	105008	37	65	162	515	250	431	389	460	420	400	235	800	715	1983	277
98	M	51324	29	74	170	544	328	453	408	508	455	366	216	839	759	2126	265
99	M	118150	28	56	171	537	380	508	470	590	540	390	210	785	695	2145	259
100	M	139345	20	80	178	570	410	533	460	570	506	382	210	830	705	2250	263
101	M	138951	21	94	176	555	395	540	460	565	570	437	185	830	725	2200	240
102	F	145757	35	57	162	543	325	430	455	506	420	400	260	830	720	1935	302
103	M	147343	22	61	174	580	385	505	483	575	500	385	245	845	725	2120	295
104	M	15701056	19	62	181	555	382	485	445	552	470	340	160	805	705	2303	219
105	M	15600056	45	86	177	588	415	595	490	602	535	440	250	825	725	2200	300
106	M	116067	31	77	185	573	371	497	461	535	493	376	202	892	792	2329	257
107	M	142976	22	55	169	530	355	458	450	518	460	340	165	770	660	2190	219
108	F	147710	20	79	163	580	345	480	462	515	450	465	280	830	715	1990	325
109	M	15701717	22	91	183	585	385	517	491	610	492	415	227	860	770	2300	280
110	F	133739	21	47	163	560	370	490	475	540	450	390	245	780	665	1990	292
111	M	115169	26	86	174	563	344	468	432	547	475	420	219	838	755	2180	270
112	M	109518	25	100	181	570	354	518	455	564	502	388	216	837	758	2275	269

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
113	M	147997	19	72	174	585	393	520	475	570	493	405	230	825	715	2160	283
114	M	57268	26	63	171	538	315	449	435	512	450	314	223	826	737	2140	270
115	F	112740	27	60	160	510	261	410	395	462	425	485	249	778	693	1957	288
116	M	15702013	21	61	177	555	400	530	492	595	507	385	210	850	735	2175	261
117	F	47682	22	58	159	505	309	450	407	508	425	392	195	737	646	1944	241
118	F	135555	30	64	165	556	330	480	460	573	477	415	235	750	666	2120	283
119	F	48325	21	54	158	520	317	447	432	511	435	338	209	801	705	1931	255
120	F	47936	28	47	165	545	321	446	422	500	420	349	225	782	684	2022	273
121	M	147045	20	66	175	564	376	475	471	570	480	390	225	820	730	2110	275
122	M	81766	25	85	176	543	309	456	435	544	451	358	234	869	765	2207	280
123	M	15701831	20	64	180	575	385	481	500	585	516	370	220	845	775	2255	273
124	F	147581	18	56	162	527	340	500	415	517	456	310	225	760	670	1980	270
125	F	147603	21	64	168	585	355	490	445	541	460	410	275	835	730	2020	321
126	M	15700995	19	95	180	580	395	545	493	590	525	480	222	890	775	2200	275
127	M	15500727	25	85	170	555	370	443	490	535	460	400	225	820	735	2140	274
128	M	128540	21	81	176	585	426	565	495	605	510	410	215	810	690	2215	270

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
129	M	81762	25	76	182	584	309	470	462	535	498	373	275	893	798	2288	321
130	F	135720	27	52	165	530	372	510	465	540	465	400	218	765	675	2080	264
131	M	15500661	22	93	174	585	380	487	445	545	465	435	225	845	755	2150	279
132	M	137635	21	64	186	635	390	530	503	585	505	380	235	930	825	2330	294
133	F	147258	19	62	152	580	335	450	460	470	420	415	290	810	705	1820	333
134	M	15702210	28	98	180	630	380	520	470	575	505	408	273	895	825	2250	326
135	M	59452	27	75	171	528	339	463	420	518	467	390	189	827	788	2140	239
136	M	115081	30	67	185	576	353	502	465	554	501	354	223	883	788	2329	275
137	M	131075	21	90	187	580	375	491	470	580	518	395	280	842	743	2350	325
138	M	148805	22	84	181	600	395	555	510	650	515	430	260	870	775	2235	311
139	M	71217	27	95	178	552	338	453	452	535	475	397	214	875	785	2234	264
140	F	139162	26	55	154	535	343	490	472	500	460	420	235	780	670	1910	280
141	F	137437	23	59	157	565	380	545	485	545	470	460	265	790	680	1790	310
142	M	15700203	22	90	175	595	360	525	455	545	485	435	280	875	780	2200	327
143	M	47145	28	115	176	564	337	479	437	562	461	447	227	844	768	2207	277
144	F	72390	27	58	163	510	293	445	439	498	435	376	220	746	661	1996	263

Table A.1 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
145	M	15701245	18	61	180	550	360	492	436	546	464	520	210	832	752	2270	261
146	M	148900	22	60	176	540	360	480	460	560	490	330	205	840	725	2220	255
147	M	147764	21	60	160	557	373	515	495	545	503	440	250	780	740	2000	296
148	M	148731	20	79	180	620	410	525	515	608	540	455	280	900	810	2285	331
149	M	89529	25	59	170	541	316	456	443	504	426	337	225	806	730	2126	272
150	M	15500439	28	90	174	575	380	447	450	555	472	455	271	840	745	2130	316
151	M	139572	21	65	173	515	348	440	435	510	441	342	170	740	648	2230	221
152	F	15500216	24	62	164	590	400	530	440	568	440	460	275	820	705	2005	322
153	F	148577	24	62	164	510	340	490	462	545	458	420	217	770	685	2020	261
154	M	147680	20	67	180	575	355	450	475	575	475	347	240	890	790	2350	290

Table A.2: Anthropometric Measures of Male Students in mm.

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
1	M	148731	20	79	180	620	410	525	515	608	540	455	280	900	810	2285	331
2	M	148783	20	83	177	563	362	482	428	545	465	410	205	820	705	2311	258
3	M	15701245	18	61	180	550	360	492	436	546	464	520	210	832	752	2270	261
4	M	148014	20	75	177	550	390	474	430	550	465	370	205	823	725	2251	256
5	M	15701056	19	62	181	555	382	485	445	552	470	340	160	805	705	2303	219
6	M	144631	24	78	178	520	360	450	422	530	475	408	240	805	748	2381	282
7	M	15702109	19	64	168	500	335	445	428	495	425	345	155	775	671	2117	206
8	M	149074	26	68	178	560	382	465	440	540	465	355	212	812	725	2350	264
9	M	139572	21	65	173	515	348	440	435	510	441	342	170	740	648	2230	221
10	M	137794	21	78	174	535	370	443	473	566	487	400	233	770	690	2230	278
11	M	131075	21	90	187	580	375	491	470	580	518	395	280	842	743	2350	325
12	M	142976	22	55	169	530	355	458	450	518	460	340	165	770	660	2190	219
13	M	15700119	22	61	161	505	318	425	435	520	420	380	195	790	680	2105	241
14	M	148251	20	62	176	550	367	455	460	543	455	360	225	830	730	2185	273
15	M	147680	20	67	180	575	355	450	475	575	475	347	240	890	790	2350	290
16	M	138507	21	81	186	575	391	540	580	610	523	401	210	840	715	2390	264

Table A.2 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
18	M	15500369	23	93	178	575	387	505	503	585	515	440	220	870	790	2270	273
19	M	15500439	28	90	174	575	380	447	450	555	472	455	271	840	745	2130	316
20	M	15500438	27	71	176	584	385	485	447	560	480	380	250	830	720	2200	300
21	M	15500727	25	85	170	555	370	443	490	535	460	400	225	820	735	2140	274
22	M	145596	24	78	176	550	377	501	450	565	490	395	190	790	685	2210	243
23	M	145074	26	95	194	660	415	543	515	615	540	440	265	930	825	2460	324
24	M	15500661	22	93	174	585	380	487	445	545	465	435	225	845	755	2150	279
25	M	15500360	29	91	179	567	400	500	490	585	486	470	215	850	780	2330	267
26	M	147354	20	69	179	550	370	472	452	485	460	360	175	800	695	2210	231
27	M	148900	22	60	176	540	360	480	460	560	490	330	205	840	725	2220	255
28	M	148535	20	75	177	585	385	480	450	570	480	407	215	840	735	2230	270
29	M	148059	20	75	171	534	380	491	460	560	472	362	185	835	740	2160	237
30	M	15701717	22	91	183	585	385	517	491	610	492	415	227	860	770	2300	280
31	M	147184	20	72	180	595	390	495	485	594	493	390	255	845	730	2180	306
32	M	144883	19	90	183	570	422	593	510	620	521	445	200	845	715	2230	255
33	M	147183	20	75	181	595	422	523	490	630	531	394	225	855	735	2210	280
34	M	147045	20	66	175	564	376	475	471	570	480	390	225	820	730	2110	275
35	M	148829	21	67	176	610	378	487	475	581	490	405	290	880	775	2190	338

Table A.2 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
36	M	137653	21	92	170	587	362	495	465	560	480	440	270	840	725	2090	317
37	M	138817	20	73	170	580	360	560	463	535	470	400	255	840	700	2040	303
38	M	139345	20	80	178	570	410	533	460	570	506	382	210	830	705	2250	263
39	M	15702210	28	98	180	630	380	520	470	575	505	408	273	895	825	2250	326
40	M	138951	21	94	176	555	395	540	460	565	570	437	185	830	725	2200	240
41	M	127692	21	62	176	530	360	525	475	570	520	372	195	790	700	2210	245
42	M	138948	21	64	182	580	400	535	505	580	522	354	235	860	760	2300	286
43	M	15701831	20	64	180	575	385	481	500	585	516	370	220	845	775	2255	273
44	M	117725	23	81	174	568	360	520	460	565	481	435	230	795	720	2140	280
45	M	137635	21	64	186	635	390	530	503	585	505	380	235	930	825	2330	294
46	M	15700203	22	90	175	595	360	525	455	545	485	435	280	875	780	2200	327
47	M	147470	22	80	181	595	375	525	500	600	531	390	265	820	725	2245	314
48	M	143589	20	75	185	600	420	530	540	605	540	425	225	850	740	2300	281
49	M	148805	22	84	181	600	395	555	510	650	515	430	260	870	775	2235	311
50	M	147997	19	72	174	585	393	520	475	570	493	405	230	825	715	2160	283
51	M	15700639	19	83	189	635	440	600	555	603	525	436	250	910	805	2350	307
52	M	15700995	19	95	180	580	395	545	493	590	525	480	222	890	775	2200	275
53	M	15700833	16	81	177	600	405	547	475	585	505	430	227	785	685	2290	282

Table A.2 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
54	M	148559	19	77	177	575	420	520	495	588	515	427	195	860	750	2270	251
55	M	148565	20	65	176	585	405	520	500	585	510	386	240	870	730	2220	291
56	M	15700484	20	70	174	575	400	550	473	592	518	390	215	810	685	2260	268
57	M	148739	20	93	174	600	405	556	465	560	515	450	232	865	765	2170	287
58	M	15702129	20	67	181	580	370	545	530	595	510	400	240	870	755	2265	291
59	M	15702013	21	61	177	555	400	530	492	595	507	385	210	850	735	2175	261
60	M	147343	22	61	174	580	385	505	483	575	500	385	245	845	725	2120	295
61	M	138113	22	72	176	600	405	563	515	600	492	410	240	720	765	2115	294
62	M	148315	20	68	174	558	410	547	485	580	530	440	205	830	725	2190	257
63	M	137579	20	111	183	635	415	537	527	600	525	500	227	910	815	2340	288
64	M	139127	20	61	174	565	370	530	485	580	505	390	270	860	735	2140	314
65	M	143186	21	55	172	570	388	538	473	550	490	400	255	805	695	2065	302
66	M	147574	21	105	171	635	366	520	473	577	520	510	288	880	765	2180	340
67	M	133394	21	76	189	625	435	565	517	608	528	400	243	920	785	2385	300
68	M	128519	22	94	170	550	370	500	490	590	510	400	240	810	695	2115	286
69	M	118150	28	56	171	537	380	508	470	590	540	390	210	785	695	2145	259
70	M	128540	21	81	176	585	426	565	495	605	510	410	215	810	690	2215	270
71	M	15600056	45	86	177	588	415	595	490	602	535	440	250	825	725	2200	300

Table A.2 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
72	M	147764	21	60	160	557	373	515	495	545	503	440	250	780	740	2000	296
73	M	127748	22	62	172	580	415	550	510	570	500	440	240	810	705	2070	291
74	M	138061	22	75	182	627	430	593	492	608	530	425	270	885	795	2280	323
75	M	47145	28	115	176	564	337	479	437	562	461	447	227	844	768	2207	277
76	M	51324	29	74	170	544	328	453	408	508	455	366	216	839	759	2126	265
77	M	81773	25	71	171	523	330	460	413	526	465	290	193	837	752	2140	242
78	M	89529	25	59	170	541	316	456	443	504	426	337	225	806	730	2126	272
79	M	59452	27	75	171	528	339	463	420	518	467	390	189	827	788	2140	239
80	M	115169	26	86	174	563	344	468	432	547	475	420	219	838	755	2180	270
81	M	115169	27	64	170	545	320	452	438	513	447	382	225	810	720	2126	273
82	M	51338	28	90	181	564	327	511	461	528	493	354	237	838	755	2275	286
83	M	109518	25	100	181	570	354	518	455	564	502	388	216	837	758	2275	269
84	M	115609	28	63	173	540	329	484	433	526	467	368	211	813	720	2167	260
85	M	81793	25	73	175	545	326	451	441	510	459	372	219	858	769	2194	267
86	M	71217	27	95	178	552	338	453	452	535	475	397	214	875	785	2234	264
87	M	72381	26	84	177	544	336	448	431	549	487	363	208	896	804	2221	258
88	M	81762	25	76	182	584	309	470	462	535	498	373	275	893	798	2288	321
89	M	57268	26	63	171	538	315	449	435	512	450	314	223	826	737	2140	270

Table A.2 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
90	M	81766	25	85	176	543	309	456	435	544	451	358	234	869	765	2207	280
91	M	71242	28	85	177	558	333	466	448	506	467	374	225	856	768	2221	275
92	M	89603	35	82	168	530	317	439	408	503	455	367	213	833	751	2099	260
93	M	48232	31	72	172	525	308	458	430	527	478	363	217	837	755	2153	263
94	M	105153	30	81	181	573	343	502	463	547	488	390	230	845	768	2275	281
95	M	116067	31	77	185	573	371	497	461	535	493	376	202	892	792	2329	257
96	M	115081	30	67	185	576	353	502	465	554	501	354	223	883	788	2329	275
97	M	105493	30	69	180	562	345	496	460	536	495	369	217	844	745	2261	268

Table A.3: Anthropometric Measures of Female Students in mm.

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
1	F	135555	30	64	165	556	330	480	460	573	477	415	235	750	666	2120	283
2	F	145757	35	57	162	543	325	430	455	506	420	400	260	830	720	1935	302
3	F	139154	21	35	150	480	339	430	486	505	440	340	200	730	635	1850	242
4	F	147953	18	65	169	524	365	485	465	525	443	415	205	780	685	1980	252
5	F	148505	19	87	155	535	335	475	460	510	470	490	248	760	675	1920	291
6	F	148577	24	62	164	510	340	490	462	545	458	420	217	770	685	2020	261
7	F	15700836	18	59	166	536	365	505	461	549	473	400	215	800	685	2050	263
8	F	147581	18	56	162	527	340	500	415	517	456	310	225	760	670	1980	270
9	F	135720	27	52	165	530	372	510	465	540	465	400	218	765	675	2080	264
10	F	122377	21	55	165	500	340	485	461	518	445	360	301	725	635	1870	331
11	F	138282	22	74	166	560	380	500	457	563	500	450	240	810	659	2130	288
12	F	147710	20	79	163	580	345	480	462	515	450	465	280	830	715	1990	325
13	F	15701089	17	85	169	535	355	485	455	533	450	400	230	780	685	1985	275
14	F	15700462	17	44	155	495	370	475	470	505	452	355	190	735	635	1940	235
15	F	148553	19	45	152	530	360	465	470	485	455	365	180	730	645	1855	232
16	F	147862	19	67	172	570	400	559	510	580	480	415	210	815	700	2200	263
17	F	140092	20	63	173	557	405	515	500	575	490	380	234	835	715	2115	282

Table A.3 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
18	F	147258	19	62	152	580	335	450	460	470	420	415	290	810	705	1820	333
19	F	147603	21	64	168	585	355	490	445	541	460	410	275	835	730	2020	321
20	F	148467	20	56	158	510	358	505	465	505	445	420	205	780	685	1940	250
21	F	139162	26	55	154	535	343	490	472	500	460	420	235	780	670	1910	280
22	F	133739	21	47	163	560	370	490	475	540	450	390	245	780	665	1990	292
23	F	128587	27	46	160	520	360	540	475	470	460	400	210	765	645	1975	256
24	F	141517	22	58	162	530	370	525	497	527	450	430	210	790	690	1995	258
25	F	128334	23	65	153	535	370	545	484	525	475	415	256	750	640	1870	298
26	F	127365	24	65	164	585	390	530	490	535	490	465	265	725	735	2010	313
27	F	137437	23	59	157	565	380	545	485	545	470	460	265	790	680	1790	310
28	F	123431	21	44	161	580	395	500	480	545	490	390	255	790	695	2005	303
29	F	15500216	24	62	164	590	400	530	440	568	440	460	275	820	705	2005	322
30	F	143145	19	97	176	600	415	550	502	590	500	505	290	850	740	2200	336
31	F	81720	28	71	182	579	333	485	461	549	470	462	246	874	772	2242	296
32	F	47936	28	47	165	545	321	446	422	500	420	349	225	782	684	2022	273
33	F	71223	25	57	174	547	313	467	439	523	450	352	235	834	747	2138	281
34	F	72392	27	75	176	572	313	463	432	524	455	452	260	860	769	2164	306
35	F	118610	21	56	161	490	292	435	417	502	435	357	195	758	664	1970	239

Table A.3 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
36	F	89712	22	71	174	545	334	481	415	562	470	406	195	844	760	2138	247
37	F	47682	22	58	159	505	309	450	407	508	425	392	195	737	646	1944	241
38	F	115671	35	59	165	518	304	451	427	503	445	425	215	772	678	2022	260
39	F	115351	31	65	148	472	358	420	385	448	390	368	215	680	610	1802	253
40	F	116264	38	64	167	509	317	457	420	502	435	456	197	793	708	2048	243
41	F	118429	23	54	170	513	311	452	433	512	445	380	202	815	716	2086	248
42	F	115386	30	55	163	506	300	447	423	510	460	355	206	760	668	1996	251
43	F	118631	25	52	170	521	320	477	443	508	460	325	201	780	695	2086	249
44	F	115532	32	62	155	504	277	429	389	471	453	356	227	732	647	1892	268
45	F	115670	31	54	162	508	295	442	412	480	470	335	213	766	681	1983	257
46	F	115779	31	54	151	478	293	400	407	469	410	365	185	700	591	1841	229
47	F	48325	21	54	158	520	317	447	432	511	435	338	209	801	705	1931	255
48	F	81724	30	64	162	517	319	443	419	494	450	412	170	758	673	1983	222
49	F	51323	27	65	162	512	285	449	420	486	435	423	236	751	666	1983	277
50	F	72379	26	70	171	542	316	488	429	524	450	437	226	793	708	2099	273
51	F	72396	28	98	168	527	268	461	426	510	431	467	241	793	708	2060	284
52	F	112740	27	60	160	510	261	410	395	462	425	485	249	778	693	1957	288
53	F	105008	37	65	162	515	250	431	389	460	420	400	235	800	715	1983	277

Table A.3 Continued

NO.	Sex	Student number	Age	Weight (KG)	Stature	Shoulder Height (SDH)	Shoulder Elbow Height	Buttock-to-Popliteal Length	Popliteal Height	Knee Height	Forearm Length	Hip Width	Elbow Sitting Height (EH)	Sitting Height	Siting Eye Height	Overhead Stretch	ES= 0.852EH+0.148SDH
54	F	47974	31	56	179	547	347	453	451	524	465	443	195	690	794	2203	247
55	F	81783	25	59	168	528	307	451	433	510	425	385	221	796	698	2060	267
56	F	71273	27	58	168	530	302	454	434	491	430	381	228	792	707	2060	273
57	F	72390	27	58	163	510	293	445	439	498	435	376	220	746	661	1996	263

Appendix B: Analysis of Anthropometric Measures

Percentile Definition

Percentile is the value of a variable under which a specific percent of observation fall.

The k^{th} percentile is the place in the data where k% of the data is below the cut point.

The 25^{th} percentile is that the area under the curve when (z = -1.65) as shown in figure (B-1)

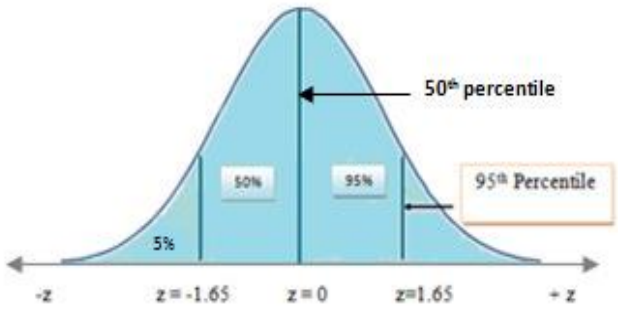

Figure B.1: The 5^{th} , 50^{th} and 95^{th} percentile

There are many alternative approaches to defining percentiles for instance the median is the 50^{th} percentile, the first quartile is 25^{th} percentile, and the third quartile is the 75^{th} percentile. It could be of importance to compute other percentiles, such as the 5^{th} or 95^{th}.

Notice to the percentiles above the mean have a positive Z-value and the lower average have a negative percentile.

Table B.1: The Common Percentiles

$p = \mu - 2{,}33\ \sigma$	$p_{88} = \mu + 2.33\ \sigma$
$p_{.4} = \mu - 1.96\ \sigma$	$p_{89.4} = \mu + 1.97\sigma$
$p_4 = \mu - 1.65\ \sigma$	$p_{84} = \mu + 1.65\sigma$
$p = \mu - 1.82\ \sigma$	$p_8 = \mu + 1.82\sigma$
$p = \mu - 0.84\ \sigma$	$p_R = \mu + 0.84\sigma$
$p_{.4} = \mu - 0.67\ \sigma$	$p_{94} = \mu + 0.67\sigma$

Table B.2: Anthropometric Data for Male

Item	**μ**	**median**	**б**	**min**	**max**	**10th**	**90th**
weight (kg)	76.54	75.00	12.91	55.00	115.00	59.88	93.20
Stature (cm)	176.76	176.00	5.59	160.00	194.00	169.55	183.97
shoulder height (mm)	569.64	570.00	30.68	500.00	660.00	530.06	609.22
shoulder elbow height (mm)	372.44	375.00	32.71	308.00	440.00	330.25	414.64
Buttock-to-popliteal length (mm)	502.45	501.00	40.70	425.00	600.00	449.94	554.96
popliteal height (mm)	470.34	465.00	32.72	408.00	580.00	428.13	512.55
knee height (mm)	563.14	565.00	33.52	485.00	650.00	519.90	606.39
forearm length (mm)	492.15	492.00	29.23	420.00	570.00	454.44	529.87
hip width (mm)	397.58	394.00	40.94	290.00	520.00	344.76	450.39
elbow sitting height (mm)	226.37	225.00	28.20	155.00	290.00	189.99	262.75
sitting height (mm)	839.59	840.00	38.70	720.00	930.00	789.66	889.51
siting eye height (mm)	742.76	740.00	38.35	648.00	825.00	693.29	792.24
overhead stretch (mm)	2218.11	2210.00	84.81	2000.00	2460.00	2108.70	2327.52

Table B.3: Mismatch Ratios for Male Students

Mismatch between	**Number of mismatches**	**Ratio**	**Percentage**
Popliteal Height and Seat Height	54	0.557	55.7
Buttock-popliteal length and Seat Depth	44	0.454	45.4
Hip Width and Seat Width	44	0.454	45.4
Shoulder Height and Backrest Height	3	0.031	3.1
Elbow Sitting Height and Table Height (Individual)	71	0.732	73.2
Underneath Table Height (Individual Table Clearance)	0	0.000	0.0
Elbow Sitting Height and Table Height (Long)	87	0.897	89.7
Underneath Table Height (Long Table Clearance)	0	0.000	0.0
Elbow Sitting Height and Table Height (Computer)	78	0.804	80.4
Underneath Table Height (Computer Table Clearance)	0	0.000	0.0

Table B.4: Anthropometric Data for Female

Item	μ	median	Ϭ	min	max	10th	90th
weight (kg)	61.23	59	11.831	35	98	45.97	76.49
Stature (cm)	163.65	163	7.359	148	182	154.16	173.14
shoulder height (mm)	533.56	530	30.232	472	600	494.56	572.56
shoulder elbow height (mm)	336.18	335	37.808	250	415	287.40	384.95
Buttock-popliteal height (mm)	475.32	475	37.001	400	559	427.58	523.05
popliteal height (mm)	447.07	451	30.488	385	510	407.74	486.40
knee height (mm)	516.60	511	31.778	448	590	475.60	557.59
forearm length (mm)	451.37	450	22.559	390	500	422.27	480.47
hip width (mm)	404.25	400	44.513	310	505	346.82	461.67
elbow sitting height (mm)	228.18	225	29.561	170	301	190.04	266.31
sitting height (mm)	779.91	780	41.189	680	874	726.78	833.05
siting eye height (mm)	688.32	685	39.160	591	794	637.80	738.83
overhead stretch (mm)	2004	1995	104.077	1790	2242	1869.92	2138.44

Table B. 5: Mismatch Ratio for Female Students

mismatch between	Number of mismatches	Ratio	Percentage
Popliteal Height and Seat Height	23	0.404	40.4
Buttock-popliteal length and Seat Depth	27	0.474	47.4
Hip Width and Seat Width	33	0.579	57.9
Shoulder Height and Backrest Height	20	0.351	35.1
Elbow Sitting Height and Table Height (Individual)	48	0.842	84.2
Underneath Table Height (Individual Table Clearance)	0	0	0.0
Elbow Sitting Height and Table Height (Long)	55	0.965	96.5
Underneath Table Height (Long Table Clearance)	0	0	0.0
Elbow Sitting Height and Table Height (Computer)	51	0.895	89.5
Underneath Table Height (Computer Table Clearance)	0	0	0.0

Table B.6: Proportion of Match Male students at Different Seat Depth (SD)

SD	SD/0.95	SD/0.8	Prob 1	Prob2	Probability
320	336.8421	400	0.00	0.00592	0.006
330	347.3684	412.5	0.00	0.013559	0.013
340	357.8947	425	0.00	0.028539	0.028
350	368.4211	437.5	0.00	0.055286	0.055
360	378.9474	450	0.00	0.098779	0.098
365	384.2105	456.25	0.00	0.128189	0.126
370	389.4737	462.5	0.00	0.163185	0.160
375	394.7368	468.75	0.00	0.203861	0.200
380	400	475	0.01	0.25004	0.244
385	405.2632	481.25	0.01	0.301246	0.293
390	410.5263	487.5	0.01	0.356706	0.345
400	421.0526	500	0.02	0.476002	0.453
410	431.5789	512.5	0.04	0.597507	0.557
420	442.1053	525	0.07	0.710206	0.641
425	447.3684	531.25	0.09	0.760381	0.672
430	452.6316	537.5	0.11	0.805401	0.695
435	457.8947	543.75	0.14	0.844856	0.708
440	463.1579	550	0.17	0.878629	0.711
460	484.2105	575	0.33	0.962653	0.636
470	494.7368	587.5	0.42	0.981665	0.557
480	505.2632	600	0.53	0.991724	0.464
490	515.7895	612.5	0.63	0.99657	0.368
500	526.3158	625	0.72	0.998697	0.278
510	536.8421	637.5	0.80	0.999546	0.199
520	547.3684	650	0.87	0.999855	0.135
530	557.8947	662.5	0.91	0.999958	0.087
540	568.4211	675	0.95	0.999989	0.053
550	578.9474	687.5	0.97	0.999997	0.030
560	589.4737	700	0.98	0.999999	0.016
570	600	712.5	0.99	1	0.008
580	610.5263	725	1.00	1	0.004
590	621.0526	737.5	1.00	1	0.002
600	631.5789	750	1.00	1	0.001
610	642.1053	762.5	1.00	1	0.000

Table B.7: Proportion of Match Female students at Different Seat Depth (SD)

SD	SD/0.95	SD/0.8	Prob 1	Prob2	Probability
320	336.8421	400	0.00	0.020894231	0.02
330	347.3684	412.5	0.00	0.044773518	0.04
340	357.8947	425	0.00	0.086920778	0.09
350	368.4211	437.5	0.00	0.153358614	0.15
360	378.9474	450	0.00	0.246891033	0.24
365	384.2105	456.25	0.01	0.303139744	0.30
370	389.4737	462.5	0.01	0.364492087	0.35
375	394.7368	468.75	0.01	0.429533183	0.41
380	400	475	0.02	0.496549825	0.48
385	405.2632	481.25	0.03	0.563664206	0.53
390	410.5263	487.5	0.04	0.628990291	0.59
400	421.0526	500	0.07	0.747616808	0.68
410	431.5789	512.5	0.12	0.842512498	0.72
420	442.1053	525	0.18	0.910309993	0.73
425	447.3684	531.25	0.22	0.934679726	0.71
430	452.6316	537.5	0.27	0.953569489	0.68
435	457.8947	543.75	0.32	0.967800646	0.65
440	463.1579	550	0.37	0.978221227	0.61
460	484.2105	575	0.59	0.996469793	0.40
470	494.7368	587.5	0.70	0.998784539	0.30
480	505.2632	600	0.79	0.999623666	0.21
490	515.7895	612.5	0.86	0.999895329	0.14
500	526.3158	625	0.92	0.999973871	0.08

Table B.8: Proportion of Match Male students at Different Backrest Height (BH)

BH	BH/0.8	BH/0.6	Prob 1	Prob2	Probability
270	337.5	450	1.92082E-14	4.81994E-05	4.8199E-05
280	350	466.6667	4.06849E-13	0.000395025	0.00039503
290	362.5	483.3333	7.32078E-12	0.00245383	0.00245383
300	375	500	1.11944E-10	0.011609597	0.0116096
305	381.25	508.3333	4.11875E-10	0.022847681	0.02284768
310	387.5	516.6667	1.45521E-09	0.042121173	0.04212117
320	400	533.3333	1.60889E-08	0.118333261	0.11833325
330	412.5	550	1.51367E-07	0.261042227	0.26104208
340	425	566.6667	1.21261E-06	0.461398447	0.46139723
350	437.5	583.3333	8.27792E-06	0.672314466	0.67230619
360	450	600	4.81994E-05	0.838799884	0.83875168
365	456.25	608.3333	0.00010961	0.896372538	0.89626293
370	462.5	616.6667	0.000239652	0.93733273	0.93709308
375	468.75	625	0.000503875	0.964413655	0.96390978
380	475	633.3333	0.001018975	0.981052387	0.98003341
385	481.25	641.6667	0.00198248	0.990552559	0.98857008
390	487.5	650	0.003711717	0.995593324	0.99188161
400	500	666.6667	0.011609597	0.999217722	0.98760812
410	512.5	683.3333	0.03127404	0.999894579	0.96862054
415	518.75	691.6667	0.048590018	0.999965145	0.95137513
425	531.25	708.3333	0.105419271	0.999996915	0.89457764
430	537.5	716.6667	0.147422102	0.999999175	0.85257707
435	543.75	725	0.19937809	0.999999794	0.8006217
440	550	733.3333	0.261042227	0.999999952	0.73895773
445	556.25	741.6667	0.331263675	0.99999999	0.66873631
450	562.5	750	0.407990461	0.999999998	0.59200954
460	575	766.6667	0.569342691	1	0.43065731
470	587.5	783.3333	0.719756812	1	0.28024319
480	600	800	0.838799884	1	0.16120012
490	612.5	816.6667	0.918786564	1	0.08121344
500	625	833.3333	0.964413655	1	0.03558634
510	637.5	850	0.986509491	1	0.01349051
520	650	866.6667	0.995593324	1	0.00440668
530	662.5	883.3333	0.998763513	1	0.00123649
540	675	900	0.99970268	1	0.00029732
550	687.5	916.6667	0.999938849	1	6.1151E-05
560	700	933.3333	0.999989258	1	1.0742E-05

Table B.9: Proportion of Match Female students at Different Backrest Height (BH)

BH	BH/0.8	BH/0.6	Prob 1	Prob2	Probability
270	337.5	450	4.43126E-11	0.002855	0.0028552
280	350	466.6667	6.32768E-10	0.01346	0.0134603
290	362.5	483.3333	7.64653E-09	0.048319	0.0483191
300	375	500	7.82371E-08	0.133482	0.1334818
305	381.25	508.3333	2.35163E-07	0.202018	0.2020175
310	387.5	516.6667	6.78207E-07	0.288153	0.2881519
320	400	533.3333	4.98471E-06	0.497009	0.4970039
330	412.5	550	3.1092E-05	0.706709	0.7066775
340	425	566.6667	0.000164771	0.863261	0.8630959
350	437.5	583.3333	0.000742938	0.950157	0.9494142
360	450	600	0.002855238	0.986014	0.9831585
365	456.25	608.3333	0.00527556	0.993307	0.9880312
370	462.5	616.6667	0.009374367	0.997011	0.9876364
375	468.75	625	0.016026263	0.998755	0.982729
380	475	633.3333	0.026371426	0.999517	0.9731456
385	481.25	641.6667	0.041789614	0.999825	0.9580359
390	487.5	650	0.06381043	0.999941	0.9361309
400	500	666.6667	0.13348184	0.999995	0.8665128
410	512.5	683.3333	0.243022553	1	0.7569771
415	518.75	691.6667	0.312110019	1	0.6878899
425	531.25	708.3333	0.469546814	1	0.5304532
430	537.5	716.6667	0.55184554	1	0.4481545
435	543.75	725	0.631964191	1	0.3680358
440	550	733.3333	0.706708606	1	0.2932914
445	556.25	741.6667	0.77353199	1	0.226468
450	562.5	750	0.830782946	1	0.1692171
460	575	766.6667	0.914770898	1	0.0852291
470	587.5	783.3333	0.96280459	1	0.0371954
480	600	800	0.986013732	1	0.0139863
490	612.5	816.6667	0.99548796	1	0.004512
500	625	833.3333	0.998755229	1	0.0012448

Table B.10: Proportion of Match Male students at Different Seat Width (SW)

SW	SW/1.3	SW/1.1	Prob 1	Prob2	Probability
320	246.1538	290.9091	0.000108	0.004586	0.0044781
330	253.8462	300	0.000223	0.008575	0.0083514
340	261.5385	309.0909	0.000445	0.015331	0.0148856
350	269.2308	318.1818	0.000859	0.026228	0.0253685
360	276.9231	327.2727	0.001604	0.04296	0.0413564
365	280.7692	331.8182	0.002164	0.054104	0.0519403
370	284.6154	336.3636	0.002897	0.067422	0.0645255
375	288.4615	340.9091	0.003846	0.083142	0.0792963
380	292.3077	345.4545	0.005065	0.101471	0.096406
385	296.1538	350	0.006617	0.122579	0.1159629
390	300	354.5455	0.008575	0.146592	0.1380175
400	307.6923	363.6364	0.01406	0.203522	0.1894615
410	315.3846	372.7273	0.022337	0.271908	0.2495707
420	323.0769	381.8182	0.034394	0.350119	0.3157256
425	326.9231	386.3636	0.042186	0.392054	0.3498677
430	330.7692	390.9091	0.051348	0.435281	0.3839332
435	334.6154	395.4545	0.062028	0.479298	0.4172701
440	338.4615	400	0.074366	0.523568	0.4492024
445	342.3077	404.5455	0.088495	0.567549	0.4790542
450	346.1538	409.0909	0.104534	0.610708	0.5061746
460	353.8462	418.1818	0.142706	0.692595	0.5498895
470	361.5385	427.2727	0.189335	0.765858	0.5765233
480	369.2308	436.3636	0.244325	0.828264	0.5839395
490	376.9231	445.4545	0.306932	0.878875	0.5719434
500	384.6154	454.5455	0.375746	0.917954	0.542208
510	392.3077	463.6364	0.448765	0.946681	0.4979158
520	400	472.7273	0.523568	0.966788	0.4432195
530	407.6923	481.8182	0.597547	0.980186	0.3826387
540	415.3846	490.9091	0.668181	0.988686	0.3205051
550	423.0769	500	0.733288	0.99382	0.2605323
560	430.7692	509.0909	0.791225	0.996773	0.2055477
600	461.5385	545.4545	0.940885	0.999848	0.0589628
620	476.9231	563.6364	0.97369	0.999975	0.0262846
640	492.3077	581.8182	0.989661	0.999997	0.0103355
660	507.6923	600	0.996423	1	0.0035765
680	523.0769	618.1818	0.998913	1	0.0010869
700	538.4615	636.3636	0.99971	1	0.0002896
720	553.8462	654.5455	0.999932	1	6.755E-05

Table B.11: Proportion of Match Female students at Different Seat Width (SW)

SW	SW/1.3	SW/1.1	Prob 1	Prob2	Probability
320	246.1538	290.9091	0.000191	0.005444	0.0052531
330	253.8462	300	0.000364	0.00959	0.0092261
340	261.5385	309.0909	0.000673	0.016267	0.0155944
350	269.2308	318.1818	0.00121	0.026584	0.0253745
360	276.9231	327.2727	0.002115	0.041876	0.0397606
365	280.7692	331.8182	0.002768	0.051847	0.0490784
370	284.6154	336.3636	0.003598	0.063618	0.0600202
375	288.4615	340.9091	0.004645	0.077372	0.0727271
380	292.3077	345.4545	0.005955	0.093274	0.0873194
385	296.1538	350	0.007582	0.11147	0.103888
390	300	354.5455	0.00959	0.132076	0.1224863
400	307.6923	363.6364	0.015034	0.180779	0.1657456
410	315.3846	372.7273	0.022946	0.23942	0.2164745
420	323.0769	381.8182	0.034108	0.307152	0.2730446
425	326.9231	386.3636	0.041178	0.343907	0.302729
430	330.7692	390.9091	0.049393	0.3822	0.3328072
435	334.6154	395.4545	0.058866	0.421682	0.3628159
440	338.4615	400	0.069709	0.461968	0.3922585
445	342.3077	404.5455	0.082029	0.502648	0.4206194
450	346.1538	409.0909	0.095921	0.543301	0.4473798
460	353.8462	418.1818	0.128746	0.622853	0.4941075
470	361.5385	427.2727	0.168646	0.697496	0.5288504
480	369.2308	436.3636	0.215723	0.764682	0.5489587
490	376.9231	445.4545	0.269638	0.822692	0.5530546
500	384.6154	454.5455	0.329571	0.870742	0.541171
510	392.3077	463.6364	0.394239	0.90892	0.5146814
520	400	472.7273	0.461968	0.93802	0.4760527
530	407.6923	481.8182	0.530821	0.959298	0.4284774
540	415.3846	490.9091	0.598762	0.974222	0.3754606
550	423.0769	500	0.663835	0.984264	0.3204288
560	430.7692	509.0909	0.724333	0.990746	0.2664123
600	461.5385	545.4545	0.900954	0.999244	0.0982898
620	476.9231	563.6364	0.948726	0.999829	0.0511025

Table B.12: Proportion of Match Male students at Different Table Clearance

TH	UD-20	Probability
400	380	2.79885E-08
410	390	1.41344E-07
420	400	6.55503E-07
430	410	2.79253E-06
440	420	1.09317E-05
450	430	3.93379E-05
460	440	0.000130185
470	450	0.000396425
480	460	0.001111428
490	470	0.002871026
500	480	0.006839218
510	490	0.015039856
520	500	0.030570166
530	510	0.057522197
540	520	0.100385257
550	530	0.162853058
560	540	0.246281009
570	550	0.348386699
580	560	0.46290419
590	570	0.580604468
600	580	0.691462461
610	590	0.787146664
620	600	0.8628294
630	610	0.917686921
640	620	0.954125172
650	630	0.976305086
660	640	0.988677146
670	650	0.995001302
680	660	0.997963676
690	670	0.999235281
700	680	0.999735474
710	690	0.999915774
720	700	0.999975329
730	710	0.999993355
740	720	0.999998355
750	730	0.999999626
760	740	0.999999922
770	750	0.999999985
780	760	0.999999997
790	770	1
800	780	1

Table B.13: Proportion of Match Female students at Different Table Clearance

TH	UD-20	Probability
400	380	8.59513E-06
410	390	3.38984E-05
420	400	0.000121653
430	410	0.000397511
440	420	0.001183524
450	430	0.003213558
460	440	0.007965933
470	450	0.018050432
480	460	0.037447533
490	470	0.0712665
500	480	0.124713924
510	490	0.201280241
520	500	0.300704988
530	510	0.417735179
540	520	0.542602439
550	530	0.663369009
560	540	0.769243719
570	550	0.853380258
580	560	0.913987308
590	570	0.953561003
600	580	0.976983519
610	590	0.989549667
620	600	0.99566064
630	610	0.99835438
640	620	0.999430685
650	630	0.999820489
660	640	0.999948452
670	650	0.999986528
680	660	0.999996797
690	670	0.999999308
700	680	0.999999864
710	690	0.999999976
720	700	0.999999996
730	710	0.999999999
740	720	1
750	730	1
760	740	1
770	750	1
780	760	1
790	770	1
800	780	1

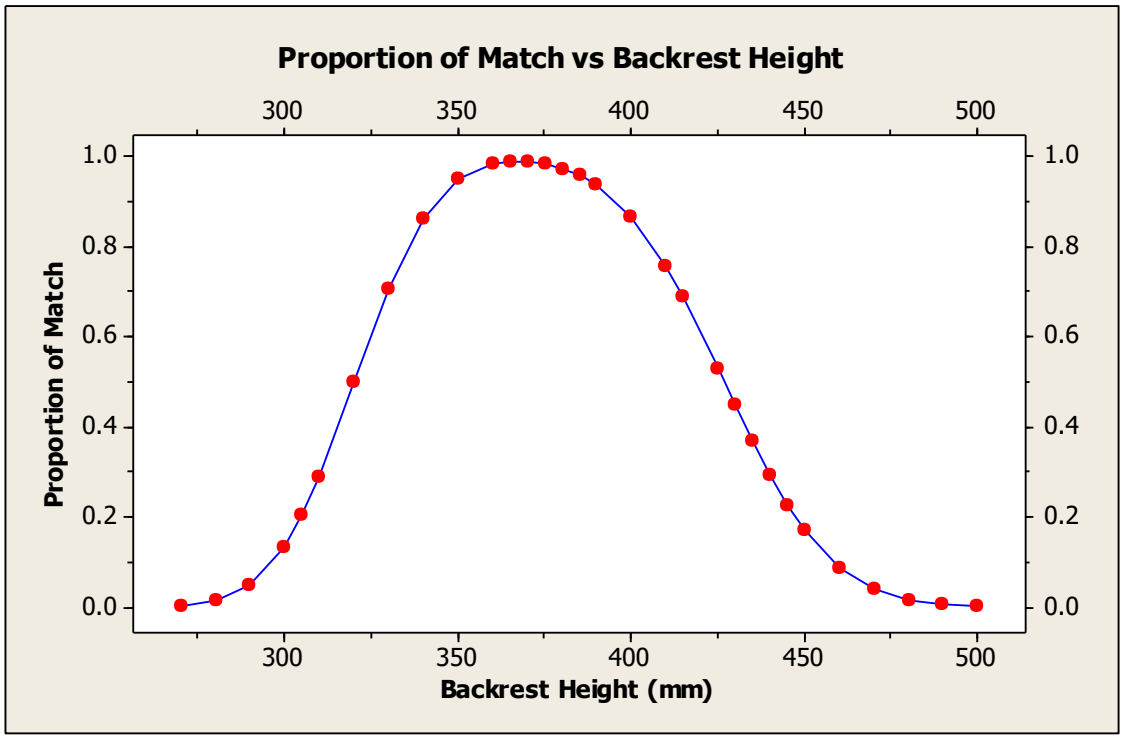

Figure B.2: Proportion of Match Population at Different Backrest Height Male.

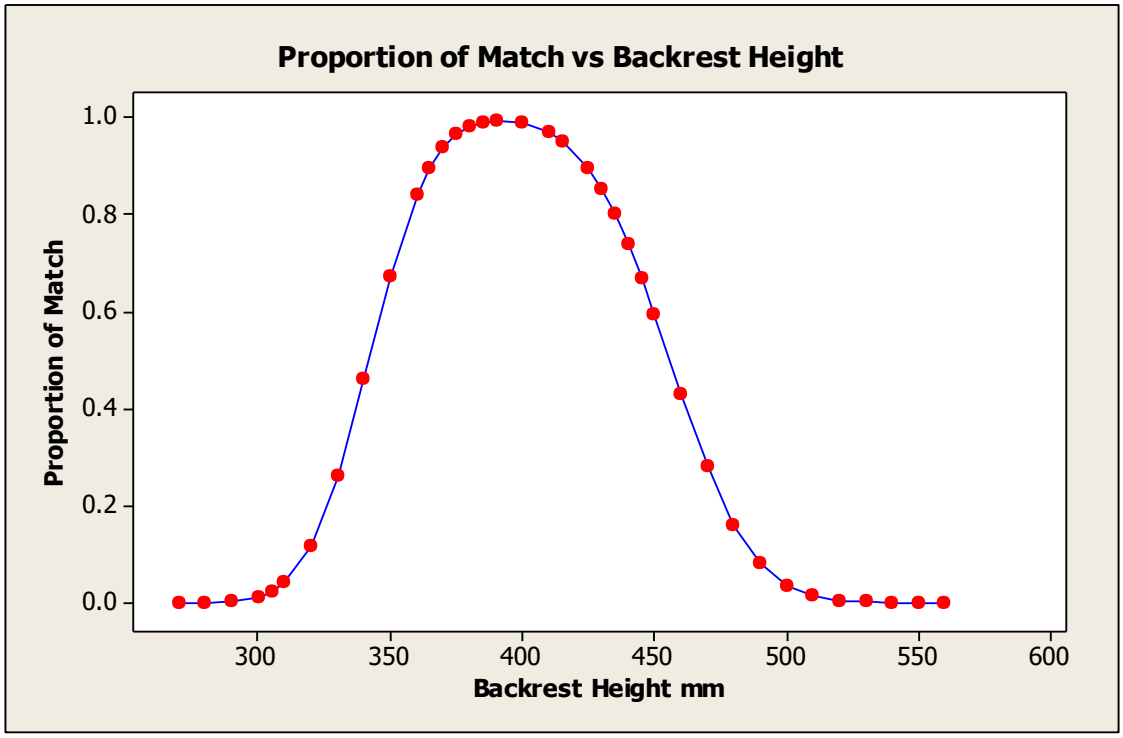

Figure B.3: Proportion of Match Population at Different Backrest Height Female.

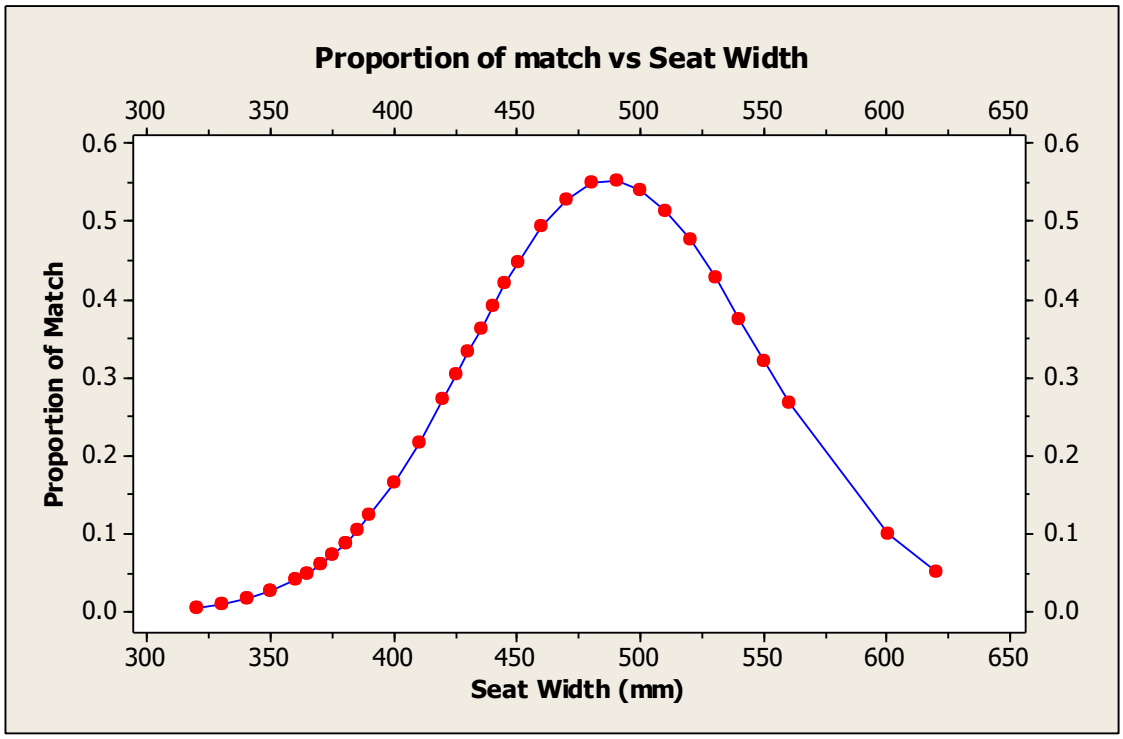

Figure B.4: Proportion of Match Population at Different Seat Width Male.

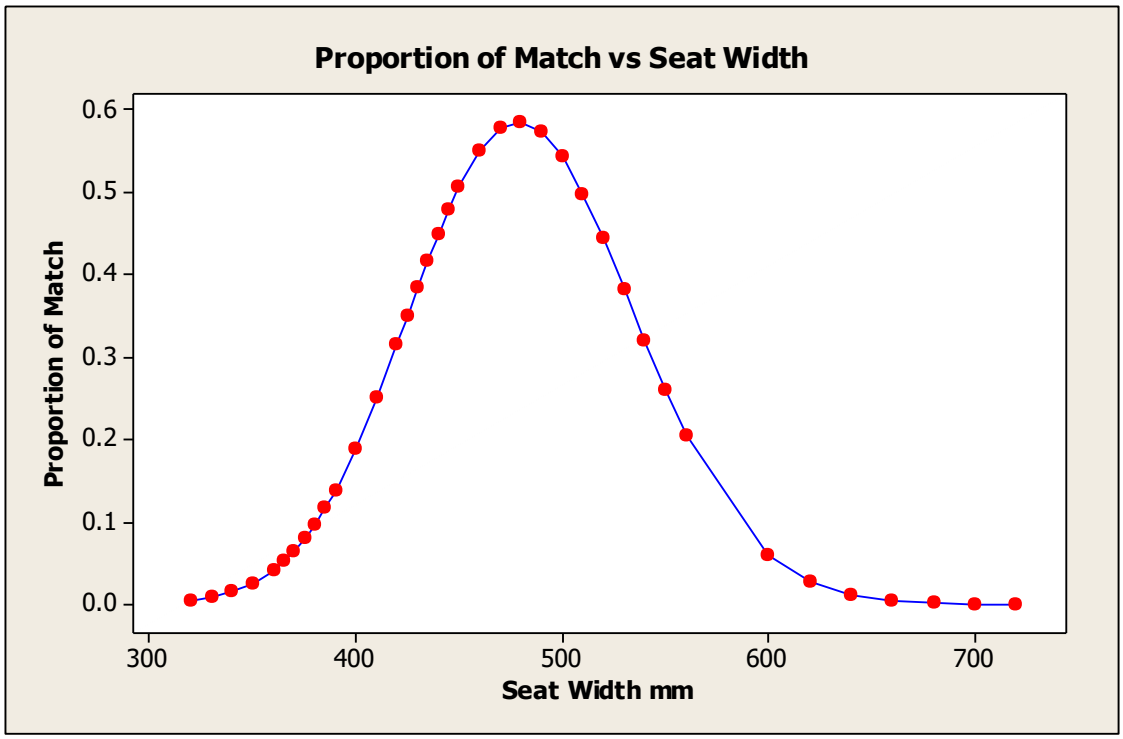

Figure B.5: Proportion of Match Population at Different Seat Width Female.

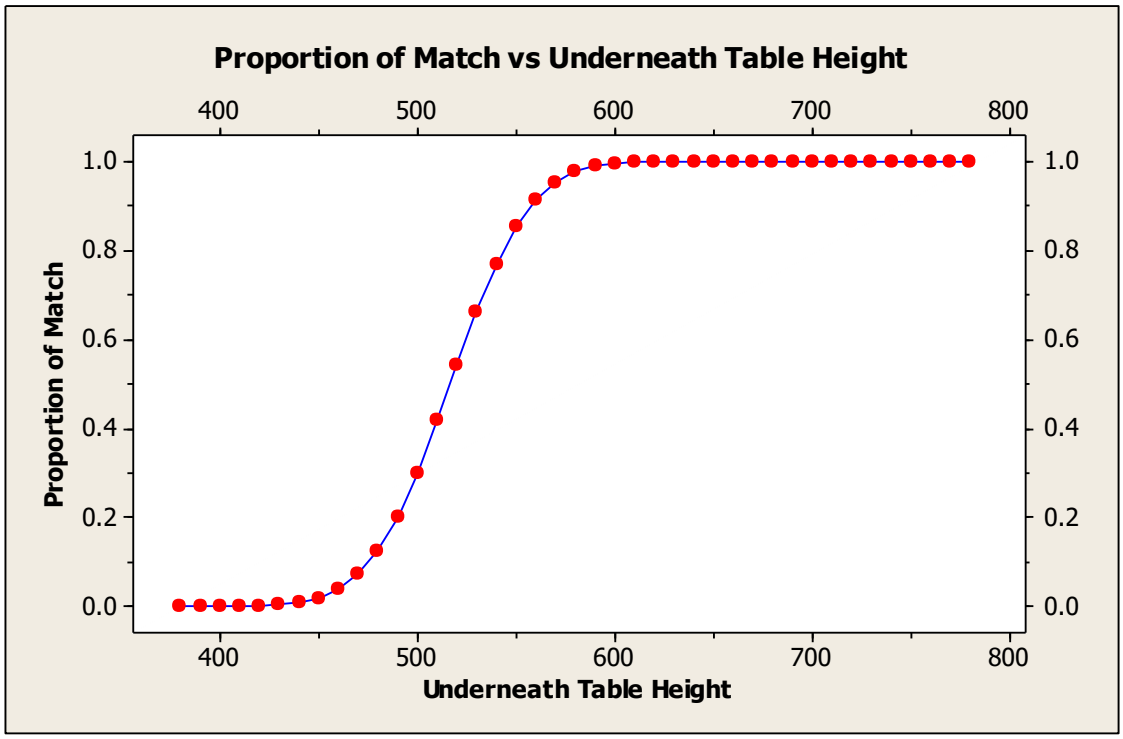

Figure B.6: Proportion of Match Population at Different Table Clearance Male.

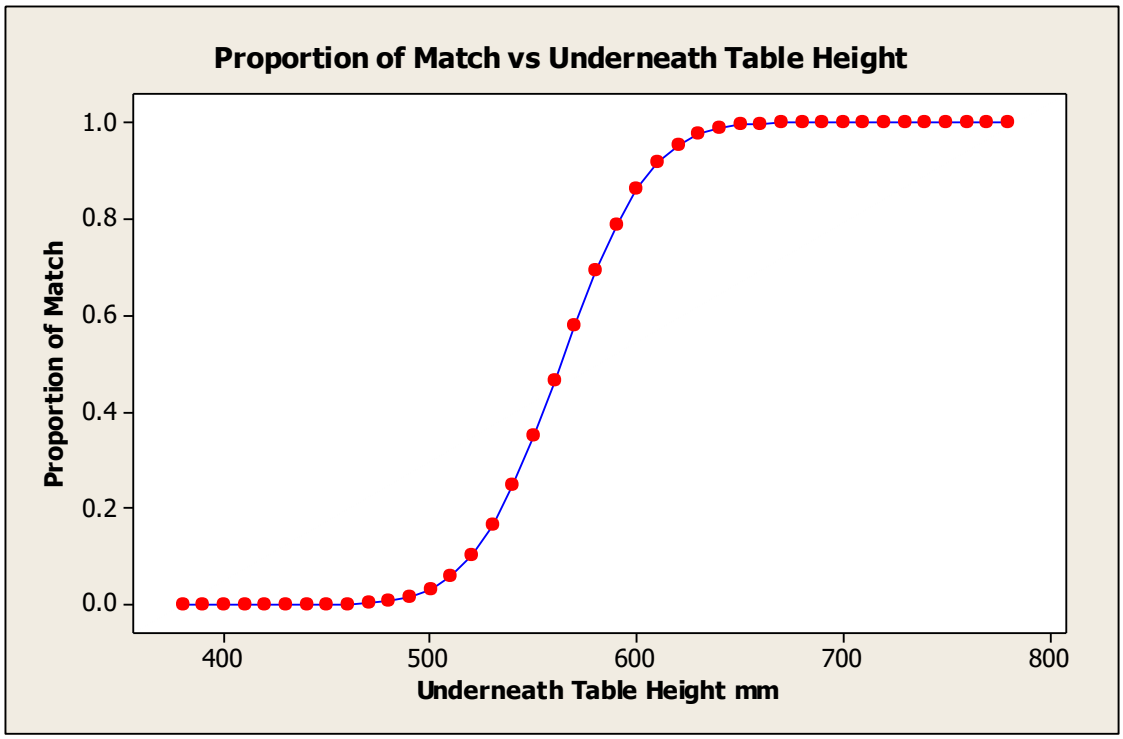

Figure B.7: Proportion of Match Population at Different Table Clearance Female.

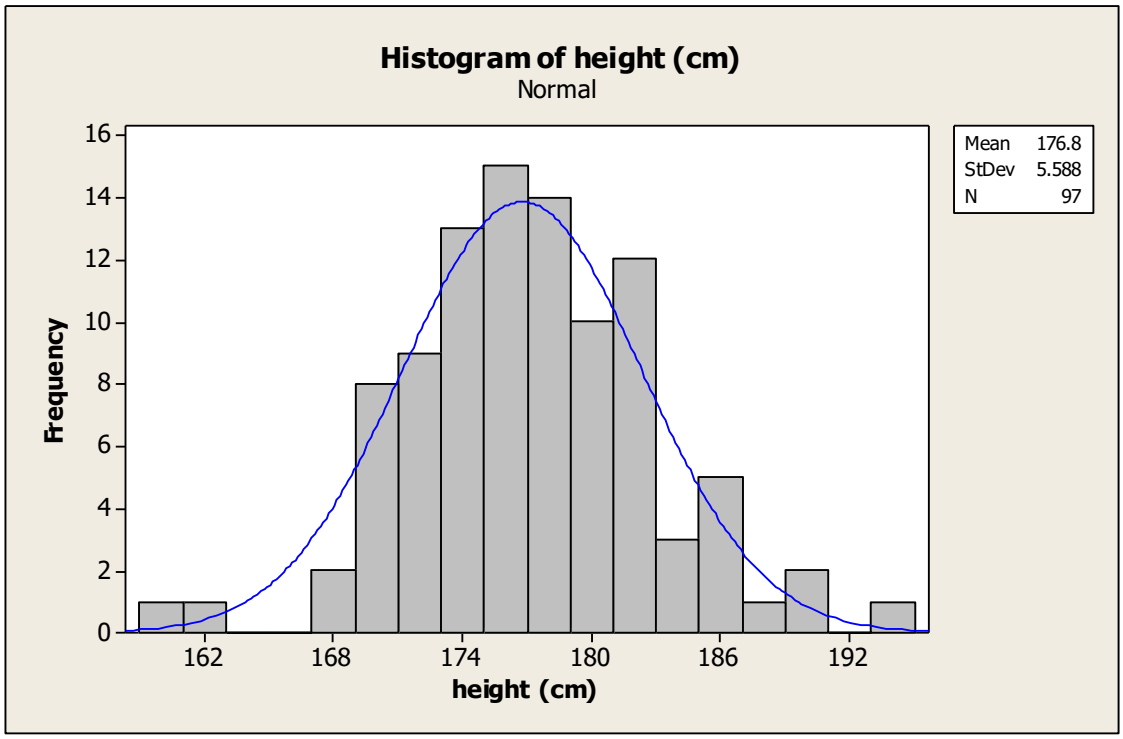

Figure B.8: Histogram of Male Students' Height

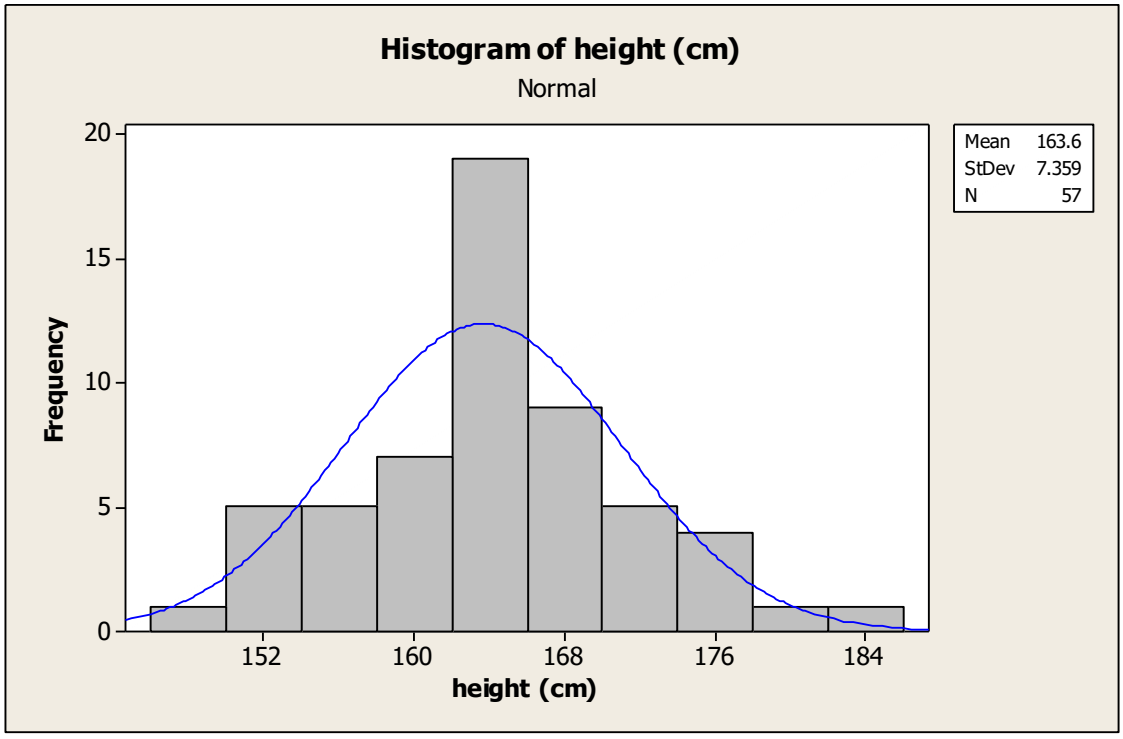

Figure B.9: Histogram of Female Students' Height

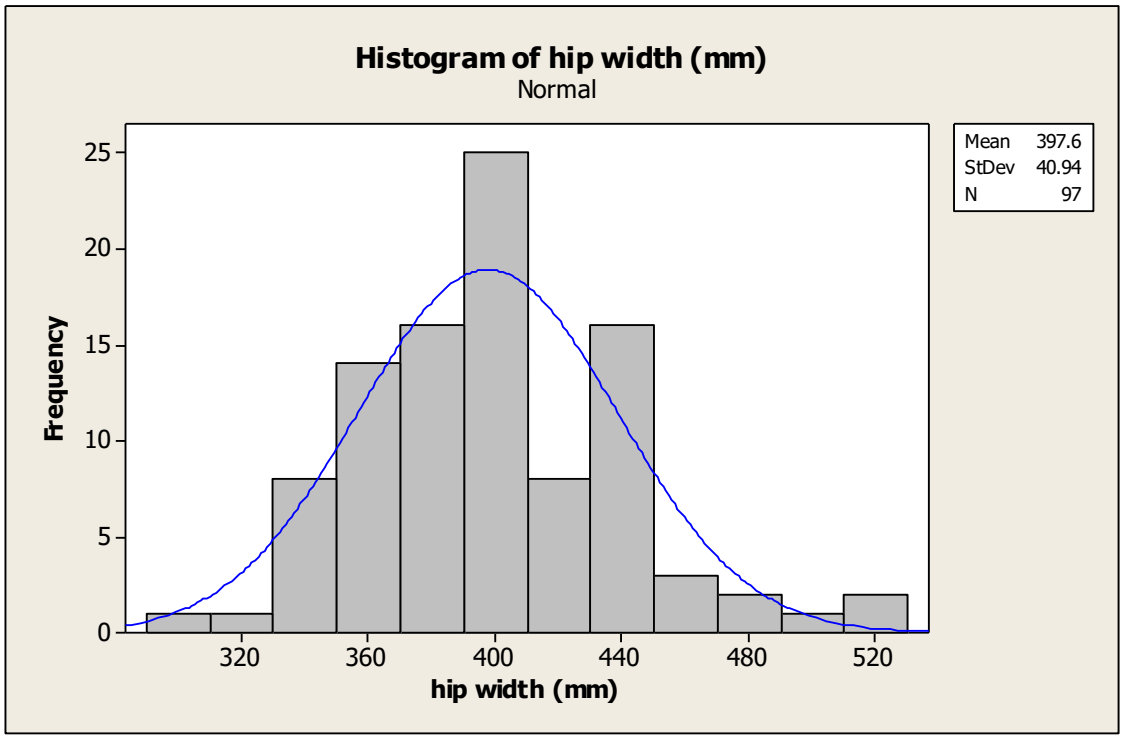

Figure B.10: Histogram of Male Students' Hip Width

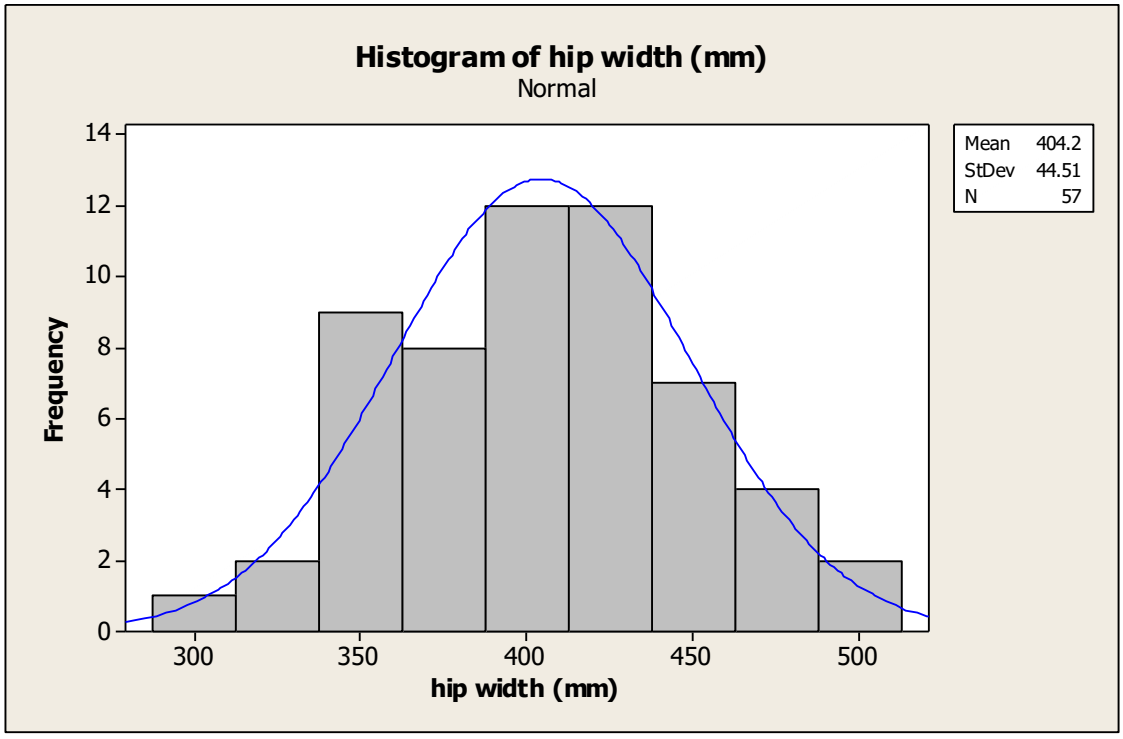

Figure B.11: Histogram of Female Students' Hip Width

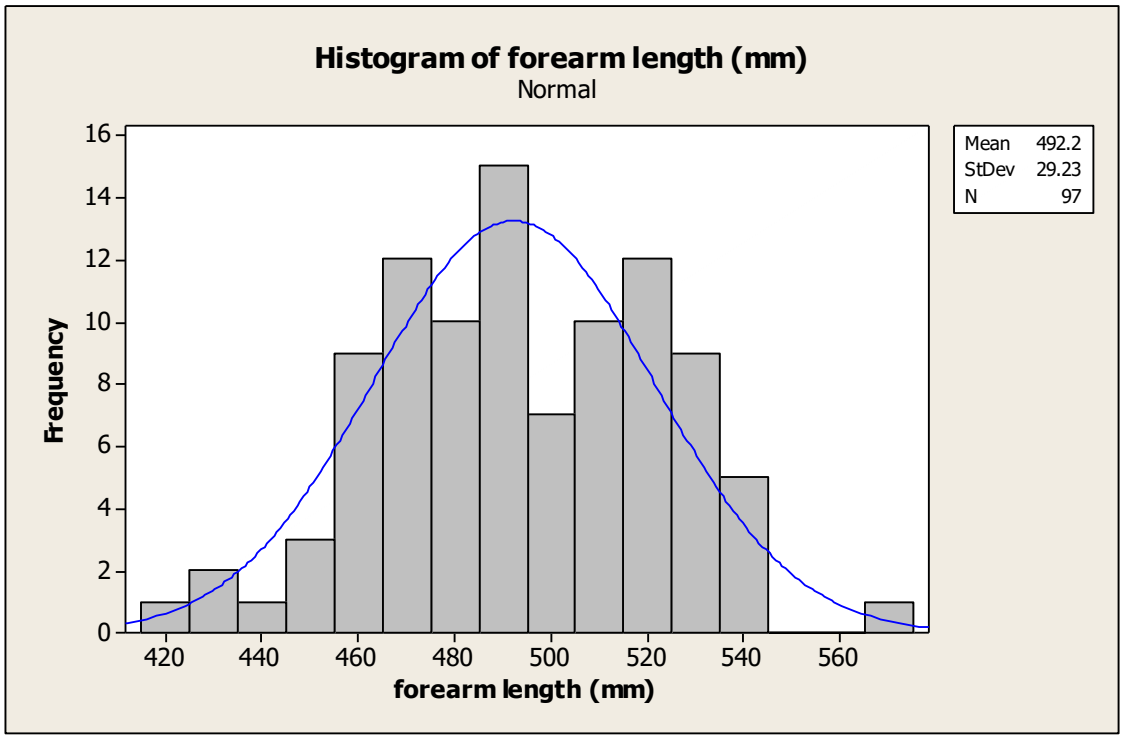

Figure B.12: Histogram of Male Students' Forearm Length

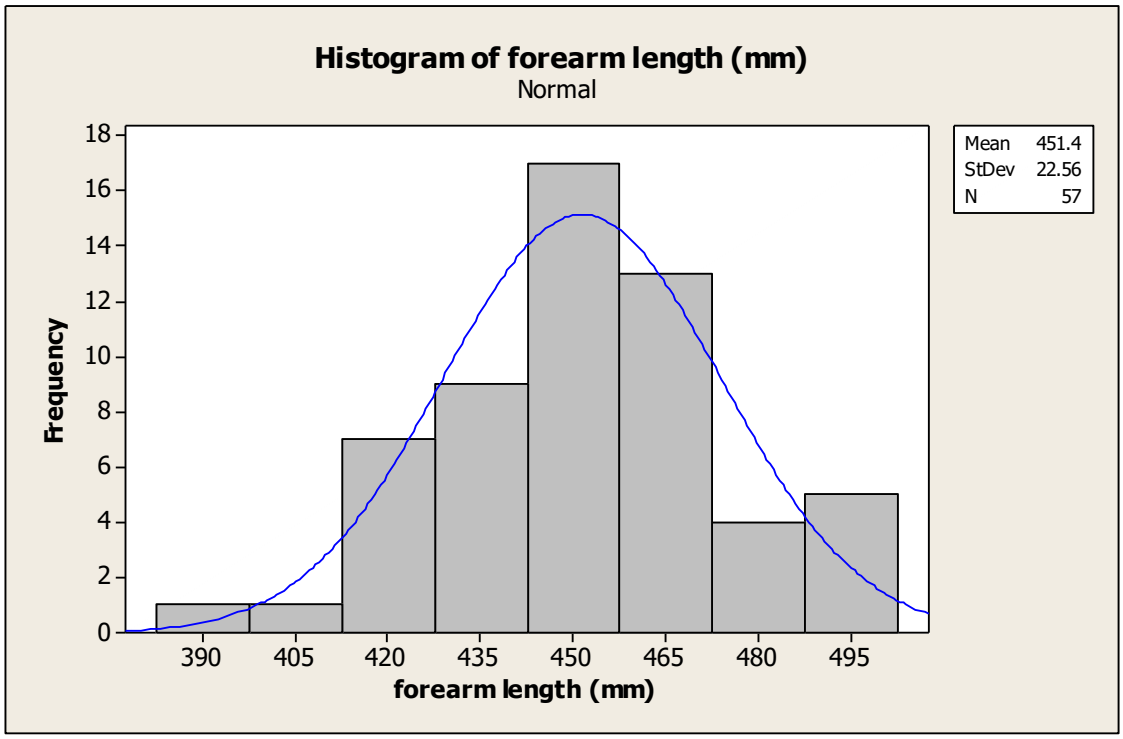

Figure B.13: Histogram of Female Students' Forearm Length

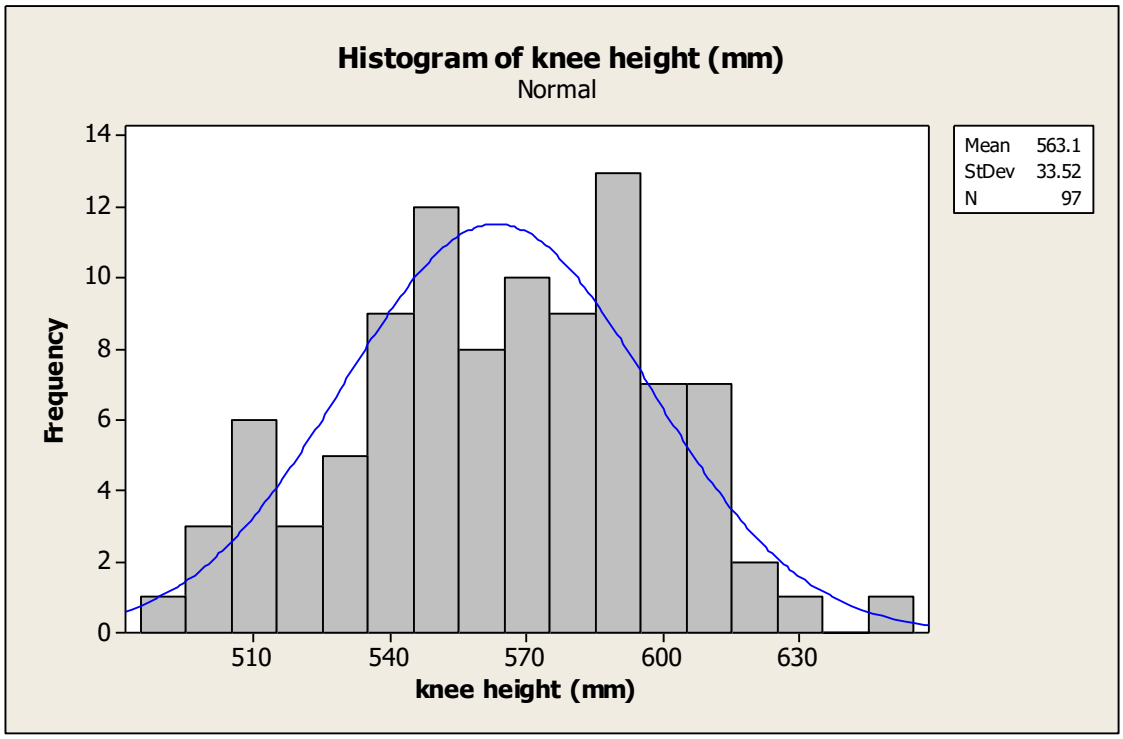

Figure B.14: Histogram of Male Students' Knee Height

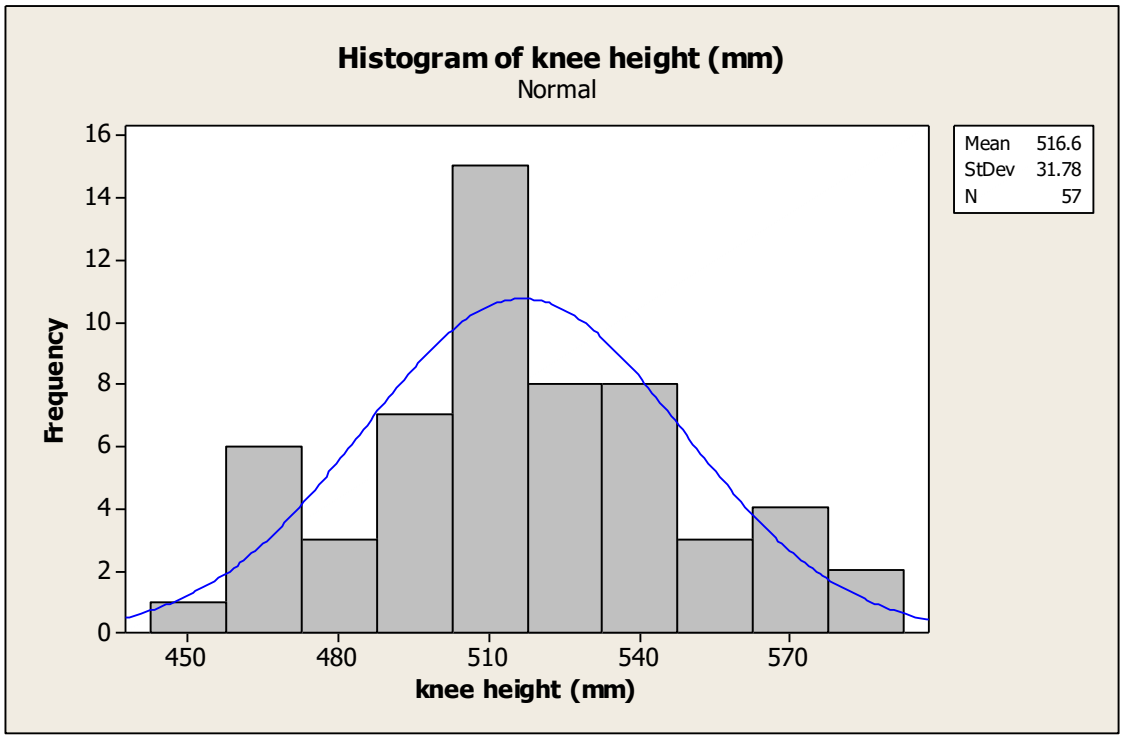

Figure B.15: Histogram of Female Students' Knee Height

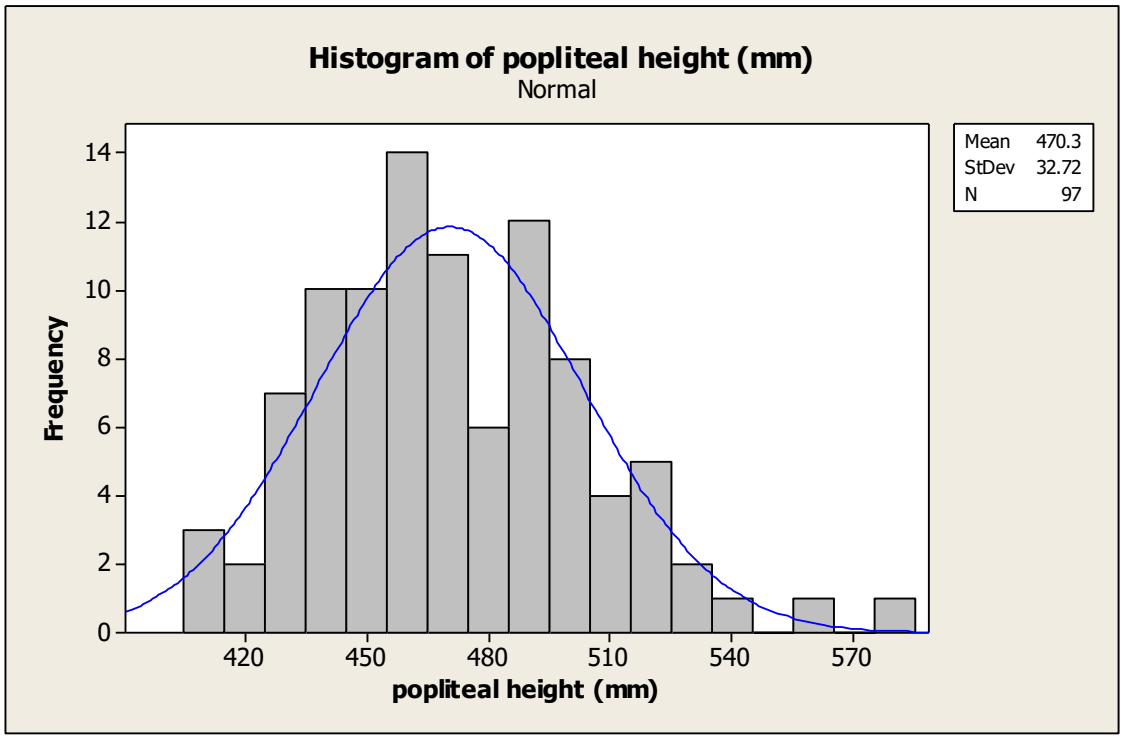

Figure B.16: Histogram of Male Students' Popliteal Height

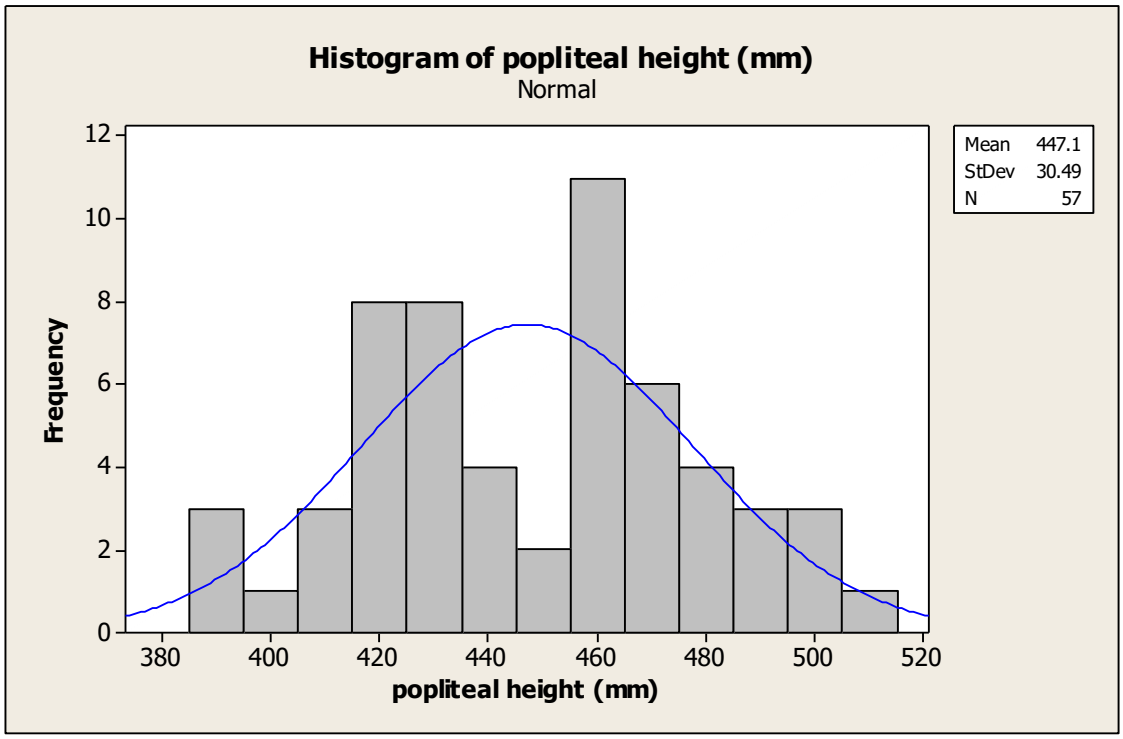

Figure B.17: Histogram of Female Students' Popliteal Height

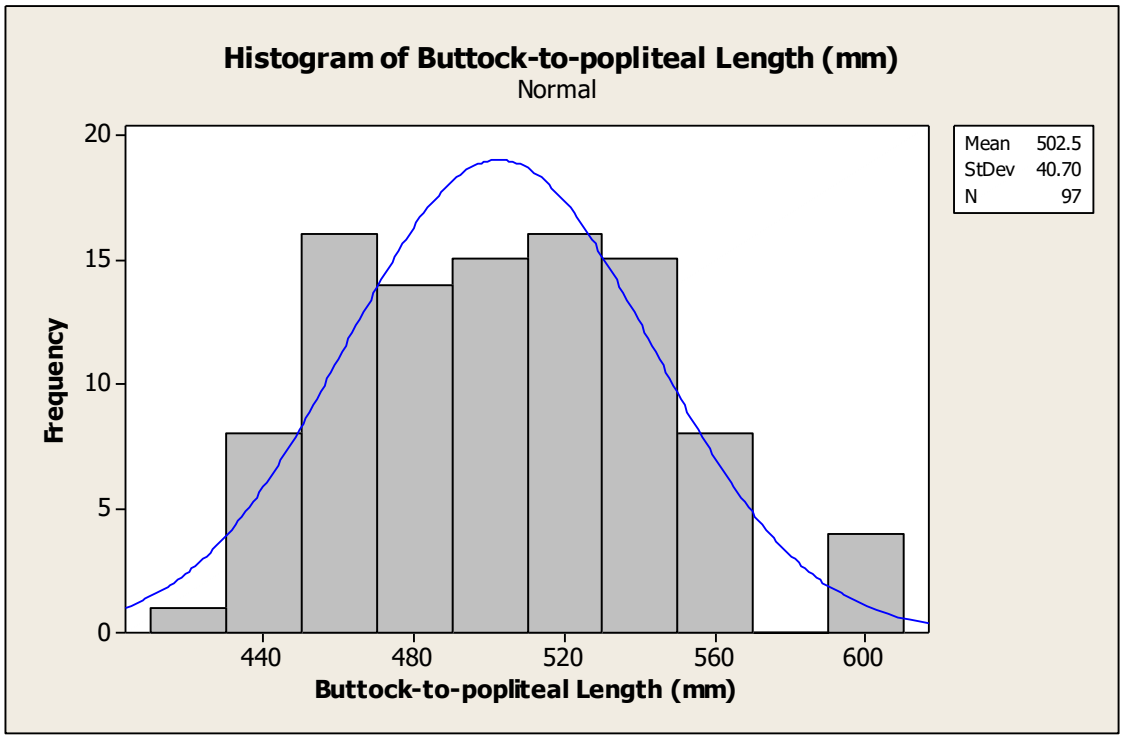

Figure B.18: Histogram of Male Students' Buttock-to- Popliteal Length

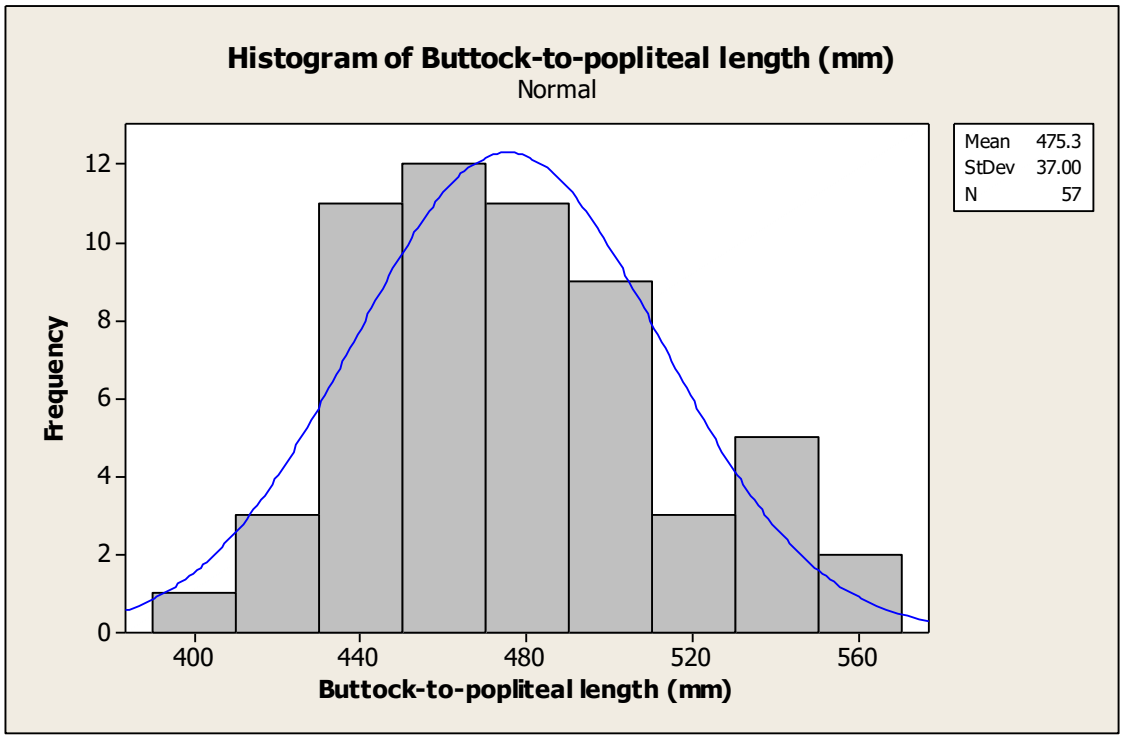

Figure B.19: Histogram of Female Students' Buttock-to- Popliteal Length

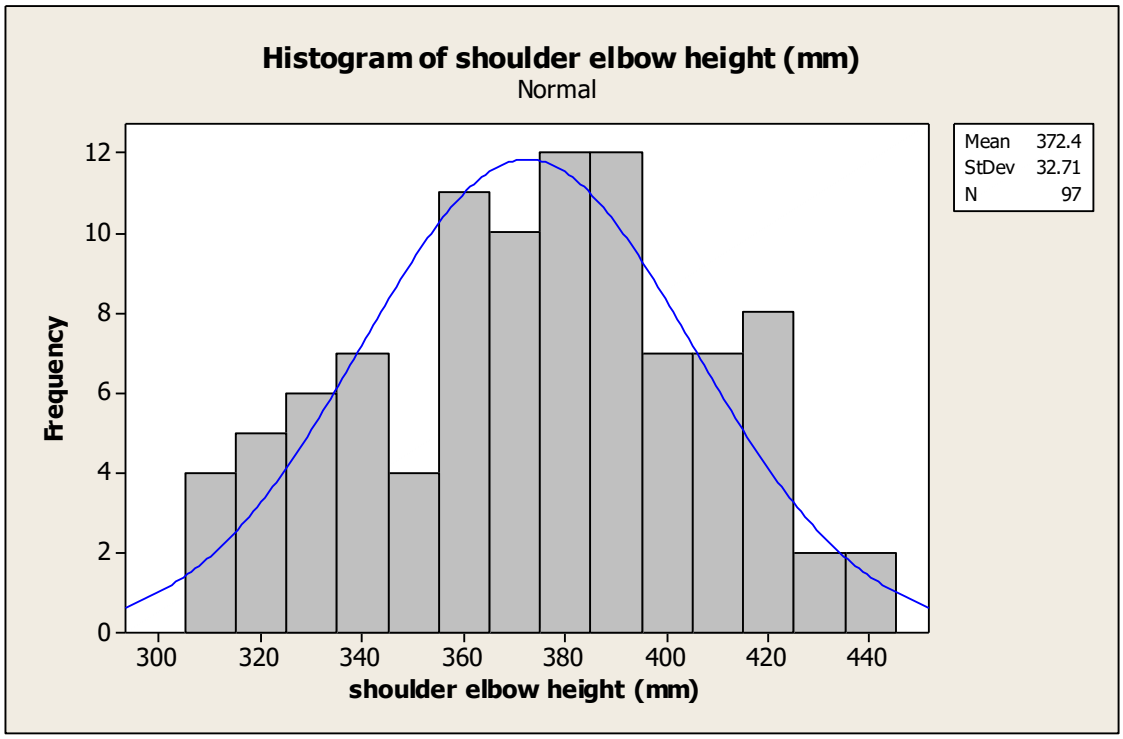

Figure B.20: Histogram of Male Students' Shoulder Elbow Height

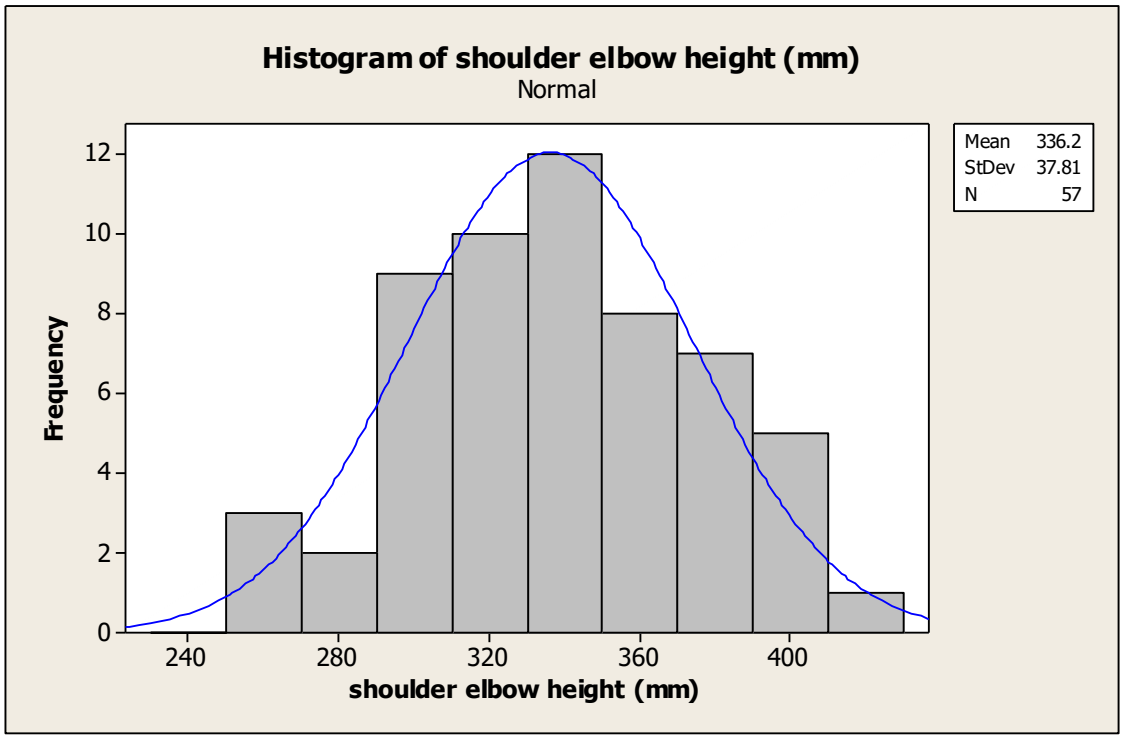

Figure B.21: Histogram of Female Students' Shoulder Elbow Height

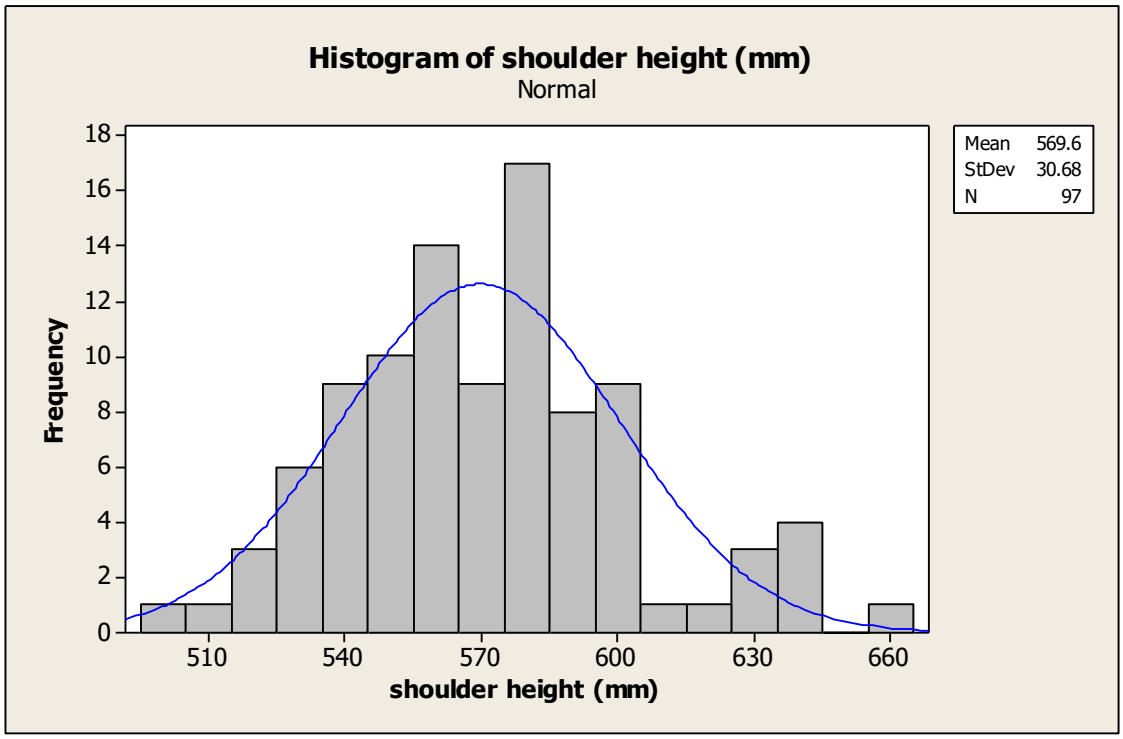

Figure B.22: Histogram of Male Students' Shoulder Height

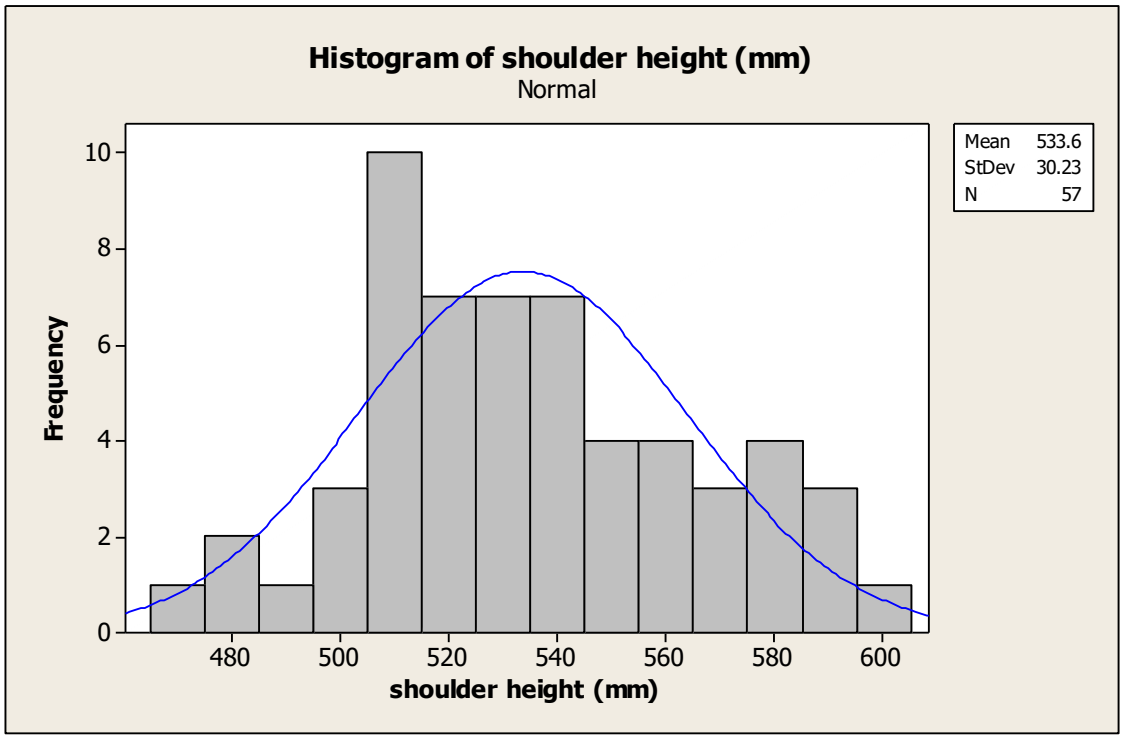

Figure B.23: Histogram of Female Students' Shoulder Height

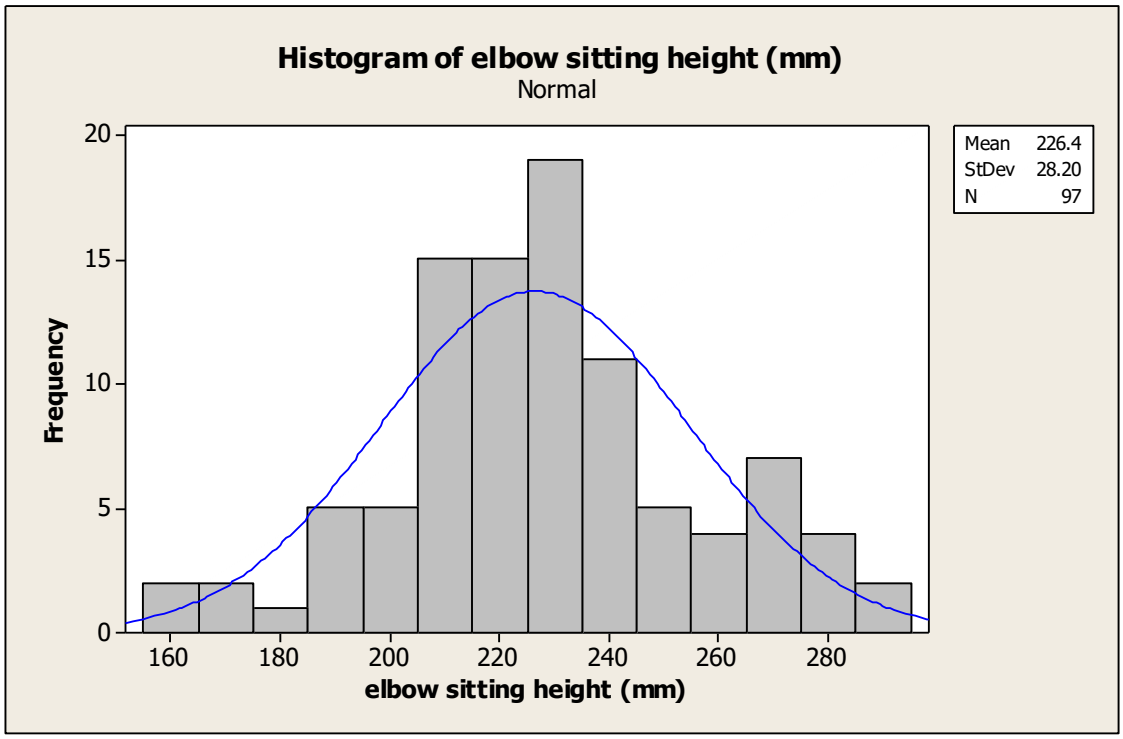

Figure B.24: Histogram of Male Students' Elbow Sitting Height

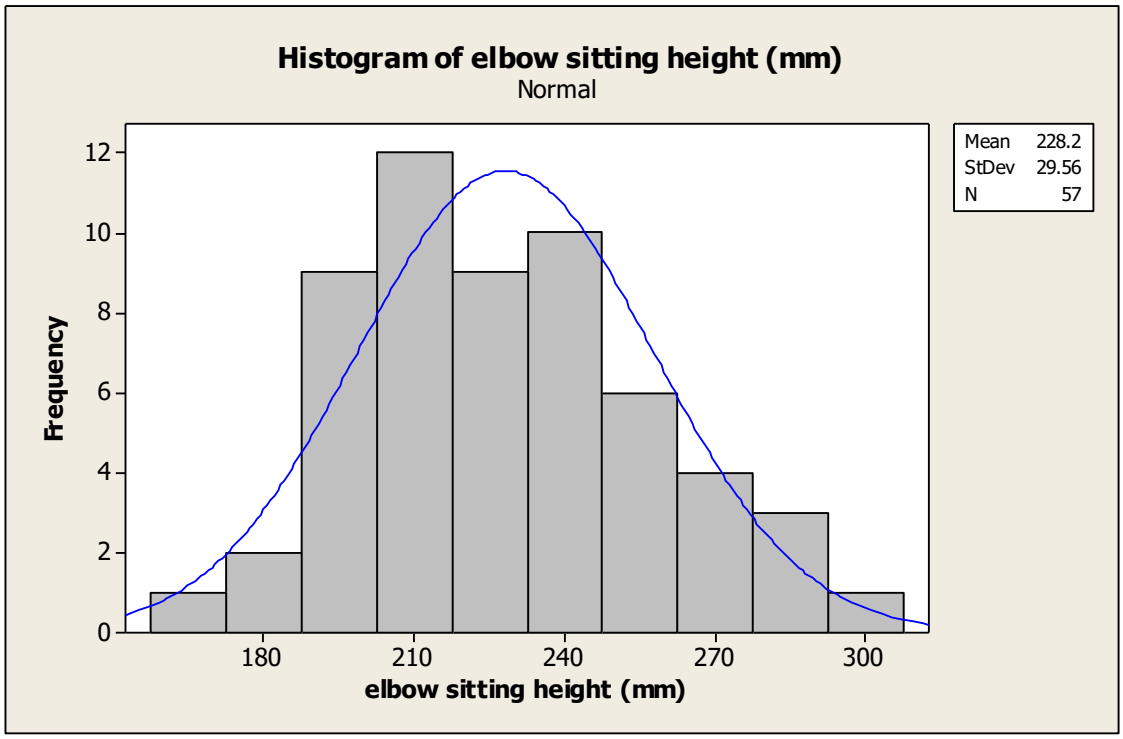

Figure B.25: Histogram of Female Students' Elbow Sitting Height

Appendix C: Results of Hypothesis Test by Minitab 16

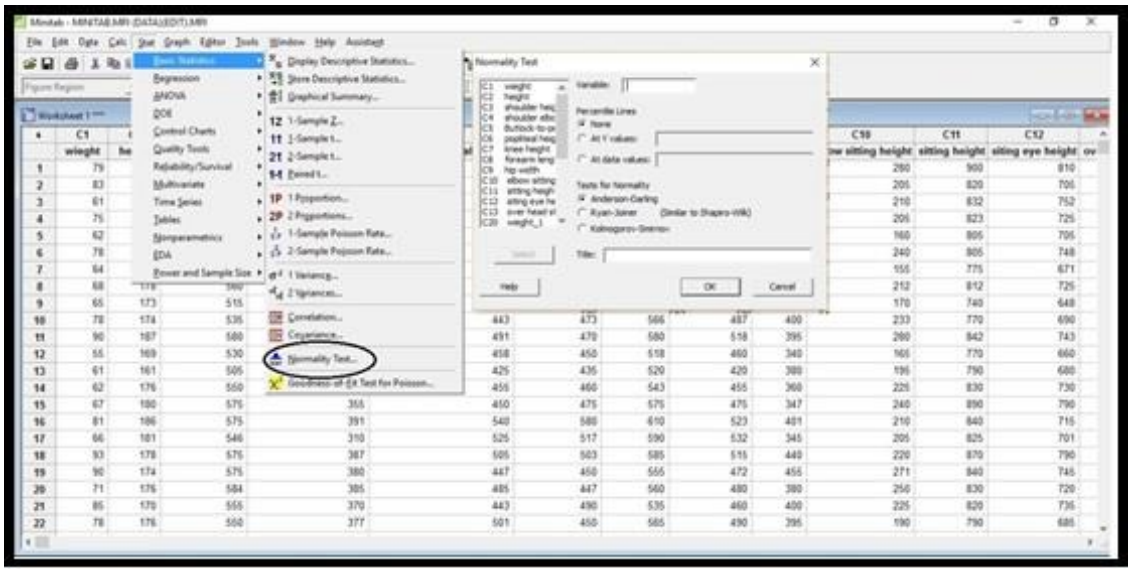

Figure C.1: The Normality Test by Minitab 16

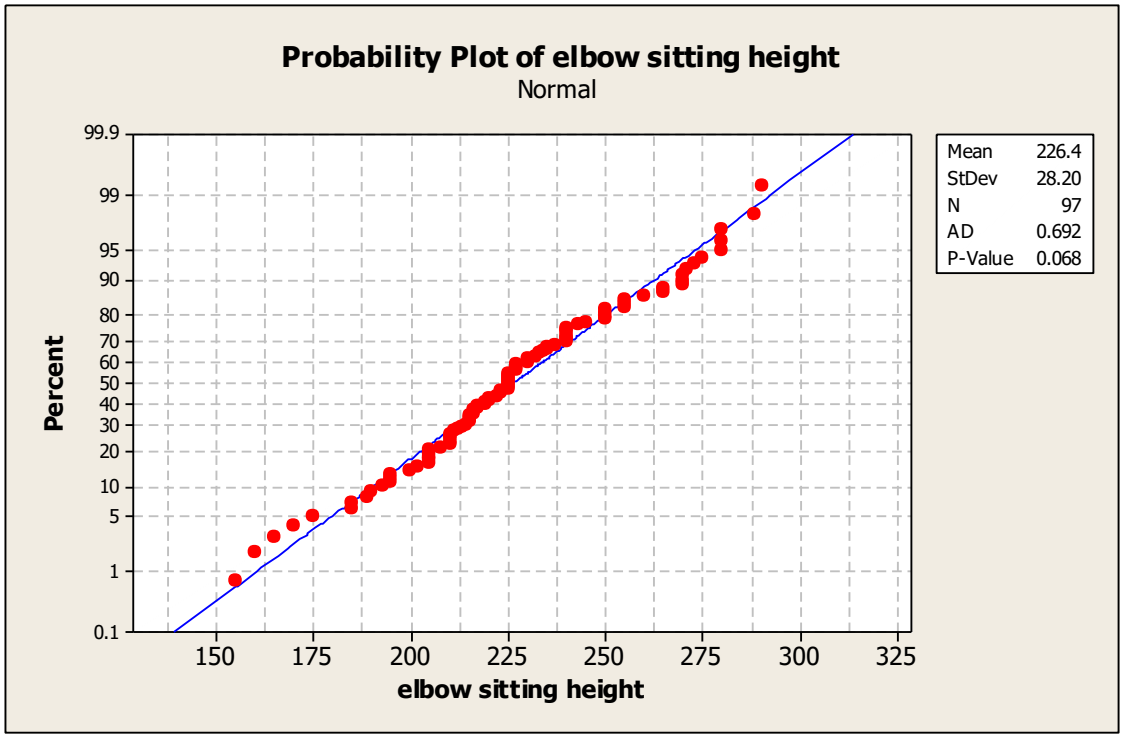

Figure C.2: Normal Probability Plot of Elbow Sitting Height Male

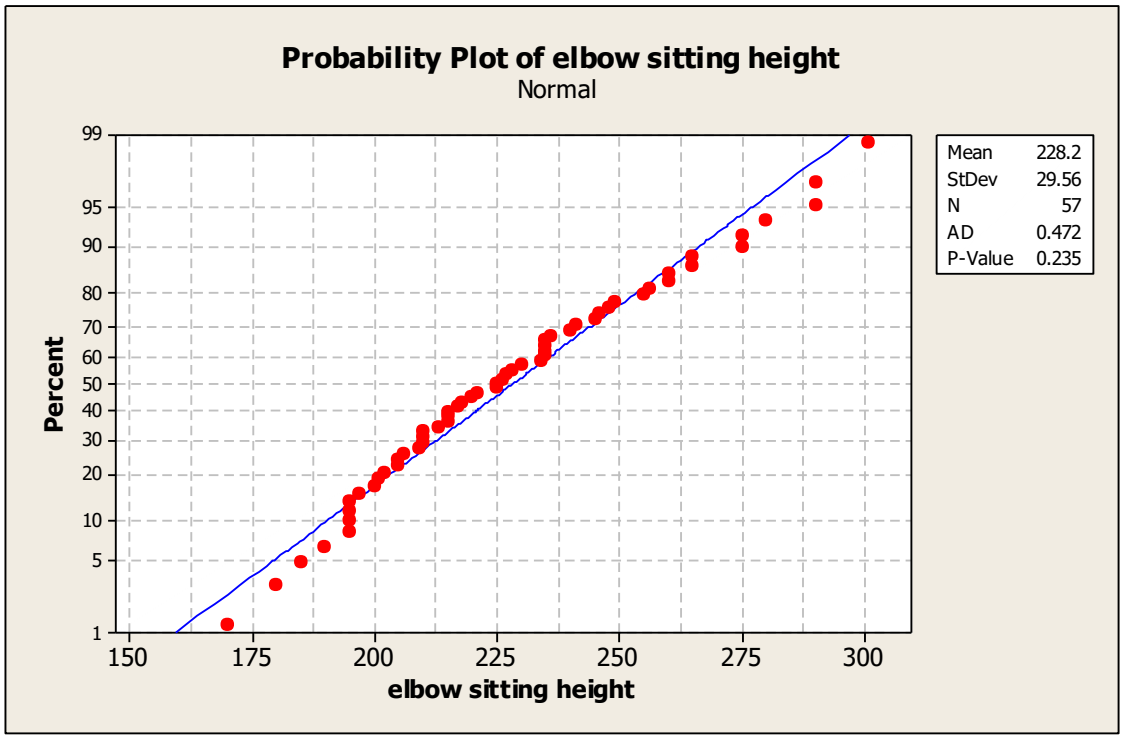

Figure C.3: Normal Probability Plot of Elbow Sitting Height Female

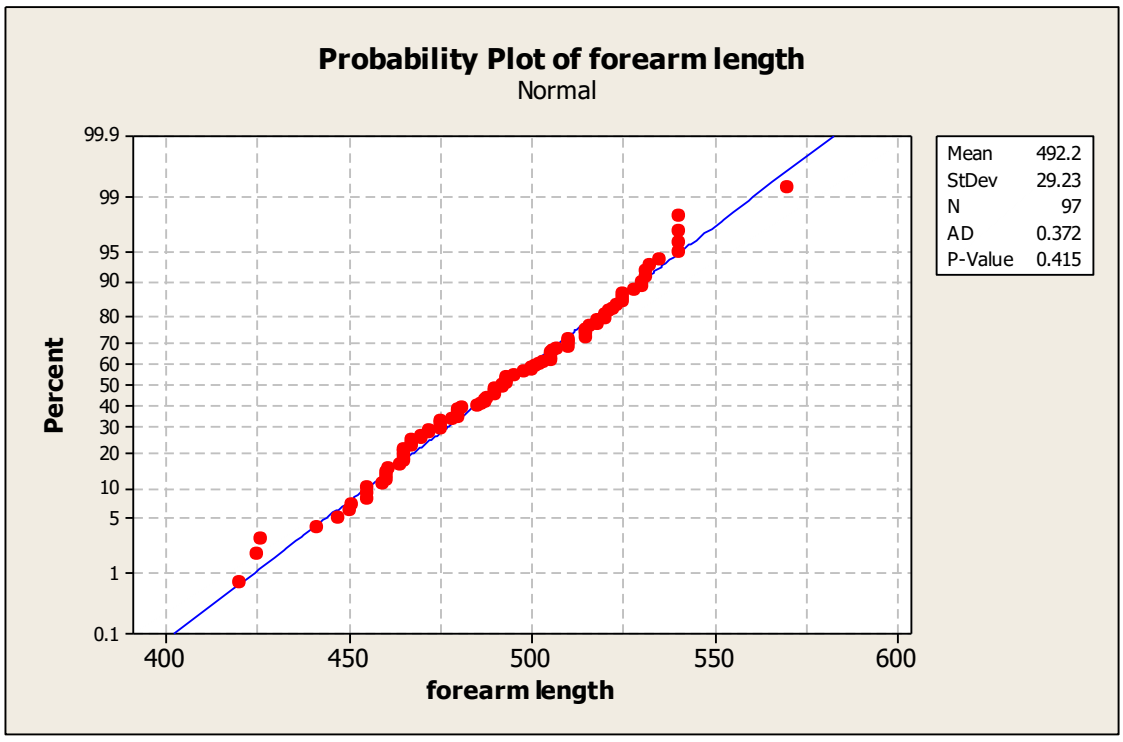

Figure C.4: Normal Probability Plot of Forearm Length Male

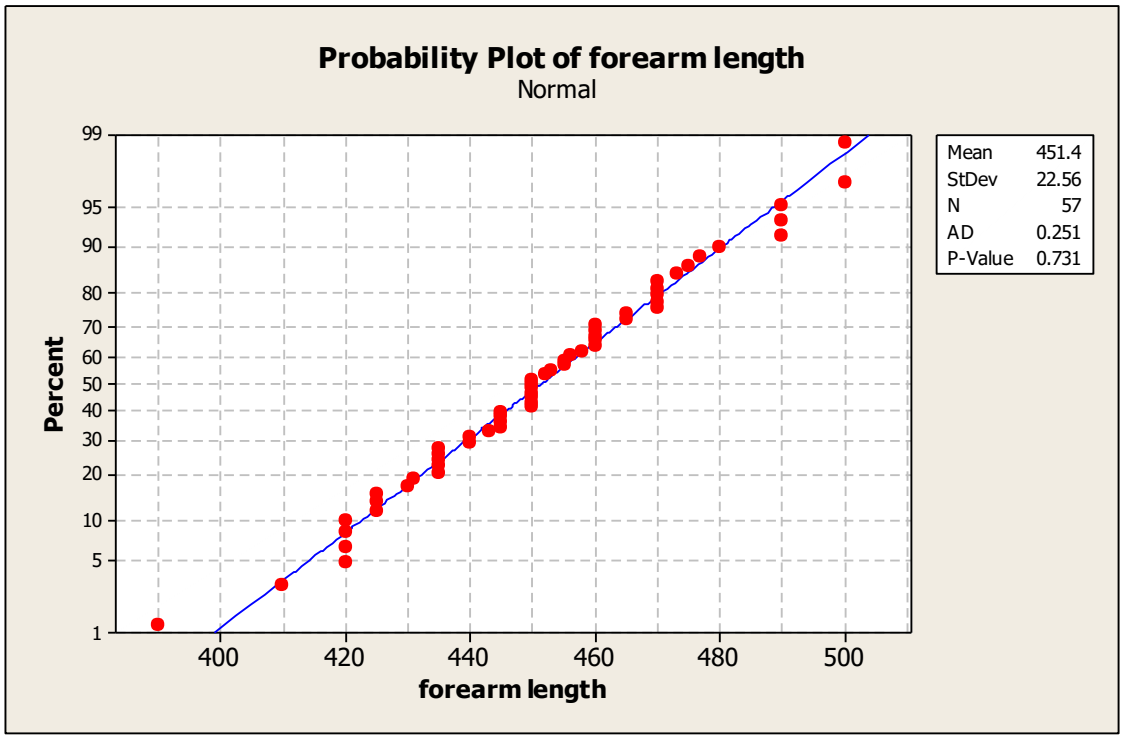

Figure C.5: Normal Probability Plot of Forearm Length Female

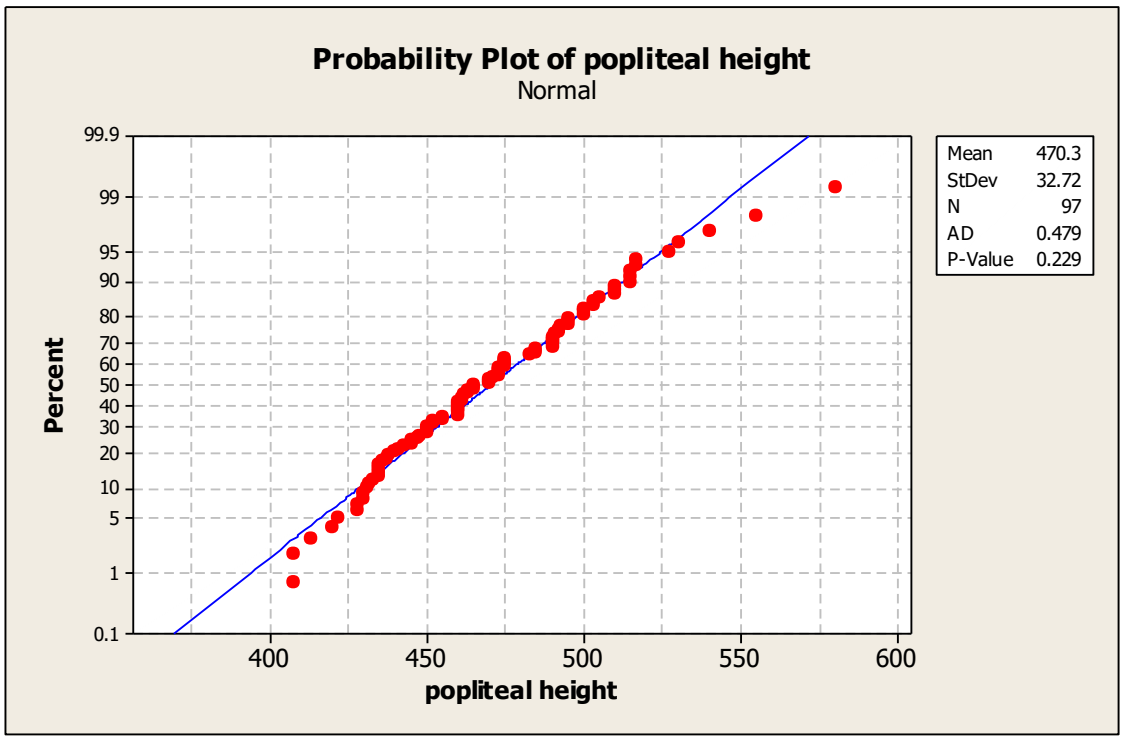

Figure C.6: Normal Probability Plot of Popliteal Height Male

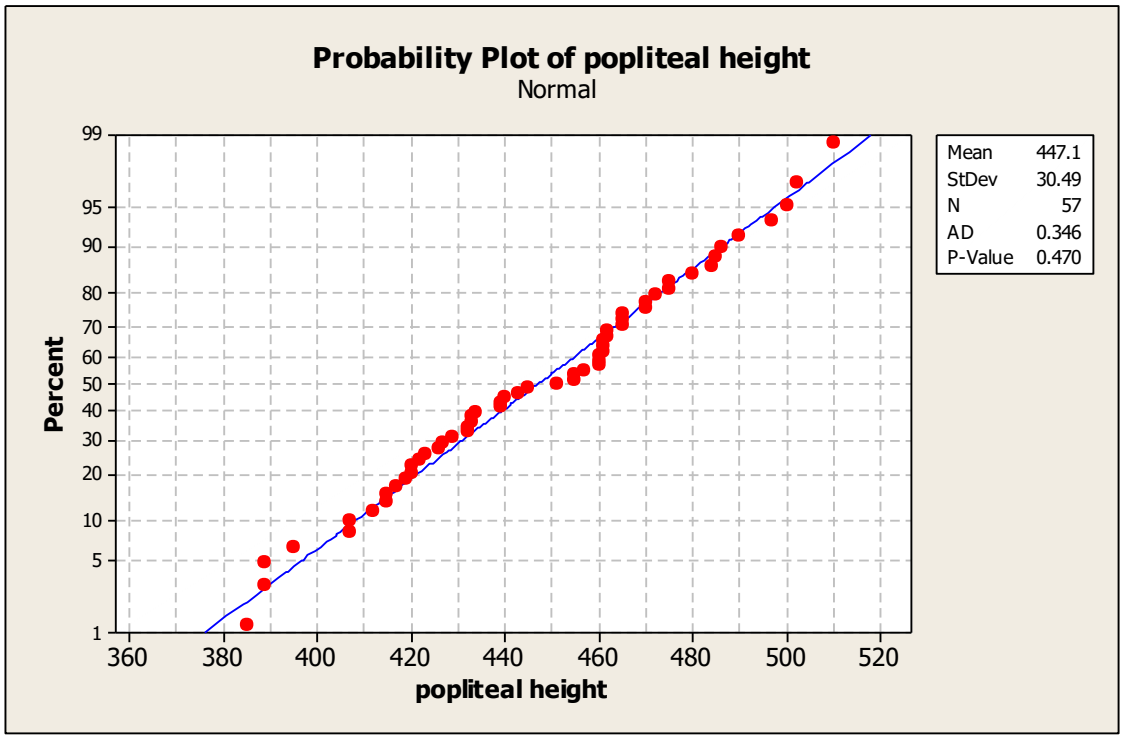

Figure C.7: Normal Probability Plot of Popliteal Height Female

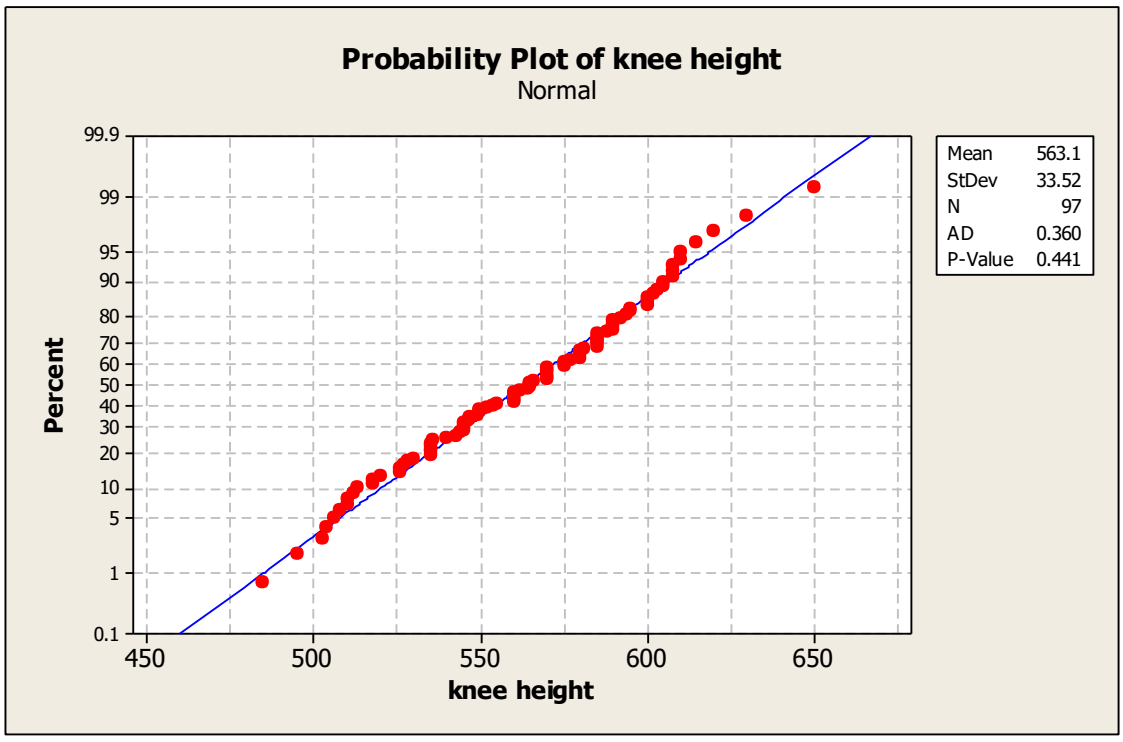

Figure C.8: Normal Probability Plot of Knee Height Male

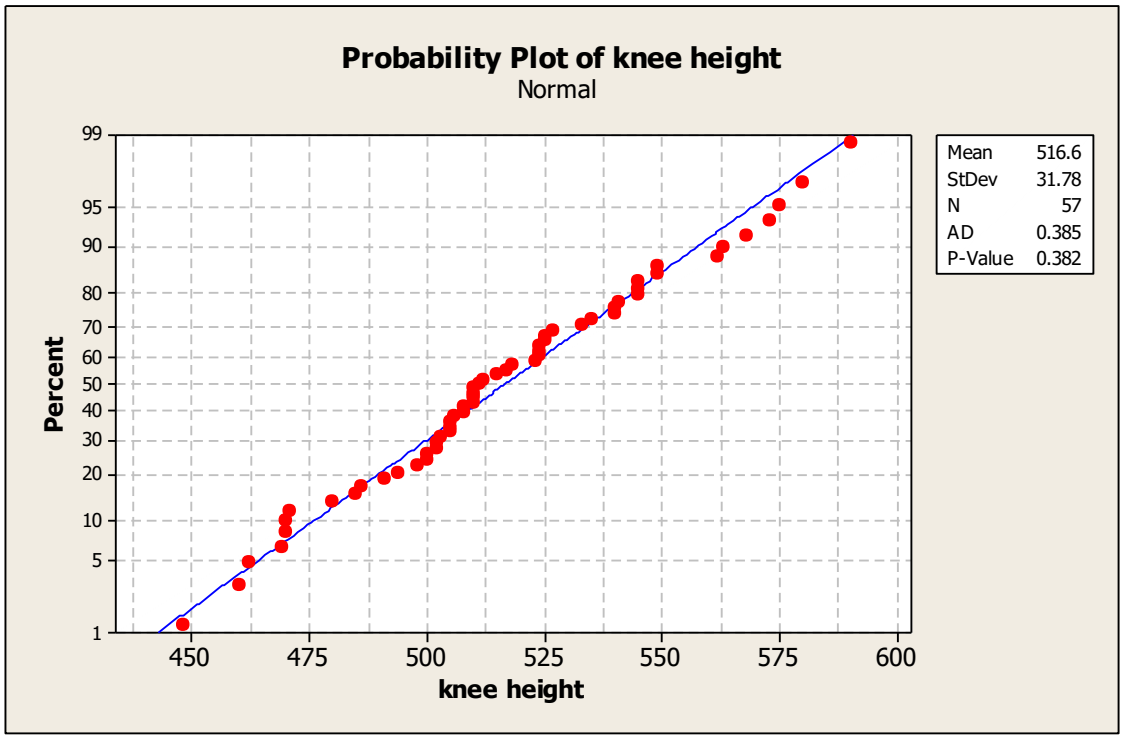

Figure C.9: Normal Probability Plot of Knee Height Female

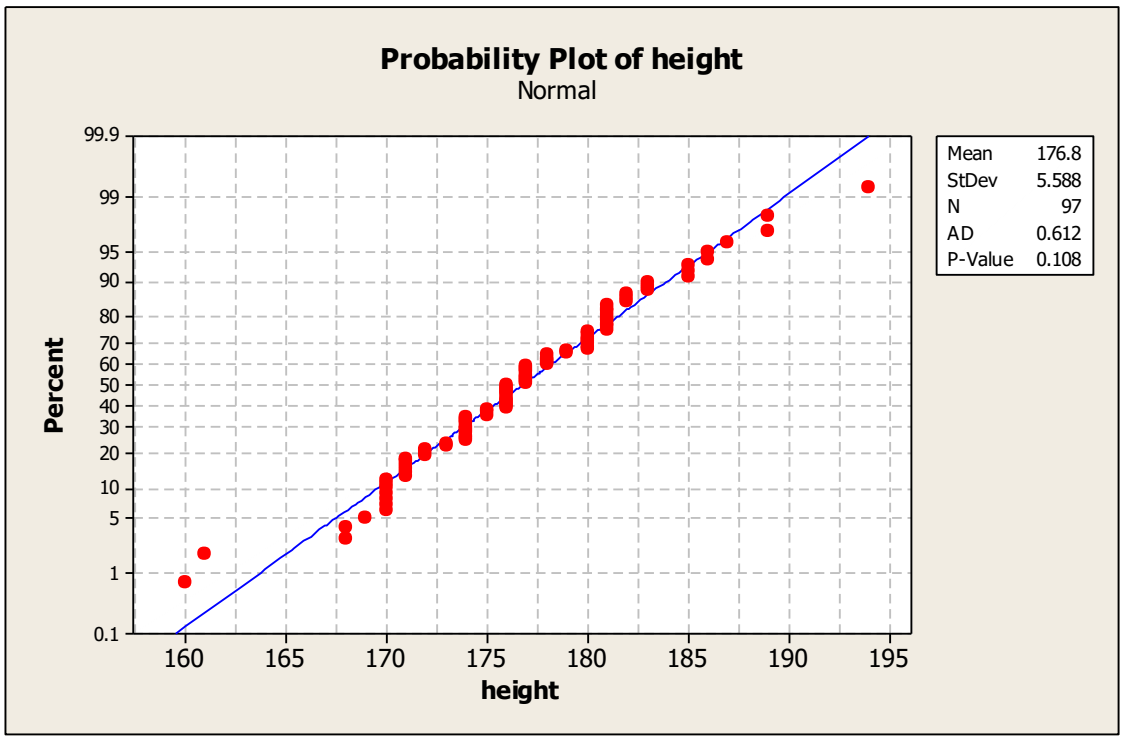

Figure C.10: Normal Probability Plot of Height Male

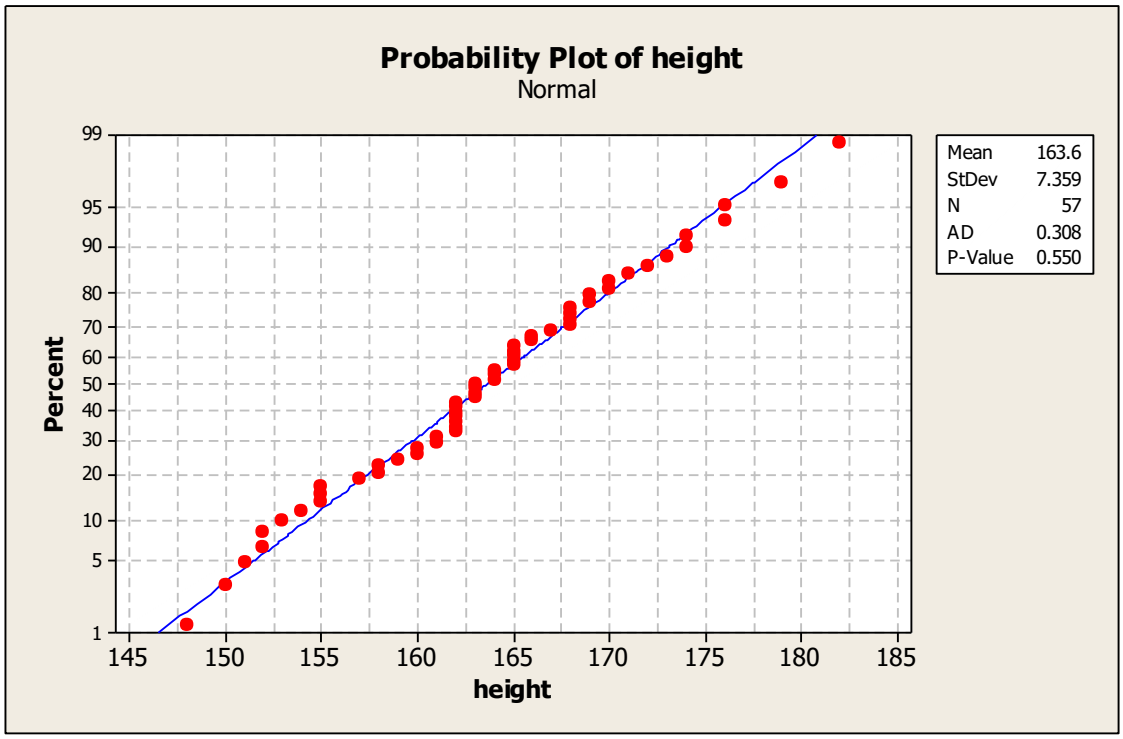

Figure C.11: Normal Probability Plot of Height Female

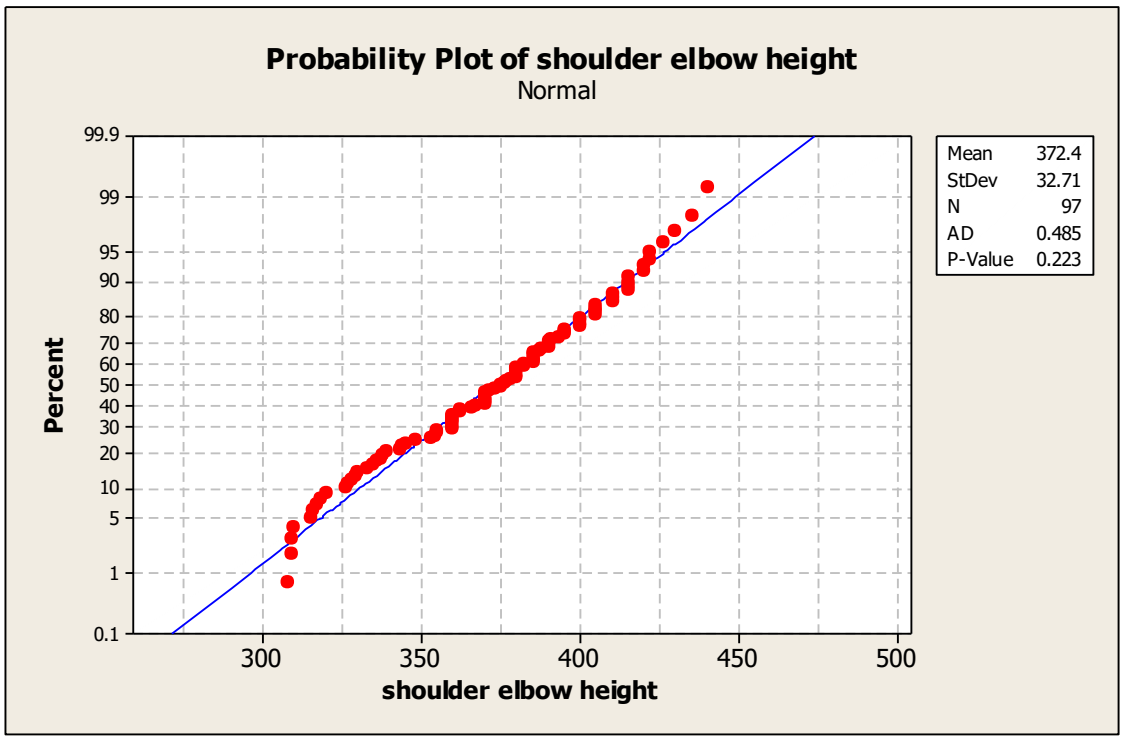

Figure C.12: Normal Probability Plot of Shoulder Elbow Height Male

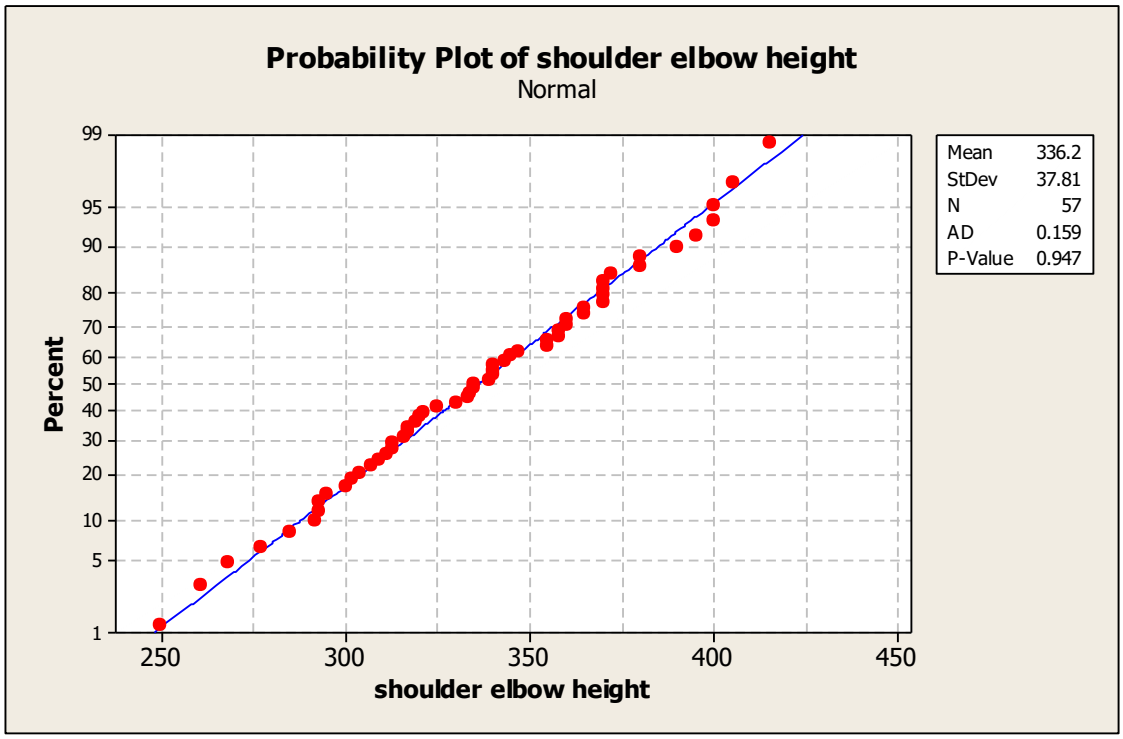

Figure C.13: Normal Probability Plot of Shoulder Elbow Height Female

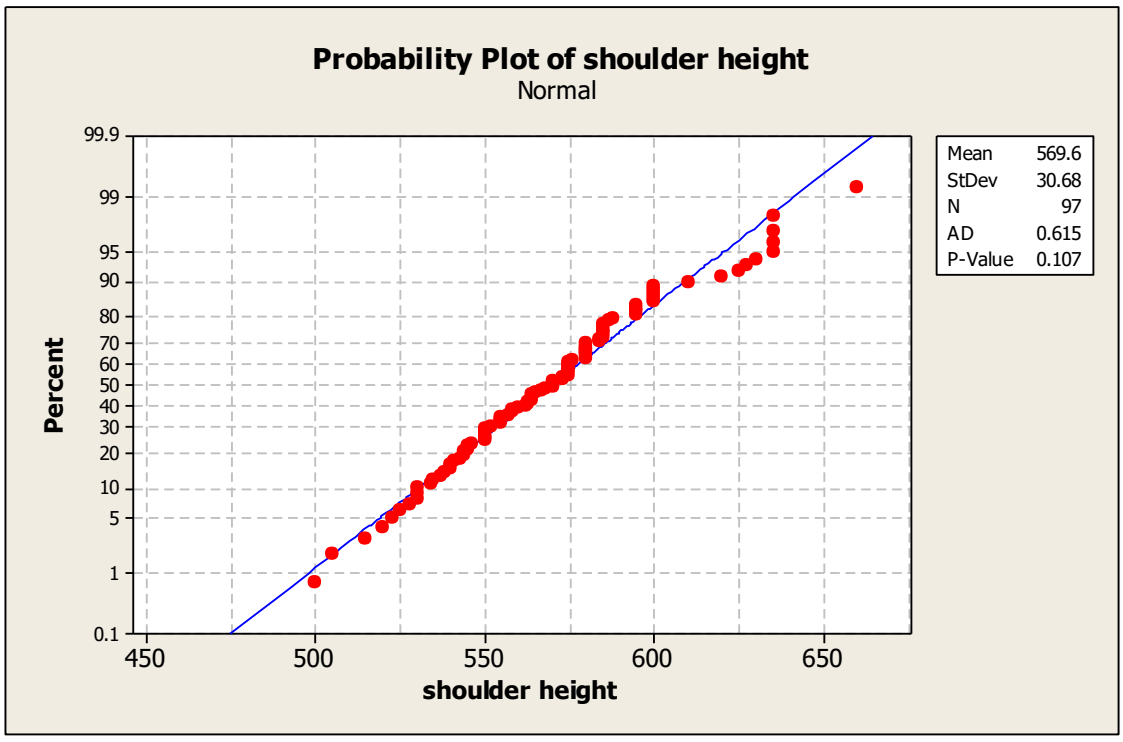

Figure C.14: Normal Probability Plot of Shoulder Height Male

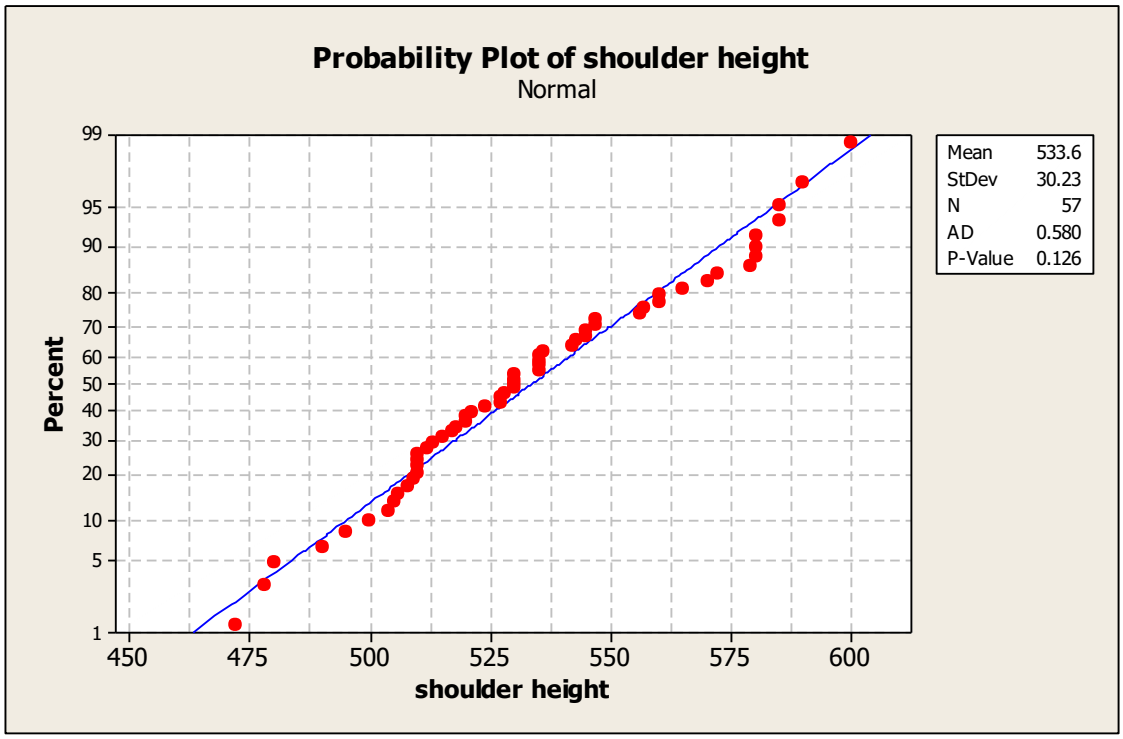

Figure C.15: Normal Probability Plot of Shoulder Height Female

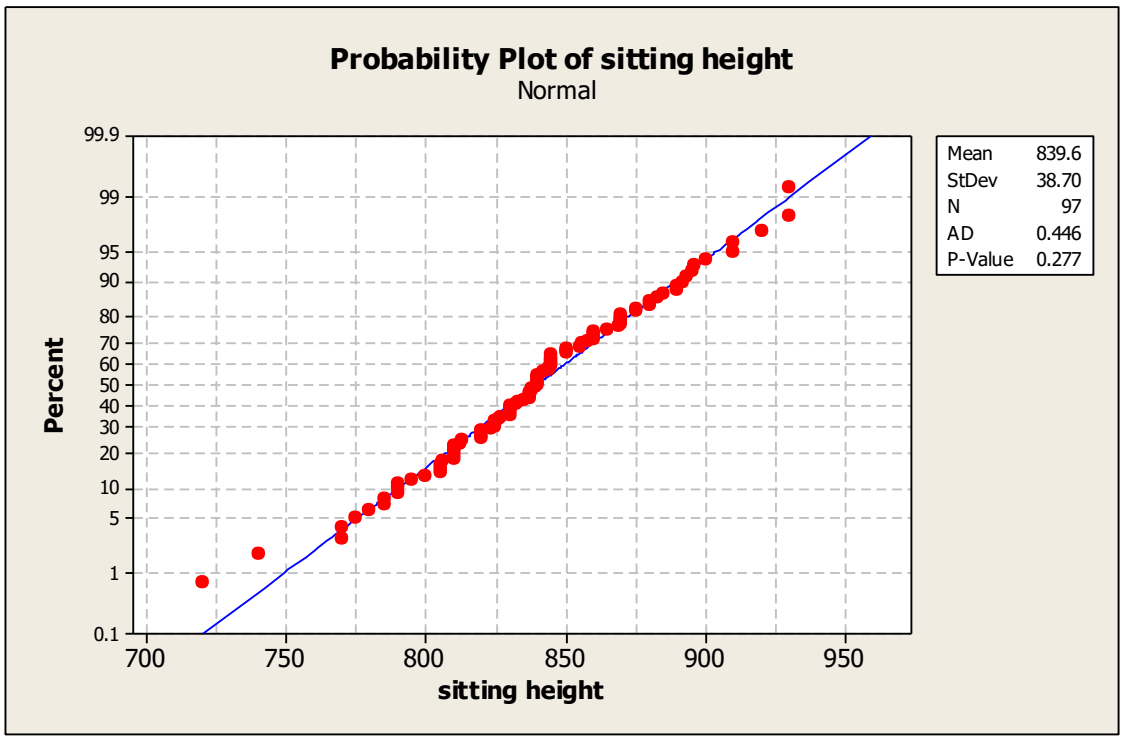

Figure C.16: Normal Probability Plot of Sitting Height Male

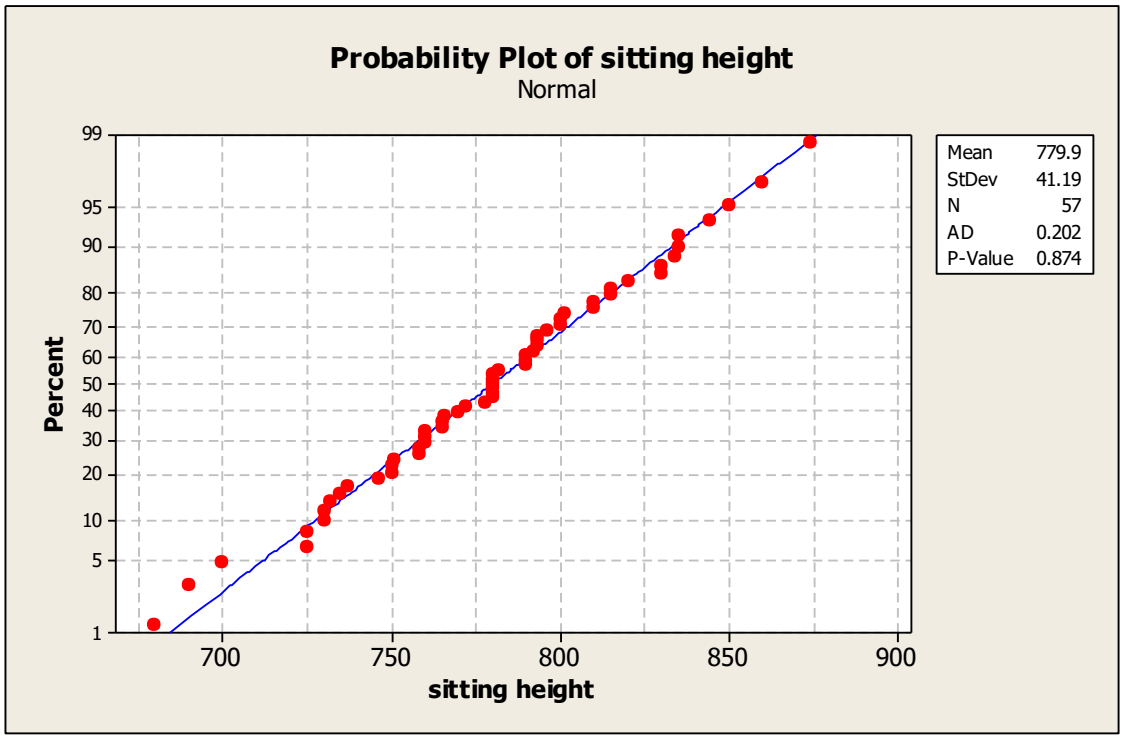

Figure C.17: Normal Probability Plot of Sitting Height Female

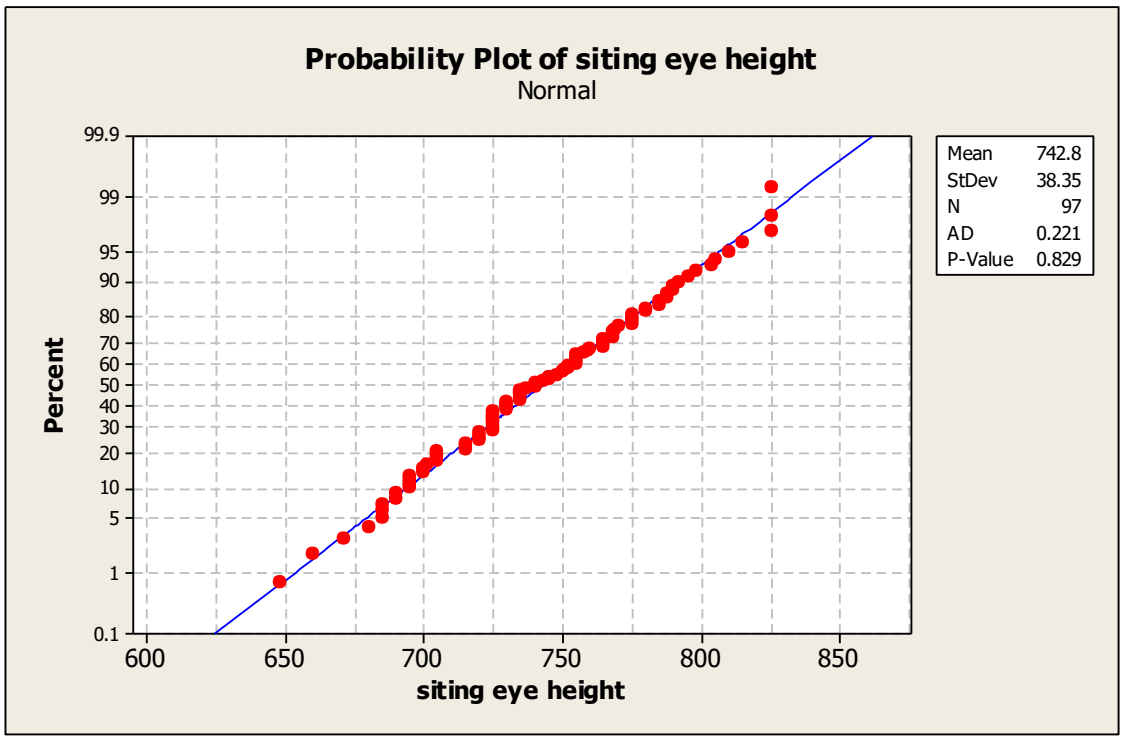

Figure C.18: Normal Probability Plot of Sitting Eye Height Male

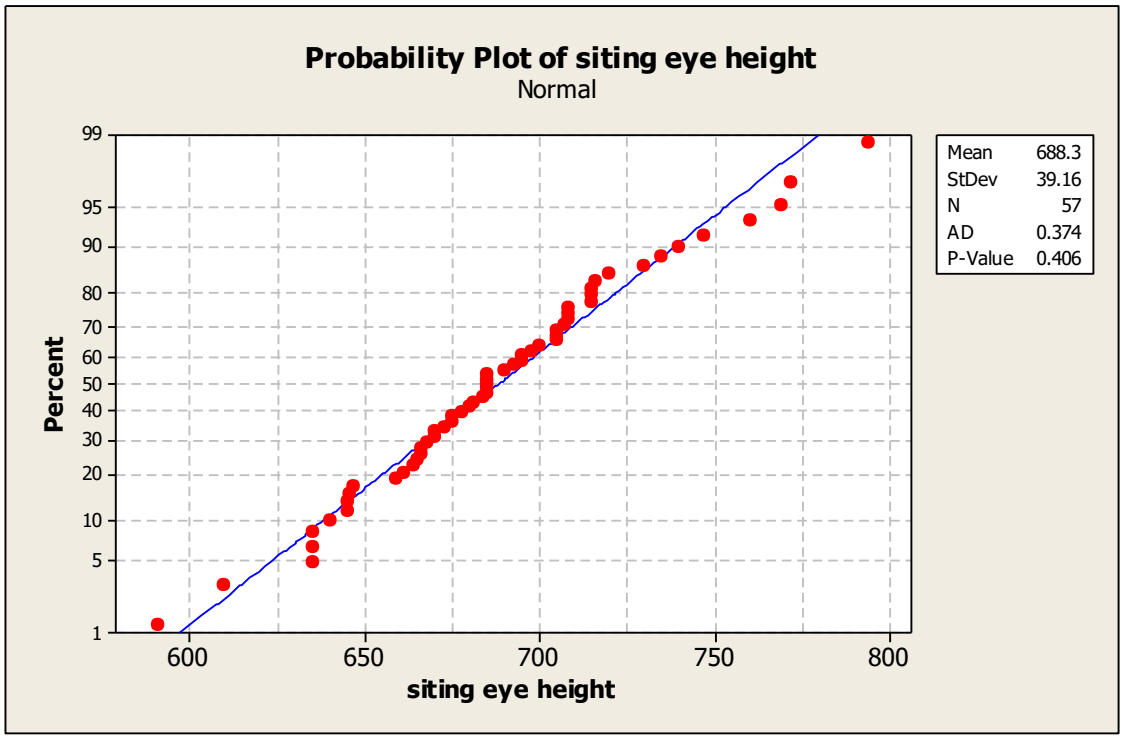

Figure C.19: Normal Probability Plot of Sitting Eye Height Female