DEVELOPMENT OF AN ANTHROPOMETRIC DATABASE TO DETERMINE SCHOOL FURNITURE DIMENSIONS FOR GRADE SIX STUDENTS

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Degree of Master of Engineering

Department of Mechanical Engineering

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Dissertation submitted in partial fulfillment of the requirements for the degree Master of Engineering in Manufacturing Systems Engineering

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

Anthropometry of school children is essential for decide the dimensions of furniture. However, no students' anthropometric studies have been carried out in Sri Lanka after 1979. Thus Sri Lanka depends on anthropometric measurements of other populations when designing furniture and other components. The deviations from the expected data and the available data of anthropometry may lead to errors in making decisions for selecting suitable furniture, equipment, and other components and importing them as well. Use of such incorrect items may result in long term health effects. Therefore Sri Lanka needs to establish anthropometric data for school children. The aim of this dissertation was thus to study anthropometric measurements required to determine the dimensions of school furniture for grade six based on a study in the Sabaragamuwa province of Sri Lanka.

The research was carried out using 508 students. The results obtained from the data analysis were used to compare existing furniture dimensions available in the selected schools and standard furniture sizes specified in Indian standard IS 4837:1990 for school furniture dimensioning. A set of recommended desk and chair sizes of grade six students based on the anthropometric data taken from the students in Sabaragamuwa province have been proposed at the end of the report.

However, a comprehensive island wide anthropometric survey is recommended covering all districts, including student categories from grade 1 to grade 12 and revisit the existing furniture dimensions because no detailed study has been performed after 1979 in Sri Lanka and also students' anthropometry may have changed with the change of standard of living, food habits, intra-individual, inter-individual, and secular variation of measurements during the past 40 years.

Key words: Anthropometry, school furniture, sitting posture

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LIST OF ABBREVIATION

Abbreviation	Description
SHH	Shoulder height sitting
EHS	Elbow height sitting
TT	Thigh thickness
BPL	Buttock-Popliteal length
PH	Popliteal height
SUH	Subscapular height
HW	Hip width
S	Stature
BKD	Buttock-Knee Depth
SH	Sitting Height
EFTL	Elbow Fingertip Length
KH	Knee height
EB	Elbow to Elbow Breadth
EH	Eye Height
SH	Seat height
SD	Seat depth
UEB	Upper edge of backrest
SDC	Seat to desk clearance
DH	Desk height
UNESCO	United Nations Educational, Scientific and Cultural Organization
ISO	International Standards for Organization
BSI	British Standards Institution
BS	British Standards
SQRT	Square Route
ISI	Indian Standards Institution

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CHAPTER 1

INTRODUCTION

1.1 Students in the class room

The ergonomics of sitting is a subject which has become vital in everyone's day to day life, not limiting to workplace, home, playground, travelling and school. People believe the need to sit up with a straight back. This has been reinforced in schools and elsewhere by the use of backboards to maintain this posture. Sitters used chairs with vertical backs and horizontal seats. The belief in a straight back when sitting on a horizontal seat is still implicit in descriptions of 'correct' sitting [1]. The shape of the chair is important for a good sitting posture, for an instance the adjustable chair with good lumber support, good arm rest, and 10°-15° inclination backward reduces the neck and shoulder muscles contraction during reading, writing etc [2]. Students' postural variation depends on the school furniture and students do adapt to their own posture regardless of the furniture [3]. Students are repetitively exposed to the hazards of abnormal or awkward postures due to classroom furniture that is often either too big or too small [4]. The table which has adjustable facility is more comfortable when compared to fixed surface table [5], [6]. There are two most frequent sitting positions assumed by the students, position one is the sitting, viewing, and listening usually the master in front of the white board. The eyes are focused at a distance of several metres. The head is held erect. The weight of the body is supported by the back, the buttocks and the feet. The second position is sitting working at a table. The head is tilted, the eyes are focused on the books on the table. It should be possible to work without strain at the visual near point. The trunk of the body slopes forward. The body is supported by the buttocks, the feet and, to a certain extent, the arms on the table [7]. The student should be able to see, reach, move, get up and down or use the back rest, maintaining the lowest working loads on their bodies [8]. The conducive learning environment in the class room, physical and mental health besides productivity depend on how compatible the equipment, furniture with the physical characteristics of the student [9]. Students spend much time, 30% of their time sitting on chairs during school time. Improper design of school chairs and desks lead to health and learning problems [10], [11].

The asymmetry between growth of children with the age and their activity elements such as carrying school bags, working conditions in schools, conditions at home: bed and sleeping pillow, chairs and table for school seating, etc leading to emerging deformation of the spine. Research shows that there is a percentage of these disorders where appropriate correction or medical treatment has been required. Absence of treatment or action on time can have far reaching consequences both for the individual and for the whole community [12].

1.2 Anatomical view

It has been observed that the anatomical differences of male and female have an effect on body mass distribution differently. Males are generally taller, heavier and have more muscular mass. They carry relatively less body fat unlike females. Females' body fat is more evenly distributed over the body. Women have wider hips, narrower shoulders, shorter legs and less muscular mass in the upper limbs. Their bone structure is lighter and weighs on average 2.8 kg as opposed to the male skeleton that weighs on average 4 kg [13].

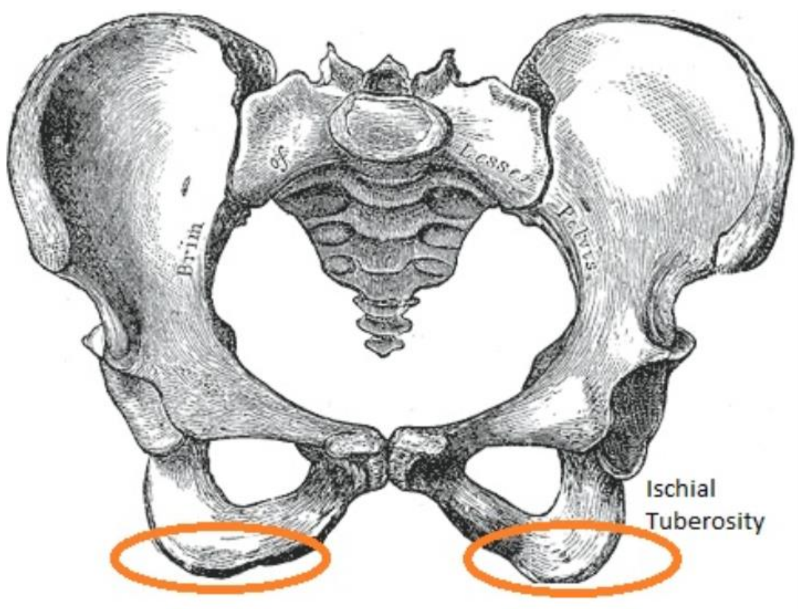

Figure 1.1: A diagram of ischial tuberosities of the pelvis [14]

A diagram of ischial tuborosities of the pelvis is illustrated in Figure 1.1 [14]. When a person is sitting on a chair 75% of his body weight is supported by 26cm^2, small area which is under the ischial tuborosities of the pelvis. High compressive stresses about 85-100 pounds per square inch (psi) is generated in this area due to load from the body weight. Structurally, the tuberosities form a two-point support system which is inherently unstable, since the center of gravity of a seated person's body above the seat may not be directly over the tuberosities. Therefore, the seat alone is insufficient for stabilization, and the use of the legs, feet, and back in contact with other surfaces, as well as muscular forces, is necessary to produce equilibrium of the body. This is further facilitated from the leg by distributing and reducing buttock and thigh loads. Feet need to rest firmly on the floor or foot support so that the lower leg weight is not supported by the front part of the thighs resting on the seat. Maintaining erect position of trunk of the body and trunk – thigh angle >90°. Students require more muscular force for sitting on an improperly designed chair for controlling equilibrium, resulting greater fatigue, discomfort, and experiencing pain at back and neck area [15]. In many sitting positions the part of the body which is mostly affected is the spine and the muscles of back, not relaxed but stressed in various ways [16]. The studies have been carried out in Denmark, Korea, Japan, New Zealand, Australia and USA and results revealed that large numbers of students with back problems [17]. Improper sitting posture leads to prolongs static muscles contraction appears in head, shoulder and neck pain [2].

1.3 Importance of anthropometric database

It has been noticed that the science of human factors is rarely incorporated into the design of school furnishings and children sit on chairs designed by tradition [18]. Understanding students' anthropometry is necessary for students' furniture designers and interior designers in environmental design to appropriately plan and suggest furniture dimensions for the age group [19]. The best practices related applied ergonomic seating and positioning has been developed in the workplace, but it has tended to be slow progress in the context schools. The degree of matching between school furniture dimension and the students' anthropometric will lead to have an idea about postural overload. For an instance when the student seat height is low, students increase upper back left inclination and right upper arm elevation. Also it has been found that students earned higher score in the intelligence test when seated in school furniture which fit to their anthropometric dimensions compared to bigger sized furniture. This has further proved that the students performed well when they are on appropriately sized desks compare to the traditional class room furniture [20].

The design can be used easily, comfortably and effectively by all users through applying anthropometric data to the selection of design of tools, equipment, workstation etc [21]. If a country has anthropometric databases they can be used effectively for designing school furniture, doing survey on school furniture, and evaluating the adequacy fitness for use [22]. On the other hand in the absence of anthropometric database of a certain country may tend to use another country’s database which may not be suitable for the school furniture designing purpose. In such situation it is vital to ensure the degree of accuracy and applicability of other country’s data. For an example, if United States measurements were used to size chairs for 14 year old Indonesians, assuming the lower leg to be 0.25 of standing height, they would be given seats 408 mm high, instead of the 350 mm they require. This is a difference of 58mm, which is significant. Similarly if United States measurements were used to size chairs for 14 year olds in the United Kingdom, the difference would only be 5mm. which is not significant [7]. This reveals that the greater importance of standardizing school furniture dimensions in an appropriate manner. Even though there are many studies have been carried out in this subject internationally, no studies have been carried out for last 40 years in Sri Lanka. The anthropometric data has been published in 1979. During this period due to change in socio-economic factors, food pattern, and living conditions etc, it is questionable about the applicability of such data today. There are considerable number of literatures published related to this area internationally in the countries such as Chile, Bangladesh, Nigeria, Iran, Portugal, Turkey, USA, Malaysia, Taiwan, Portuguese, and Gaza strip etc, no evidence in literature available locally to match school chairs and desks dimensions and students’ anthropometry in Sri Lanka.

With the heavy school work of students they require to spend long hours sitting down. The problems in students' learning process may occur with the potential inadequate use of school furniture. The students' anthropometric characteristics are required to be considered during designing of school furniture to the needs of students and also to have safer school furniture. There is an increase in the number of standards for school furniture in different countries such as Chile, Colombia, European Union, Japan, and United Kingdom.

The studies have revealed that the students from higher socio-economic levels are taller than those of lower and medium socio-economic levels. When selecting samples of students from the society this phenomenon has been taken into consideration by stratifying the population as public, semi-public and private schools. Furthermore, ethnic diversity too has been considered in addition to the age and gender. From the research it has been identified that most of the average anthropometric dimensions and all of the bodily proportions have significant differences among four Asian peoples namely Chinese, Japanese, Korean and Taiwanese [23].

It is important to take into consideration the student growth, how they develop and mature with the age. For an instance, before puberty, the legs grow more rapidly than the trunk. In adolescents, the growth spurt is largely in the trunk. The body proportions related to stature(s) between different segments of the body, may be helpful for analysing the situation. "Stature" is defined as the vertical distance between the floor and the top of the head, and measured with the subject erect and looking straight ahead [23].

CHAPTER 2

LITERATURE REVIEW

2.1 Literature database

A literature database was developed under the scope of school furniture and students anthropometry. The search terms used were “school furniture ergonomics”, “students anthropometry”, “classroom furniture”, and “sitting posture”. The flow diagram of the used strategy and exclusion criteria for literature review is shown in the Figure 2.1.

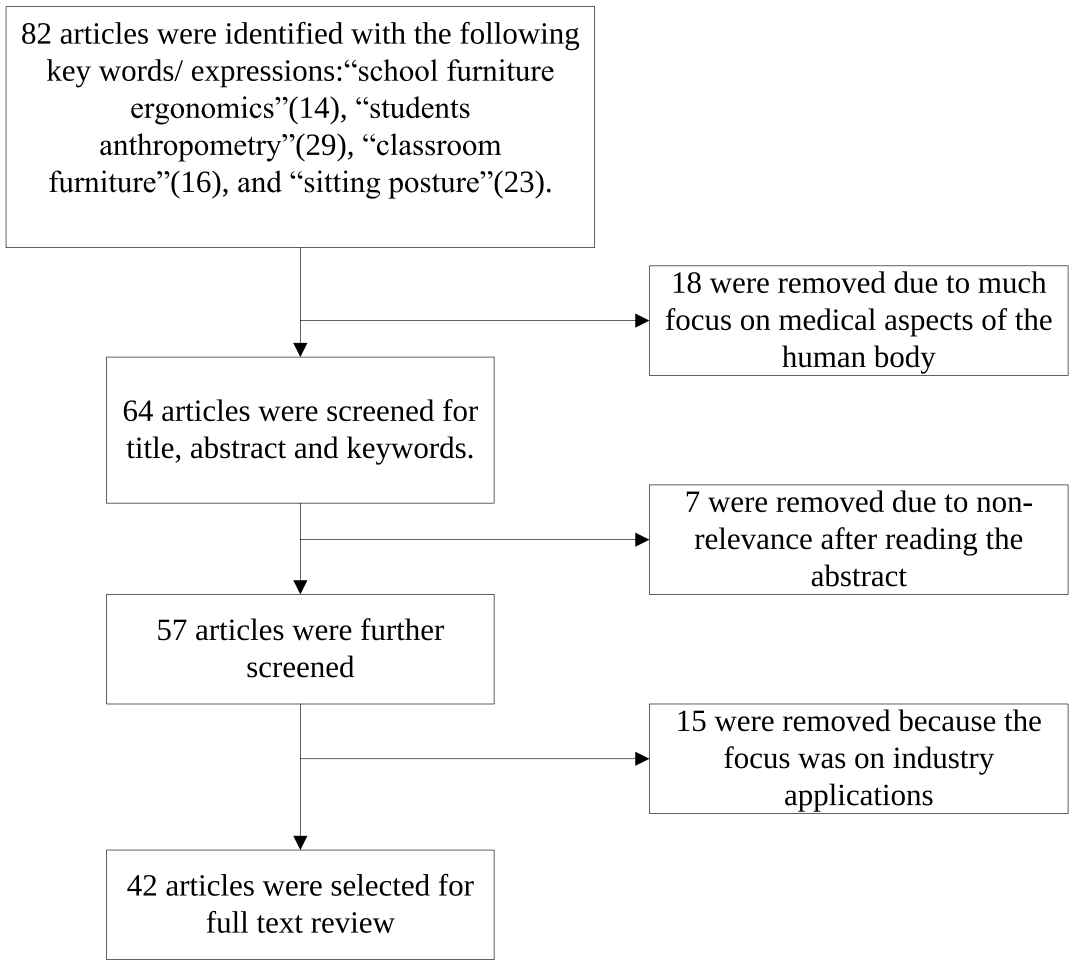

Figure 2.1: Flow diagram of the used strategy and exclusion criteria

The selected literatures were all reviewed. They were original studies written in English language and published between years 1979 and 2016. The literature review was ocused towards anthropometric measurements required to determine dimensions of school furniture.

2.2 Students' anthropometric dimensions required for designing school furniture

Anthropometric measurements have been defined in different ways in the literature and generalized definitions are given below and schematic representation anthropometric measurements are illustrated in Figure 2.2. The measurements are in two categories, static measurements (eg. Seating and working surface sitting), based purely on the size of the body and dynamic measurements (working surface standing and vertical writing surface), based on what can be performed. Static anthropometric data are commonly used for designing purposes compared to dynamic data. In static anthropometry, the measurements are made either from one anatomical structure to another or with reference to a fixed reference point in space [24].

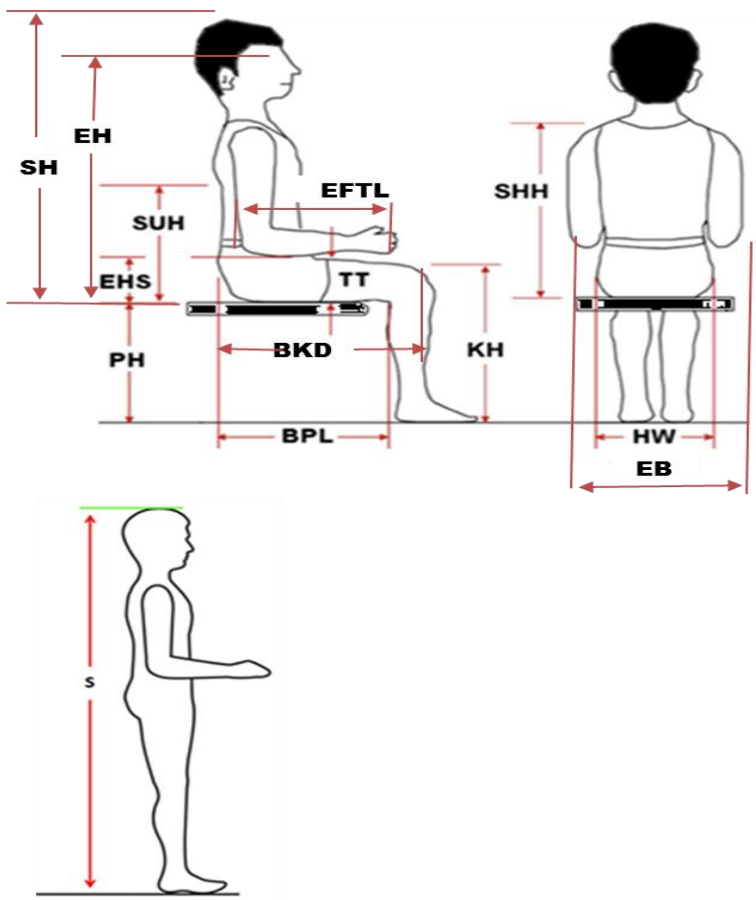

Figure 2.2: Schematic diagram of anthropometric measurement [23]

1. Shoulder height sitting (SHH): Vertical distance from student seated surface to the acromion.
2. Elbow height sitting (EHS): Taken with a 90° angle el-bow flexion, as the vertical distance from the bottom of the tip of the elbow (olecranon) to the student seated surface.
3. Thigh thickness (TT): The vertical distance from the highest uncompressed point of thigh to the student seated surface.
4. Buttock-Popliteal length (BPL): Taken with a 90° angle knee flexion as the horizontal distance from the posterior surface of the buttock to the Popliteal surface.
5. Popliteal height (PH): Measured with 90° knee flexion, as the vertical distance from the floor or footrest and the posterior surface of the knee (Popliteal surface).
6. Subscapular height (SUH): The vertical distance from the lowest point (inferior angle) of the scapula to the student seated surface.
7. Hip width (HW): The horizontal distance measured in the widest point of the hip in the sitting position.
8. Stature (S): Determined as the vertical distance between the floor and the top of the head, and measured with the subject erect and looking straight ahead (Frankfort plane).
9. Buttock-Knee Depth (BKD): Distance measured horizontally from the front of the kneecap to the back of uncompressed buttock.
10. Sitting Height (SH): Vertical distance from the tip of the head to the surface of the sitting object (stool)
11. Elbow Fingertip Length (EFTL): It is refers to the horizontal distance from the back of the elbow to the tip of the middle finger at standard sitting position.
12. Knee height (KH): Vertical distance from floor to the top of knee cap

13. Elbow to Elbow Breadth (EB): Distance measured horizontally across the lateral surface of the elbows (standard writing position on the desk), spreading sideways was measured.
14. Eye Height (EH): Eye height refers to the vertical distance from inner canthus of the eye to the sitting surface.

In the anthropometric study in Chilean region, main focus was on most relevant anthropometric dimensions for school furniture selection and the aim of the study is to determine if popliteal height can be used as a better or more adequate measure for class room furniture selection when comparing with stature. The Pearson correlation coefficient was calculated between considered anthropometric measurements used in the research studies. Another study has been carried out to determine stages of growth of both male and female students and the variation of proportion of shoulder height sitting and popliteal height to stature.

According to the study carried out in Malaysia using engineering students results has showed, mean values of male students body dimensions such as eye height, popliteal height, arm reach forward and sitting height and shoulder height of male students are found to be higher than female students. This enforced neediness of modifying study equipment fitting both male and females uses before introduced them [9]. The anthropometric dimensions of students vary with the age. The students who in closer ages like 10 years and 11 years do not show significant difference in mean values of data while 10 years and 15 years show significant difference [25].

It has been observed in previous research, in addition to the age, gender ethnic diversity also contributed to above proportions and people of different nationalities like Chinese, Japanese, Korean and Taiwan show different bodily proportions. Anthropometric dimensions of American and Greek children are longer than the anthropometric measurements of Iranian students, less than Taiwanese and similar to Mexican [26]. The base body dimension for ergonomic design, 5% percentile of popliteal height figures of American and Korean males and females are 39cm and 36cm, respectively, even though the heights of Korean males and females were lower by about 1cm than those of American counterparts, respectively [27].

Anthropometric data obtained for a certain region will change with the time in terms of changing socio-economical conditions and therefore, updating of anthropometric measurements made in the studies before at every five years is recommended [28].

2.3 Furniture characteristics required for designing school furniture

School furniture dimensions have been defined and their generalized definitions are given below and the schematic representation of school furniture dimensions is shown in the Figure 2.3.

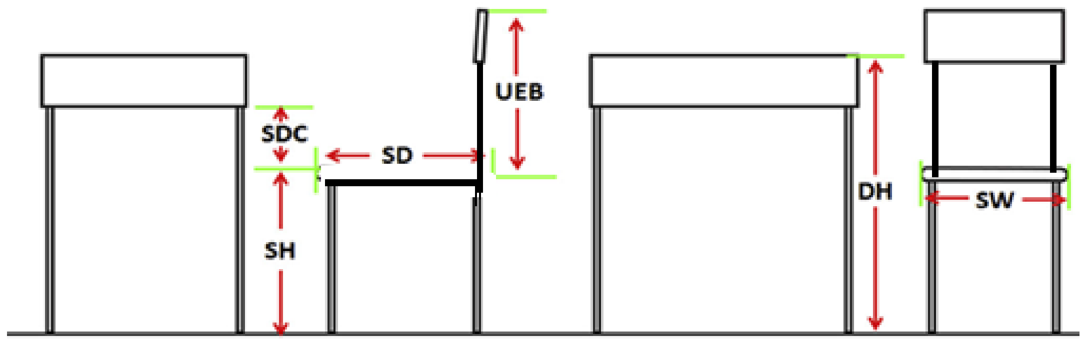

Figure 2.3: Schematic diagram of school furniture measurement [16]

1. Seat height (SH): Vertical distance from the floor to the middle point of the front edge of the sitting surface
2. Seat depth (SD): Distance from the back to the front of the sitting surface
3. Upper edge of backrest (UEB): Vertical distance between the middle points of the upper edge of the backrest and the top of the sitting surface
4. Seat to desk clearance (SDC): Vertical distance from middle point of the front edge of the sitting surface to the lowest structure point below the desk
5. Desk height (DH): Vertical distance from the floor to the top of front edge of the desk
6. Table slope: The table slope is the angle of pitch of the top of the desk.

7. Table clearance: The table clearance is the vertical distance from the floor to the bottom of the front edge of the desk or table.

Availability of both male and female anthropometric data in a country provides great benefit for school furniture designers and importers of goods to the country. The differences of anthropometric data of developed countries and developing countries such as Sri Lanka are responsible for the variations and incompatibility of imported goods to the country [29]. According to the anthropometric studies carried out by United Nations Educational, Scientific and Cultural Organization (UNESCO) in year 1979 for selected males and females, students' stature measurements of different countries in the Pacific and Asia region such as USA, UK, Venezuela, Iran, Japan, Sri Lanka, Philippines, Thailand, India, and Indonesia, it is evident that the student stature is different from country to country. For an instance, a 14 year old Indonesian has the standing height of a 10 year old North American. Statistical differences will be insignificant within groups but may be either significant or insignificant between groups. Also furniture designed to fit children in the Philippines could be used in Thailand without the need to collect statistics in that country. The study further revealed that anthropometric measurements are required for furniture design for seating, working surface sitting, working surface standing, and vertical writing surface. Seating requires popliteal height, popliteal length, hip width, and shoulder width. Working surface sitting design requires height of elbow, thigh thickness, and eye height. Anthropometric measurements applicable to seating and working surface sitting are considered for chair and desk design [7].

When conducting studies related to the subject, different countries have used different sample sizes and also taken into consideration age, gender, socio economic factors and student activities etc. Table 2.1 shows for the different studies carried out in different countries' their sample sizes with reference to male and female categories.

Table 2.1: A summary of sample sizes used in different studies in different countries

Country	Sample size	Male students	Female students	Reference literature
South Korea	121	91	30	[3]
Portugal	432	216	216	[4]
Turkey	183	104	79	[9]
USA	74	37	37	[15]
Chile	2,261	1,259	1,002	[20]
India	300	150	150	[21]
Chile	3,046	1,664	1,382	[23]
Turkey	1,049	714	335	[24]
Iran	2,030	1,015	1,015	[26]
Gaza strip	120	120	-	[29]
Bangladesh	300	150	150	[30], [31]
Nigeria	240	120	120	[32]
Nigeria	160	81	79	[33]
Turkey	1,948	1106	842	[34]
Malaysia	125	73	52	[35]
Malaysia	153	Not specified	Not specified	[36]

2.4 Anthropometric data for furniture sizing & school furniture characteristics

The study has been carried out in Chilli with the aims to describe the criteria equation for defining the mismatch between student and school furniture, to apply the different mismatch equations to a specific sample, and to propose a methodology to evaluate school furniture suitability. Mismatch equations one way and two ways have been considered. Both maximum and minimum limit values are considered for two way equations and either maximum or minimum limits are considered for one way equations. In the study, anthropometric measurements have been taken while the student is sitting on a height adjustable chair, sitting in an erect position with a horizontal surface, with student feet flat on the floor or an adjustable footrest, and with the leg flexed 90° angle. The students were without shoes and wearing light clothing during taking measurement [16]. According to the study carried out in Turkey the method of measurement taking of selected anthropometric measurements include eye height (vertical distance from the floor to the inner canthus or corner of the eye), elbow height (vertical distance from the floor to the radial), shoulder breadth (horizontal distance across the shoulders measured between the acromia, bony points), and buttock-knee length (horizontal distance from the back of the uncompressed buttock to the front of the knee cap) [34]. The shoe correction has been included in calculating and comparing seat height and popliteal height [20]. SH need to be lower than PH so that the lower leg forms a 5° to 30° angle relative to the vertical. The angle will permit the student to sit in a chair high enough so that both feet are placed on the floor. The seat should be low enough to avoid an extension, more than 30° relative to the vertical in the knee joint. If the feet cannot place flat on the floor or thighs would not be supported enough, it will result to generate discomfort.

Seat depth (SD) is evaluated based on the buttock popliteal height (BPH). This equation explains the relationship between the SD and buttock popliteal length (BPL). An uncomfortable situation may be due to the compression of the popliteal surface. To avoid this uncomfortable situation students would sit forward and would not be able to use the backrest of the seat proper way. Seat width (SW) should be at least 10%, but not more than 30% larger than HW in order to provide proper seating [23].

Another finding of Chilean study was the interaction between table and chair dimensions. The furniture dimensions which have been considered were underneath desk height (UDH), and seat to desk clearance (SDC) and anthropometric measurements Thigh thickness (TT), Popliteal height (PH), and Knee height (KH).

In a previous research it has been found that desk clearance should be 2 cm higher than KH. UDH has to be large enough to push the chair under the desk and to have enough space to allow leg movement [20].

In the study carried out in Bangladesh for finding out mismatch between classroom furniture and anthropometric measurements of Bangladeshi primary school students, the following observations have been made [30], [31].

1. Popliteal Height (PH) against Seat Height (SH)

The Seat Height (SH) is required to be adjusted relative to the Popliteal Height (PH) and allowing the knee to be flexed so that the lower legs form a maximum of 30º angle relative to the vertical axis. Generally, PH should be higher than the SH. The lower leg constitutes a 5°– 30° angle relative to the vertical. A mismatch between PH and SH is defined when the seat height is either > 95% or < 88% of the popliteal height (3 cm correction for shoe height is included to the popliteal height).

2. Buttock popliteal length (BPL) against seat depth (SD)

Seat Depth should be at least 5 cm less than the Buttock Popliteal Length However, the thigh would not be supported enough if the SD is substantially less than the BPL of the Students the backrest of the seat can support the lumbar spine without compression of the popliteal surface. Thus, a mismatch between SD and BPL is defined when SD is either < 80% or >95% of BPL.

3. Hip Breadth (HB) against Seat Width (SW)

The seat width must be large enough to accommodate the user with the largest hip breadth to attain stability and permit space for lateral movements. To accommodate hip breadth the SW should be at least 10% and at the most 30% (for space economy) larger than the hip breadth.

4. Sitting elbow height (SEH) against desk height (DH)

The elbow height is measured as the major factor for the desk height as the load on the spine reduces significantly when the arms are supported on the desk [20] and the desk height also be subject to on the shoulder flexion and shoulder abduction angles the desk height should be 3-5 cm higher than the SEH

5. Thigh clearance (TC) against Seat to desk clearance (SDC)

The suitable seat to desk clearance needs to be greater than thigh clearance in order to make available leg movement. The ideal seat to desk clearance should be 2 cm higher than knee height.

In the study carried out in Nigeria for anthropometric design of furniture for use in tertiary institutions showed the following findings.

The mismatch between the thigh length and seat depth creates discomfort and the mismatch in seated elbow height and desk height leads to neck and shoulder pain. The mismatch between thigh length and seat depth is significantly related to seating discomfort, and the mismatch between seated elbow height and the table height was significantly related to pain in the shoulder and neck [6]. In the study carried out in Belgium by using seventeen students with the help of video monitoring and some manual measurements, it was revealed that higher and forward sloped chairs contributed to larger hip angles during active working, the inclination of desktop contributed to neutral position of the head, neck and trunk compared to a flat table [38].

In the analysis of anthropometric dimensions and during furniture designing process percentile values has to be calculated for each parameter. Percentile values can be defined as, if a sample is arranged in order from the shortest to the tallest, the mean will be the point where half the sample have measurements lower and half higher.

This is expressed as a percentage. (½) x 100 = 50% and is called the 50th percentile. Similarly the 5th or 95th percentile point indicates the percentage of the sample at or below a given figure [7]. Refer Figure 2.4 for additional details.

The anthropometric measurements of students such as sitting height, sitting elbow height, thigh clearance, knee height, popliteal height, body weight, buttock popliteal length, hip breadth, eye height, buttock knee length, forearm hand length and age have been considered in the Nigerian study. During the analysis mean, standard deviation, minimum value, maximum value, 5th percentile, 50th percentile, and 95th percentile have been calculated for further the purpose of evaluation. Percentiles of some of the above anthropometric measurements can be recommended for determining design values for school furniture.

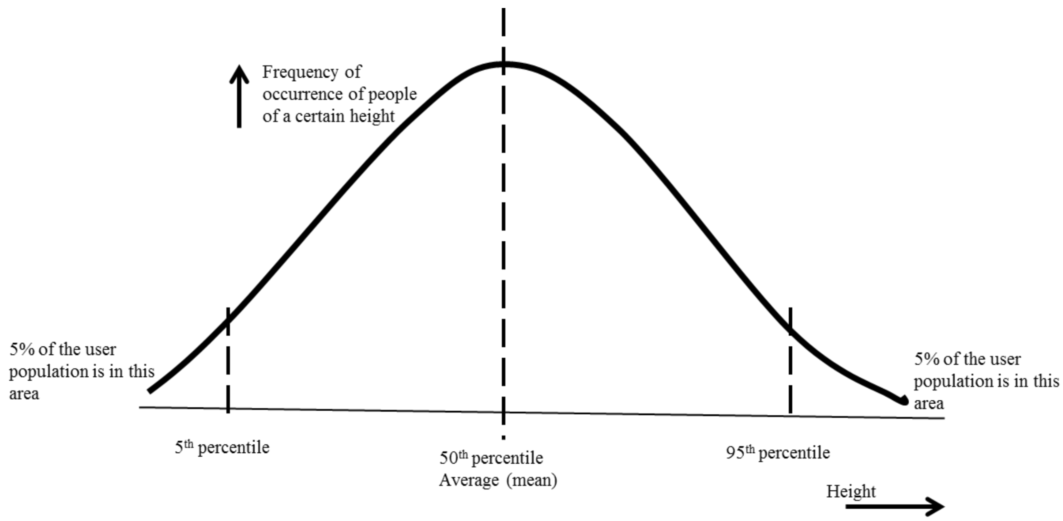

Figure 2.4: Representation of 5th, 50th and 95th percentile in normal distribution curve

The popliteal height should be considered in the design of seat height and for non-adjustable seats; the 5th percentile may be used as the maximum allowable seat height enabling to accommodate a larger number of the population and thus allow shorter person to use the chair.

The anthropometric dimension to be considered in the design of the seat depth is the buttock-popliteal length. The seat depth should not exceed the buttock- popliteal length of the shortest user. 5th percentile of buttock popliteal length has been recommended for seat depth. 5th percentile of popliteal Sitting shoulder height is recommended for upper back rest height. 5th percentile of popliteal Arm rest length is recommended for lower back rest height. The dimension of the seat width should be determined using the hip breadth of those with wide hips. The seat width should be wide enough not only to accommodate the user's hips and clothing but also allow the use of arms comfortably 95th percentile of hip breadth is recommended for the design of the seat and also table/desk widths to accommodate many people and thus allow a fat person to use the chair. The seat surface height, seat depth, seat width, backrest height, and backrest width are the important dimensions for the design of chairs while table height, table width and table length are the dimensions that are essential for the design of tables.

According to study carried out in Taiwan for ergonomic design of desk and chair for primary school, a model for school students' desks and chairs for Taiwanese school students has been established under categories of extremely design and adjustable design. "Extremely design" which is considering the application for extremely figure, such as fat, thin, tall and short people. For example like seat width. "Adjustable design" is for ordinary people. The ideal ergonomic dimension for primary school students apply by in this category for example like seat depth. The requirement of all students can be met with the design of adjustable chairs and desks with the advantage, schools does not require to spare different types of chairs and desks and purchasing is convenient due to less number of options [39].

According to the study carried out in Portugal on ergonomic design of school furniture: challenges for the Portuguese schools, the seat height is typically the starting point for the design of this type of furniture. The potential relationship between anthropometric dimensions and the furniture dimensions are required to be considered when selecting designing criteria in school furniture design. The correlation between variables can be an important point, as most of recommendations for furniture selection tend to use, as reference, the stature [40]. Spending money in properly designed, good quality furniture would be cost effective in the long run and would produce predictable health benefits [41]. According to the study carried out in Nigeria the interaction between students' anthropometric measurements and relevant furniture dimensions are shown in the Table 2.2 [26].

Table 2.2: Interaction between students' anthropometric measurements and relevant furniture dimensions

Furniture dimension	Anthropometric measurement
Seat surface height	Popliteal height
Seat depth	Buttock popliteal length
Seat width	Hip breadth, sitting
Back rest width	Hip breadth, sitting
Back rest height (upper) above seat	Sitting shoulder height
Back rest height (lower) above seat	Arm rest height
Backrest angle to horizontal	110º
Arm rest height	Sitting elbow height
Seat angle to horizontal	0º
Table height	Functional elbow height+ shoe heel allowance
Table depth	Forearm hand length
Table width	Hip breadth
Table angle to horizontal	15º

2.5 Methods used and standards applicable for taking anthropometric and furniture data for technological design

According to the ISO 7250:2008 standard for basic human body measurements for technological design (including body measurement definitions and land marks) is a good guiding tool to carry out preliminary preparation and taking anthropometric measurements at the field. The students should wear minimal clothing and without shoes, standing on the floor facing forward and arms hanging beside the body. For sitting dimensions, each student has to be seated erect on a flat horizontal surface, not compressible, with knees bent 90° and feet flat on the surface, facing forward, and arms hanging besides the body. Measurements have to be taken on either side of the body, if not possible take on single side, and it is important to indicate on which side the measurement is taken. The measurements which are affected by the breathing shall be taken during gentle breathing and in relaxed mode.

The standard measuring instruments such as an anthropometer, sliding calipers, spreading calipers, weighing scale and tape measure would be used to take measurements at the field are included in the Table 2.3.

Table 2.3: Standard anthropometric measuring instruments recommended in ISO 7250

Standard measuring instrument	Purpose
Anthropometer	For measuring linear distances between points on the body and standard reference surfaces, such as floor or a seat platform
Sliding caliper	For measuring breadth and depth of body segments and distances between reference marks
Spreading caliper	For measuring breadth and depth of body segments and distances between reference marks
Tape	For measure body circumferences
Measuring cube (200 mm on each side)	For determining the maximal posterior protrusion of seated person
Weighing scale	For measure the body weight

National standards for school furniture and standards for basic human body measurements for technological design have been published by various countries and different organizations. The designers and engineers who are involved in school furniture designs can consult respective national standards in the country, specially for developing their own furniture models and thus helps to minimize obvious mistakes during designing and manufacturing school furniture.

Further, International organization for standards in Geneva, Switzerland has developed international standards for school furniture establish ranges of body height of users and indicate the best respective sizes for a desk and chair, regardless of the school level: ISO 5970:1979 Furniture – Chairs and tables for educational institutions – Functional sizes and European Committee for Standardization has developed the standard EN 17291:2006 Furniture – Chair and tables for educational institutions – part 1: Functional dimensions at international level [39].

The available standards for taking body measurements for technological designs are;

- ISO 7250-1:2008 Basic human body measurements for technological design [42]
- IS 4837:1990 Indian Standard for school furniture, classroom chairs and tables – recommendations [8]
- Australian/New Zealand Standard AS/NZS 4024.1701 Part 1701 Human body measurements-Basic human body measurements for technological design [1]
- BS EN 13402-3 Size designation of clothes - Body measurements and intervals

CHAPTER 3

METHODOLOGY

3.1 Sample size calculation and Sample profile

3.1.1 Sampling method

Stratified convenience sampling approach was used. Sabaragamuwa province consists of two administrative districts namely Kegalle and Rathnapura. Sampling was done covering schools in both rural and urban areas in the districts. Student t-distribution tests were done to test whether there is a significant difference between mean stature values of students in Kegalle and Rathnapura for both male and female separately and also to test whether there is a significant difference between mean stature values of male students and female students in the province.

3.1.2 Sample size calculation

The sample size for the study was determined using following statistical formula [43].

Formula:

$$\mathbf{n} = \frac{\mathbf{t^2 * p(1-p)}}{\mathbf{m^2}} \qquad 01$$

where,

n = Sample size **p =** Estimated proportion of the population

t = Confidence level **m =** Accuracy level

3.1.3 Sample profile

Equal number of male students and female students were selected from six government schools in the province covering both rural and urban areas. This was considered to obtained balanced student sample and to perform a balanced research study. The socio-economic aspects of families can be varied from rural to urban in the province. The information related to student well-being also was gathered during the study because it was needed to look at the patterns of student well-being data too along with the students' anthropometry.

3.2 Students' anthropometric measures and well-being (structured checklist)

[1]. School				
[2]. Student's Grade		[3]. Student's No		
[4]. Age		[5]. Living area		
[6]. Main source of family income	Government employment	Private employment	Self-employment	
[7]. Mode of travel to school	Public transport	Private transport	Cycling	Walking
[8]. Weight (kg)				

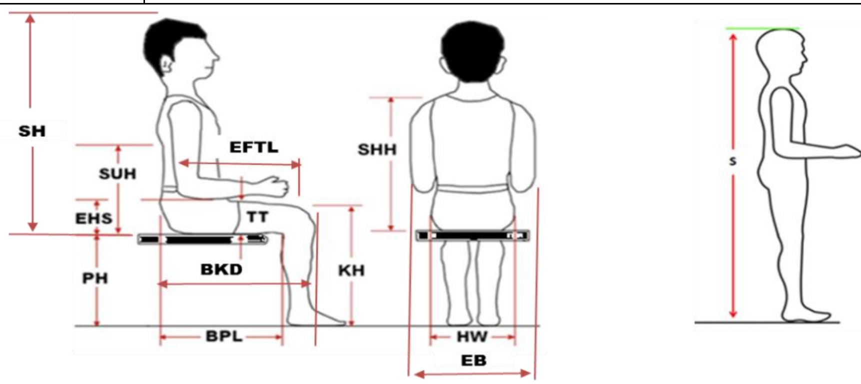

Figure 3.1: Student's anthropometric measurements [23]

Student's well being

[9]. Breakfast	Take at home	Do not take breakfast before come to school		Bring to school	Other
[10]. Having meals at school	Bring meal to school	Do not bring meal to school		Other	
[11]. Frequency of eat rice per day	Eat rice thrice		Twice per day	Once per day	
[12]. Food style	Vegetarian		Non-vegetarian		
[13]. No of hours sleep per day	Going to bed at night		Awake up in the morning at		
[14]. No of hours study per day (excluding school hours)		[15]. No of hours watching TV per day			
[16]. Physical activities	Doing sports		Not doing sports		
[17]. Use of spectacles	Yes		No		

From the literature review it was understood that many anthropomotric measurements have been taken when conducting anthropometric surveys in other countries, Figure 3.1 presents the anthropometric measures and fields of students' well-being information gathered through a structured check list in the study. Since the socio-economic aspects can vary from rural to urban information like main source of family income, mode of travel to school, meal pattern, food styles, number of hours sleep per day, number of hours study outside the school time, number of hours watching television per day, attending for physical activities, use of spectacles etc were included in the check list. A separate sheet of above checklist was maintained for each and every student considered in the sample population and maintained for future reference. The photographs which are included in the Appendix E shows the way of measuring students' anthropometric data in the selected schools.

3.3 Furniture reference dimensions

Figure 3.2 presents the relevant school furniture dimensions which were considered in the study to compare with available furniture standards. Even though six furniture dimensions were discussed in the literatures fourteen furniture dimensions were measured during the study.

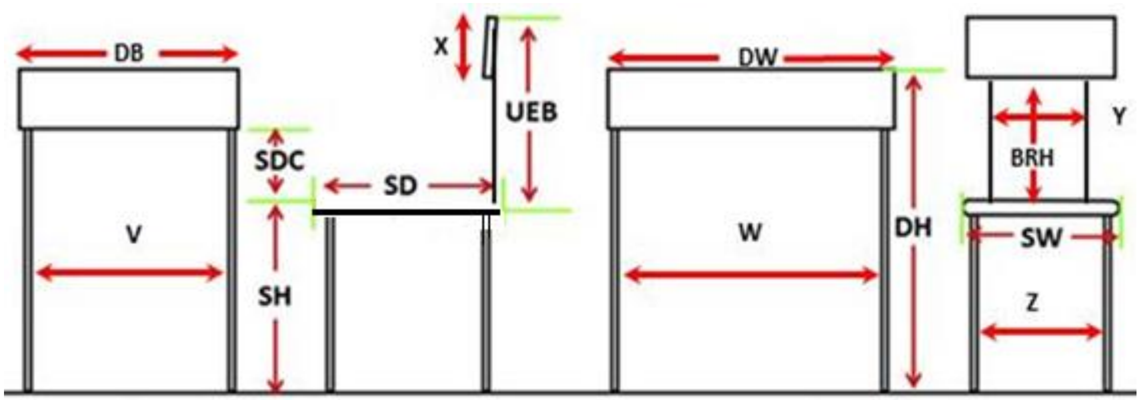

Figure 3.2: Schematic diagram of school furniture

According to the interactions shown in Table 2.2 between furniture dimensions and anthropometric measurements, it was revealed that measuring furniture dimensions indicated in the Figure 3.2 were necessary for the research study.

3.4 Pilot run

A pilot run was carried out taking actual anthropometric measurements using anthropometer, sliding caliper, measuring tape, and weighing scale. The ISO 7250:2008 standard for basic human body measurements for technological design (including body measurement definitions and land marks) was used as an appropriate guiding tool to carry out preliminary preparation and taking measurements at the field. The students who participated in the pilot run to take measurements were without shoes, standing against the wall facing forward and arms hanging beside the body for taking stature measurements. For sitting dimensions, student has to be seated erect on a flat horizontal surface, not compressible, with knees bent 90° and feet flat on the surface facing forward, and arms hanging besides the body. Measurements were taken on one side of the body. The measurement which is affected by the breathing shall be taken during gentle breathing and in relaxed mode.

Figure 3.3: Use of height adjustable foot rest

In the pilot run it was identified that the shorter students cannot keep their feet on the floor in seated position, the legs just hanging and will create difficulty in taking popliteal height measurements. A special height adjustable foot rest was fabricated for shorter students to place their foot while sitting on the chair. Refer Figure 3.3.

3.5 Guideline for measuring field data and people training

The standard measuring instruments such as an anthropometer, sliding calipers, weighing scale and tape measure would be used to take measurements at the field are included in the Table 3.1.

Table 3.1: Expected standard measuring instruments will be used in the research

Standard measuring instrument/ fixture	Purpose
Anthropometer (HOLTAIN)	For measuring linear distances between points on the body and standard reference surfaces, such as floor or a seat platform
Sliding caliper (LAFAYETTE)	For measuring breadth and depth of body segments and distances between reference marks
Tape	For measure body circumferences
Weighing scale (CONSTANT)	For measure the body weight
Height adjustable footrest	For the use with shorter students
Student chair	For taking sitting dimensions

The procedures of selected anthropometric measurement which were taken in the study are in compliance with ISO guideline are included in the Appendix A.

It was important to ensure that the measurement processes for all participants were done correctly and accurately to minimize measurement error in data collection. To ensure the accuracy of data recording, measurement taking person and the helper had to train on the use of anthropometer, sliding caliper, measuring tape and the weighing scale and the methods of taking measurements precisely. A trial run was conducted to ensure that they were capable of taking measurements. The measurements were taken at the field under the direct supervision of researcher and ensured maintaining accuracy of measurements throughout the period when measurements were taken.

3.6 Obtaining approval to take field measurements

Written approval was obtained from Chief Accountant (Procurement) of Ministry of Education, Assistant Director (Education- Administration) of Zonal Education office Mawanella, Zonal Education Director of Zonal Education office Rathnapura, and Assistant Education Director of Zonal Education office Kegalle for taking grade six students' anthropometric measurements and other relevant data in the study. Further school principals, masters, mistresses and participated students were briefed about the purpose of taking anthropometric measurements their consent was obtained. The written approval received are attached in the Appendix F-I.

3.6 Statistical data analysis

It is impractical to develop single school furniture design that fits for all students or customer made design because students continue to grow and leave for next grade at the end of each year. It is usual to aim at suiting 90% of a group: between the 5^{th} and 95^{th} percentile [30]. The aim of the research is to identify anthropometric measurements required to determine dimensions of school furniture for grade 6 of selected student sample in Sri Lanka. In this study a sample of 508 students were selected randomly where 254 males and 254 females with no physical disabilities from the above grades covering both rural and urban. Required anthropometric measurements, school furniture dimensions and other relevant details require to be collected are given in the checklist included in section 3.2.

All measurements were taken in millimeters (mm) except weight measurement that was in kilogram (kg). In the research project it was expected to carry out descriptive statistical analysis and inferential statistical analysis.

3.6.1 Descriptive data analysis

1. Skewedness, kurtosis values were calculated. Hence the number of samples considered 30, statistical normality check was performed using skewness and kurtosis values.
2. Since the field measurement data involve large number of data, summarization of data through statistical analysis is required and results were used for discussion and future references. Most essential statistical parameters and desirable parameters for both males and females were calculated using MS Excel as following.

a) Means and Standard deviations of the each anthropometric measurement

b) Percentile values of each parameters (Eg. 01^{st}, 05^{th},10^{th}, 25^{th}, 50^{th} ,75^{th} , 90^{th}, 95^{th}, and 99^{th})

c) Coefficient of variation (Std. Dev./ Mean)

d) Correlation coefficient between each and every anthropometric parameter

e) Regression equations of anthropometric measurements

f) Minimum and Maximum values of each parameters

3. Student t-test for mean stature values.
4. Pearson coefficient correlation in between considered anthropometric measurements, determining regression equations and graphical representation of correlation of each anthropometric measurement.
5. Comparison of anthropometric measurements of each individual student with the relevant school furniture dimensions with the objective of identifying anthropometric measurements required to determine dimensions of school furniture.
6. Comparison of furniture dimensions with expected furniture values in selected international school furniture standards.
7. Determining match/ mismatch as the discrepancy between the school furniture dimensions and the students' anthropometric measurements. This would help for designing and evaluation of school furniture and to define the range in which

each furniture dimension is considered appropriate, applied anthropometric and ergonomic principles should be used.

3.6.2 Inferential data analysis

Students' well-being data were analyzed using MS Excel and graphical representation of those statistical data was presented.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Sample size calculation

Formula:

$$\mathbf{n} = \frac{\mathbf{t^2 * p(1-p)}}{\mathbf{m^2}} \qquad 01$$

where,

n = Sample size

t = Confidence level at 95% (standard value of 1.96)

p = Estimated proportion of the population

m = Accuracy level (Considered it as 0.05 for the study to have high accuracy)

95% confidence level and 5% accuracy level were considered for the calculation. Since no information related to anthropometric study in Sri Lanka was not available considering the maximum possible variability 0.5 was considered for the p estimated proportion of the population.

Calculation

$$n = [\![1.96^2 * 0.5(1 - 0.5)]\!]/0.05^2$$

$$n = 384.16 = 385$$

Even though calculated sample size was 385, 508 students (254 male and 254 female) were selected from six schools in the province.

4.2 Sample profile

The sample population which was selected through stratified convenience sampling method consist of gender balance, rural and urban balanced sample. The students were in age 10 – 11 years range and living with their family. No boarded students were found in the selected sample. Parents main source of income was categorized in to three groups, government employment (34%), private employment (31%), and self-employment (35%). Private transport was used by 49% of students to come to the school daily while 38% public transport, 8% walking and 5% cycling. The student pattern of having breakfast was 84% take their breakfast at home while 16% do not take breakfast before coming to school. 98% students bring meals to school and have it during break time. From the student sample 74% students eat rice thrice a day and 23% eat rice twice a day. 88% students were non-vegetarian and 12% students are vegetarian. 64% students do regular physical activities while 36% do not do regular physical activities. The information related to use of spectacles was also gathered and found 99% student do not wear spectacles. The graphical representations of qualitative statistics of students' well-being are shown in Appendix B. No of hours of sleep per day of students was 8.73 hrs, no of hours of study per day (excluding school hours) was 1.85 hrs and no of hours watching TV per day was 1.24 hrs.

4.3 Sample normality and variability calculation

Kurtosis, skewness, and coefficient of variation of males and females anthropometric dimensions are also shown in Table 4.1. The kurtosis values are indicated that whether the data are heavily tailed or lightly tailed relative to the normal distribution. If the values are closer to 3 then the data are more towards normal distribution pattern. The skewness measures the symmetry or distribution of data. If skewness is positive, the data are positively skewed to right, meaning that the right tail of distribution is longer than the left (vise-versa). If skewness is zero, the data are perfectly symmetrical which is quite unlikely [44].

Kurtosis values of all anthropometric data except thigh thickness and popliteal height of male data and sitting height of female data are close to 3 indicating that sample data are close to normal distribution.

With reference to skewness values, except thigh thickness, popliteal height, and hip width of male anthropometric data and sitting height, thigh thickness, and hip width of female anthropometry of all other sample data are close to zero. Hence the sample population is close to the normal distribution pattern.

The reasons for significant deviations of above mentioned anthropometric measurements are not known and there is a need to carry out further research studies in this regard.

Table 4.1: Students male and female anthropometry kurtosis, skewness and coefficient variations

Anthropometric measurement	Male			Female		
	Kurtosis	Skewness	Coefficient of variation	Kurtosis	Skewness	Coefficient of variation
Stature (S)	0.24	0.41	0.05	-0.43	-0.12	0.05
Weight (kg)	2.47	1.50	0.25	1.26	1.20	0.29
Sitting Height (SH)	2.28	-0.77	0.08	8.18	-1.78	0.08
Eye Height (EH)	5.03	0.61	0.08	-0.17	0.53	0.08
Shoulder height sitting (SHH)	4.91	-0.72	0.08	0.95	0.14	0.08
Knee height (KH)	6.61	-0.69	0.07	0.50	0.40	0.07
Popliteal height (PH)	17.64	2.80	0.07	2.69	0.05	0.08
Thigh thickness (TT)	21.45	3.18	0.20	2.34	1.24	0.23
Buttock-Knee Depth (BKD)	7.30	1.20	0.09	0.02	-0.16	0.09
Buttock-Popliteal length (BPL)	2.43	-0.21	0.09	0.18	0.18	0.10
Hip width (HW)	2.61	1.46	0.12	1.10	1.17	0.15
Elbow to Elbow Breadth (EB)	1.52	1.03	0.12	2.92	0.81	0.14
Elbow height sitting (EHS)	-0.21	0.15	0.18	0.32	0.26	0.17
Subscapular height (SUH)	1.78	0.11	0.18	0.99	0.38	0.15
Elbow Fingertip Length	2.68	-1.75	0.15	4.50	-1.01	0.08
Shoulder width (SW)	2.53	0.95	0.08	0.90	0.53	0.10
Age	1.66	-0.29	0.04	-1.59	-0.41	0.05

The coefficient of variation gives the relative variability which is the ratio of standard deviation to the mean. The calculated values of coefficient variation shows that almost all the anthropometric measurements' coefficient variability are very low except thigh thickness and subscapular height of male data and thigh thickness of female data. This indicates that sample data are having low relative variability.

4.4 Student t-test calculation for mean values of different student populations

According to the students' t-test which was carried out for below mentioned scenarios.

4.4.1 Student t-test for stature values male students in Rathnapura district and Kegalle district
4.4.2 Student t-test for stature values female students in Rathnapura district and Kegalle district
4.4.3 Student t-test for stature values male and female students in Sabaragamuwa province
4.4.4 Student t-test for stature values male students in Sabaragamuwa province Sri Lanka and India
4.4.5 Student t-test for stature values female students in Sabaragamuwa province Sri Lanka and India

4.4.1. Student t-test for stature values male students in Rathnapura district and Kegalle district

$\mu_{1=}$ Population mean of stature values of male students in Rathnapura district

$\mu_{2=}$Popu1lation mean of stature values of male students in Kegalle district

Hypothesis are,

$H_0: \mu_{1=}\mu_2$

$H_0: \mu_1 \neq \mu_2$

Significance level, $\alpha = 0.05$ $|\mathrm{T}| > 0.025$

Test statistics, $t = \frac{(\overline{X_1} - \overline{X_2})}{\sqrt{\left[\frac{S_1{}^2}{n_1} + \frac{S_2{}^2}{n_2}\right]}}$ (02)

The two samples are independent, large samples, σ_1 and σ_2 are unknown.

Table 4.2: Male students field data in Rathnapura and Kegalle

Statistic	Rathnapura	Kegalle
Sample mean ($\overline{X}$)	$\overline{X_1}$= 1,371.75	$\overline{X_2}$= 1,361.16
Variance (S^2)	$S_1{}^2$= 3,643.68	$S_2{}^2$= 3,267.17
Number of samples (n)	n_1 = 63	n_2 = 63

By substituting the values in Table 4.2 in equation (02),

t = 1.0111

From the student t-table, t = 1.9990 (Degrees of freedom, n-1 = 62)

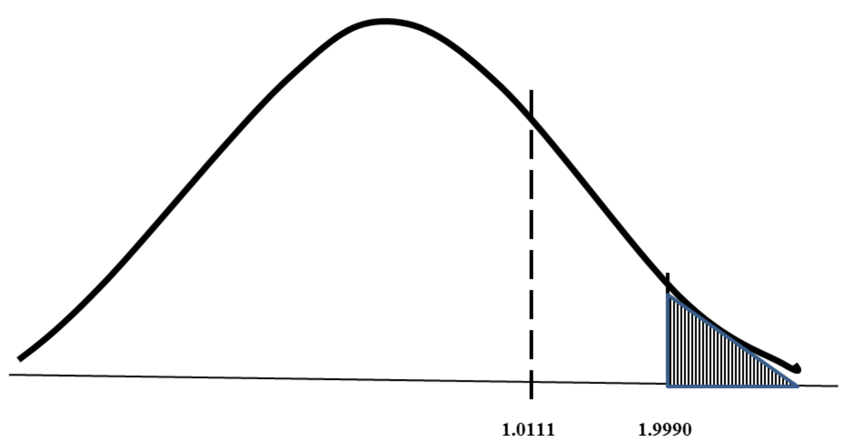

Figure 4.1: Graphical representation of test statistics and critical region (4.4.1)

Since test statistics have not fallen in the critical region (Figure 4.1), there is no sufficient evidence to reject H_0 in favour of 5% significance level. According to the sample given, we can conclude that there is no significant difference between population means of stature values of male students in two districts.

Therefore anthropometric data of male students in both districts could be analyzed together. In other words district wise analysis was not required for determining student anthropometric data required for furniture designing.

4.4.2. Student t-test for stature values female students in Rathnapura district and Kegalle district

$\mu_{1=}$ Population mean of stature values of female students in Rathnapura district

$\mu_{2=}$Popu1lation mean of stature values of female students in Kegalle district

Hypothesis are,

$H_0: \mu_{1=}\mu_2$

$H_0: \mu_1 \neq \mu_2$

Significance level, $\alpha = 0.05$ $|\mathrm{T}| > 0.025$

Test statistics,

Test statistics, $t = \frac{(\overline{X_1} - \overline{X_2})}{\sqrt{\left[\frac{S_1{}^2}{n_1} + \frac{S_2{}^2}{n_2}\right]}}$ (02)

The two samples are independent, large samples, σ_1 and σ_2 are unknown.

Table 4.3 Female students field data in Rathnapura and Kegalle

Statistic	Rathnapura	Kegalle
Sample mean ($\overline{X}$)	$\overline{X_1}$= 1,376.00	$\overline{X_2}$= 1,384.54
Variance (S^2)	S_1^2= 5,252.34	S_2^2= 4,347.42
Number of samples (n)	n_1 = 54	n_2 = 54

By substituting the values in Table 4.3 in equation (02),

t = -0.6405,

From the student t-table, t = 2.0057 (Degrees of freedom, n-1 = 53)

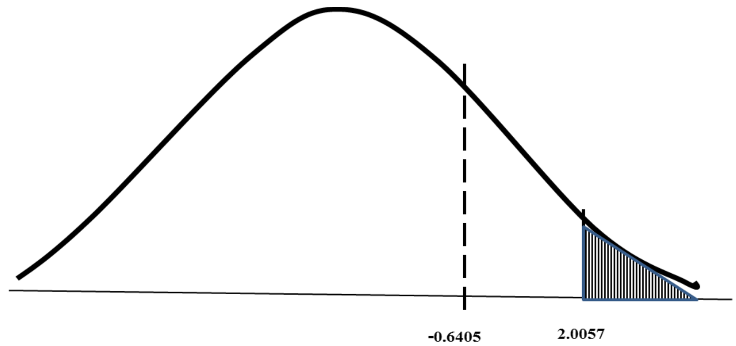

Figure 4.2: Graphical representation of test statistics and critical region (4.4.2)

Since test statistics have not fallen in the critical region (Figure 4.2), there is no sufficient evidence to reject H_0 in favour of 5% significance level. According to the sample given, we can conclude that there is no significant difference between population means of stature values of female students in two districts.

Therefore anthropometric data of female students in both districts could be analyzed together. In other words district wise analysis was not required for determining student anthropometric data required for furniture designing.

4.4.3. Student t-test for stature values male and female students in Sabaragamuwa province

$\mu_{1=}$ Population mean of stature values of male students in Sabaragamuwa province

$\mu_{2=}$Popu1lation mean of stature values of female students in Sabaragamuwa province

Hypothesis are,

$H_0 : \mu_{1=}\mu_2$

$H_1 : \mu_{1\neq}\mu_2$

Significance level, α=0.05 |T| > 0.025

Test statistics,

Test statistics, $t = \frac{(\overline{X_1} - \overline{X_2})}{\sqrt{\left[\frac{S_1{}^2}{n_1} + \frac{S_2{}^2}{n_2}\right]}}$ (02)

The two samples are independent, large samples, σ_1 and σ_2 are unknown.

Table 4.4: Male & female students field data in Sabaragamuwa

Statistic	Male	Female
Sample mean ($\overline{X}$)	$\overline{X_1}$= 1,365.55	$\overline{X_2}$= 1,385.15
Variance (S^2)	S_1^2= 4,143.50	S_2^2= 5,667.08
Number of samples (n)	n_1 = 204	n_2 = 204

By substituting the values in Table 4.4 in equation (02),

t = -2.8263

From the student t-table, t = 1.6449 (Degrees of freedom, n-1 = 203)

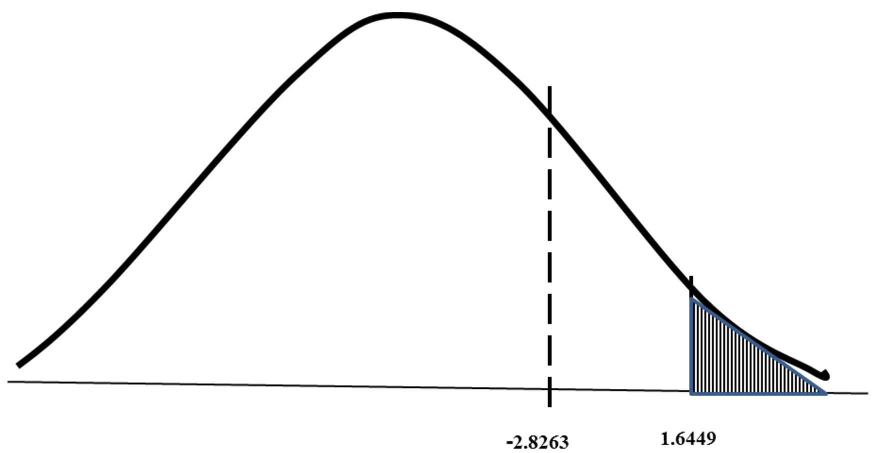

Figure 4.3: Graphical representation of test statistics and critical region (4.4.3)

Since test statistics were not fallen in the critical region (Figure 4.3), there is no sufficient evidence to reject H_0 in favour of 5% significance level. According to the sample given, we can conclude that there is no significant difference in between population means of stature values of male students and female students Sabaragamuwa province.

The t-test results showed that no significant difference between stature values of male students and female students. Therefore it was fair enough to considered both male and female students' anthropometric data together to determine student anthropometry values required for furniture design because common furniture were designed for both categories. In other words no furniture was designed for male and female students separately.

4.4.4. Student t-test for stature values male students in Sabaragamuwa province Sri Lanka and India

$\mu_{1=}$ Population mean of stature values of male students in Sabaragamuwa province Sri Lanka

$\mu_{2=}$Popu1lation mean of stature values of male students in India

Hypothesis are,

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

Significance level, α=0.05 $|T| > 0.025$

Test statistics,

Test statistics, $t = \frac{(\overline{X_1} - \overline{X_2})}{\sqrt{\left[\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right]}}$ (02)

The two samples are independent, large samples, σ_1 and σ_2 are unknown.

Table 4.5: Male students' field data in Sabaragamuwa province Sri Lanka and India

Statistic	Sabaragamuwa	India
Sample mean ($\overline{X}$)	$\overline{X_1}$= 1,365.55	$\overline{X_2}$= 1,302.90
Variance (S^2)	S_1^2= 4,143.50	S_2^2= 36.85
Number of samples (n)	n_1 = 254	n_2 = 298

By substituting the values in Table 4.5 in equation (02),

t = 15.4531

From the student t-table, t = 1.645

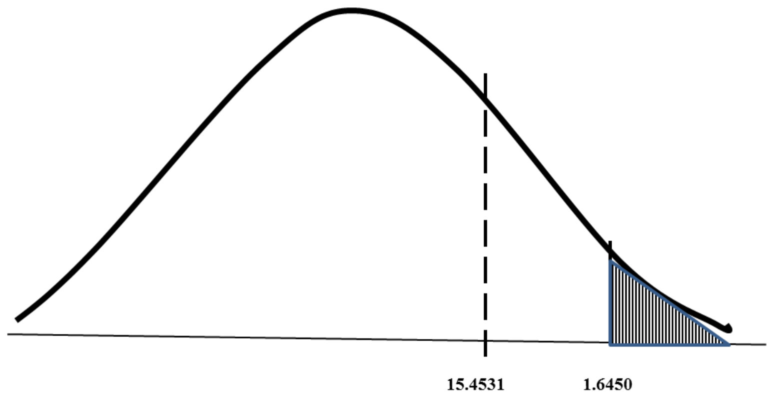

Figure 4.4: Graphical representation of test statistics and critical region (4.4.4)

Since test statistics were not fallen in the critical region (Figure 4.4), there is no sufficient evidence to reject H_0 in favour of 5% significance level. According to the sample given, we can conclude that there is no significant difference in between population means of stature values of male students in two districts.

4.4.5. Student t-test for stature values female students in Sabaragamuwa province Sri Lanka and India

$\mu_{1=}$ Population mean of stature values of female students in Sabaragamuwa province Sri Lanka

$\mu_{2=}$Population mean of stature values of female students in India

Hypothesis are,

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

Significance level, α=0.05 $|T| > 0.025$

Test statistics,

Test statistics, $t = \frac{(\overline{X_1} - \overline{X_2})}{\sqrt{\left[\frac{S_1{}^2}{n_1} + \frac{S_2{}^2}{n_2}\right]}}$ (02)

The two samples are independent, large samples, σ_1 and σ_2 are unknown.

Table 4.6: Female students' field data in Sabaragamuwa province Sri Lanka and India

Statistic	Sabaragamuwa	India
Sample mean ($\overline{X}$)	$\overline{X_1}$= 1,385.15	$\overline{X_2}$= 1,316.30
Variance (S^2)	$S_1{}^2$= 5,667.08	$S_2{}^2$= 20.07
Number of samples (n)	n_1 = 254	n_2 = 312

By substituting the values in Table 4.6 in equation (02),

t = 14.5551

From the student t-table, t = 1.645

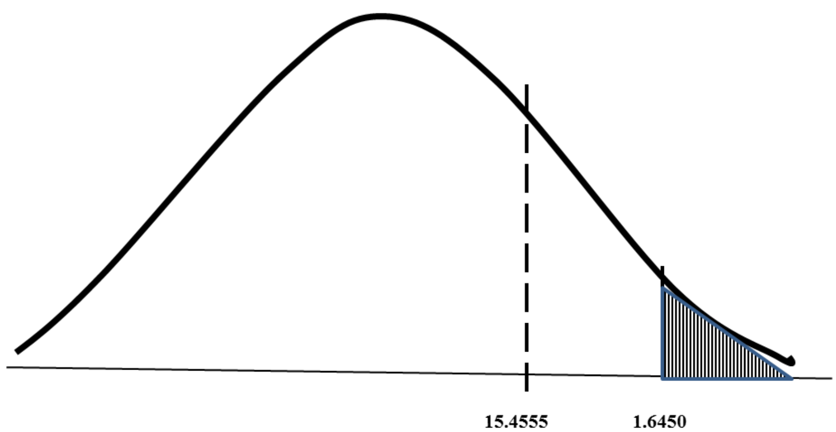

Figure 4.5: Graphical representation of test statistics and critical region (4.4.5)

Since test statistics were not fallen in the critical region (Figure 4.5), there is no sufficient evidence to reject H_0 in favour of 5% significance level. According to the sample given, we can conclude that there is no significant difference in between population means of stature values of female students in two districts.

Therefore furniture sizes of Sabaragamuwa province and furniture sizes specified in Indian standards were able to compare together.

4.5 Anthropometrics

The grade six both male and female students' anthropometric measurements were taken using anthropometer, sliding caliper, spreading caliper, tape, special fixture adjustable foot rest, and weighing scale in randomly selected six government schools in Sabaragamuwa province. Few female academic staff members in every school were trained on taking female students' anthropometric measurements and measurements were taken under direct supervision of researcher. The measured data were randomly crossed checked to ensure the accuracy of measurement taken by the trained staff. All male students' anthropometric measurements were taken by researcher and students and staff assistants were taken for data recording.

The obtained values by measuring sixteen anthropometric dimensions of all participants and their standard deviations and percentile values (1^{st}, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th}, and 99^{th}) are shown in Table 4.7 Students' anthropometry statistics (male) and Table 4.8 Students' anthropometry statistics (female).

Table 4.7: Students' anthropometry statistics- Male

Anthropometric dimension (All dimensions are in mm except weight)	**Average**	**Standard deviation**	**1st Percentile**	**5th Percentile**	**10th Percentile**	**25th Percentile**	**50th Percentile**	**75th Percentile**	**90th Percentile**	**95th Percentile**	**99th Percentile**
Stature	1365.65	64.37	1215.6	1260.0	1283.2	1322.4	1365.5	1408.7	1447.9	1471.1	1515.5
Weight	28.62	7.06	12.2	17.0	19.6	23.9	28.6	33.3	37.7	40.2	45.1
Sitting Height	656.98	52.28	535.2	571.2	590.1	622.0	657.0	692.0	723.9	742.7	778.8
Eye Height	540.68	43.69	438.9	469.0	484.8	511.4	540.7	570.0	596.6	612.3	642.5
Shoulder height sitting	407.43	31.43	334.2	355.9	367.2	386.4	407.4	428.5	447.7	459.0	480.7
Knee height	431.44	29.57	362.6	383.0	393.6	411.6	431.4	451.2	469.3	479.9	500.3
Popliteal height	343.94	24.72	286.4	303.4	312.3	327.4	343.9	360.5	375.6	384.5	401.5
Thigh thickness	84.28	17.22	44.2	56.0	62.2	72.7	84.3	95.8	106.3	112.5	124.4
Buttock-Knee Depth	458.28	39.75	365.7	393.1	407.4	431.6	458.3	484.9	509.2	523.5	550.9
Buttock-Popliteal length	380.11	35.75	296.8	321.5	334.3	356.2	380.1	404.1	425.9	438.7	463.4
Hip width	249.20	31.11	176.7	198.2	209.4	228.4	249.2	270.0	289.0	300.2	321.7
Elbow to Elbow Breadth	329.89	39.62	237.6	264.9	279.2	303.3	329.9	356.4	380.6	394.9	422.2
Elbow height sitting	126.79	22.22	75.0	90.4	98.3	111.9	126.8	141.7	155.2	163.2	178.6
Subscapular height	195.22	35.77	111.9	136.6	149.4	171.3	195.2	219.2	241.0	253.9	278.6
Elbow Fingertip Length	361.02	52.41	238.9	275.1	293.9	325.9	361.0	396.1	428.1	447.0	483.1
Shoulder width	322.37	25.39	263.2	280.7	289.9	305.4	322.4	339.4	354.9	364.0	381.5

Table 4.8: Students' anthropometry statistics- Female

Anthropometric dimension (All dimensions are in mm except weight)	**Average**	**Standard deviation**	**1st Percentile**	**5th Percentile**	**10th Percentile**	**25th Percentile**	**50th Percentile**	**75th Percentile**	**90th Percentile**	**95th Percentile**	**99th Percentile**
Stature	1385.15	75.28	1209.75	1261.69	1288.80	1334.72	1385.15	1435.59	1481.51	1508.61	1560.56
Weight	31.91	9.15	10.57	16.89	20.19	25.77	31.91	38.04	43.62	46.92	53.24
Sitting Height	678.31	56.11	547.58	586.29	606.49	640.72	678.31	715.90	750.13	770.33	809.05
Eye Height	563.79	42.61	464.51	493.91	509.25	535.24	563.79	592.34	618.33	633.67	663.07
Shoulder height sitting	422.52	33.57	344.31	367.47	379.56	400.03	422.52	445.01	465.49	477.58	500.74
Knee height	441.85	30.15	371.60	392.40	403.26	421.65	441.85	462.05	480.44	491.30	512.10
Popliteal height	347.88	26.39	286.40	304.60	314.10	330.20	347.88	365.56	381.66	391.16	409.37
Thigh thickness	89.72	20.62	41.68	55.91	63.33	75.91	89.72	103.53	116.11	123.53	137.76
Buttock-Knee Depth	469.25	40.86	374.05	402.24	416.95	441.87	469.25	496.62	521.55	536.25	564.45
Buttock-Popliteal length	385.21	38.45	295.62	322.15	335.99	359.45	385.21	410.98	434.43	448.27	474.80
Hip width	259.35	39.37	167.63	194.79	208.97	232.98	259.35	285.73	309.74	323.91	351.08
Elbow to Elbow Breadth	330.60	45.16	225.37	256.53	272.79	300.34	330.60	360.86	388.41	404.67	435.83
Elbow height sitting	140.28	23.19	86.25	102.25	110.60	124.75	140.28	155.82	169.97	178.32	194.32
Subscapular height	199.63	30.66	128.20	149.35	160.39	179.09	199.63	220.17	238.87	249.91	271.06
Elbow Fingertip Length	376.24	30.52	305.13	326.19	337.18	355.79	376.24	396.69	415.31	426.30	447.36
Shoulder width	324.51	31.83	250.35	272.31	283.77	303.19	324.51	345.84	365.25	376.71	398.68

Table 4.9: Gender wise anthropmetric dimensions

Anthropetric Parameter	Male Average	Female Average	Male 5^{th} Percentile	Female 5^{th} Percentile	Male 95^{th} Percentile	Female 95^{th} Percentile
Stature	1365.65	1385.15	1260.0	1261.69	1471.1	1508.61
Sitting height	656.98	678.31	571.2	586.29	742.7	770.33
Eye height	540.68	563.79	469.0	493.91	612.3	633.67
Shoulder height sitting	407.43	422.52	355.9	367.47	459.0	477.58
Knee height	431.44	441.85	383.0	392.40	479.9	491.30
Popliteal height	343.94	347.88	303.4	304.60	384.5	391.16
Thigh thickness	84.28	89.72	56.0	55.91	112.5	123.53
Buttock-knee depth	458.28	469.25	393.1	402.24	523.5	536.25
Buttock-popliteal length	380.11	385.21	321.5	322.15	438.7	448.27
Hip width	249.20	259.35	198.2	194.79	300.2	323.91
Elbow to elbow breadth	329.89	330.60	264.9	256.53	394.9	404.67
Elbow height sitting	126.79	140.28	90.4	102.25	163.2	178.32
Subscapular height	195.22	199.63	136.6	149.35	253.9	249.91
Elbow fingertip length	361.02	376.24	275.1	326.19	447.0	426.30
Shoulder width	322.37	324.51	280.7	272.31	364.0	376.71

The comparison of male female anthropometric dimensions average, 5^{th} percentile and 95^{th} percentile values are shown in the Table 4.9. Except 95^{th} percentile values of subscapular height and elbow finger-tip length of female students all other parameters were higher than the male.

The Pearson correlation coefficient results showed positive correlation among considered anthropometric parameters as shown in Table 4.10 and Table 4.11. Strong positive correlation was observed in between weight and elbow to elbow breadth (R^2= 0.7), weight and hip width (R^2= 0.6), weight and shoulder width (R^2= 0.5), and stature and knee height (R^2= 0.5) of male anthropometric data. Also positive strong correlation was observed in between weight and hip width (R^2= 0.5), weight and stature (R^2= 0.5), weight and elbow fingertip length (R^2= 0.5), weight and knee height (R^2= 0.5), weight and elbow to elbow breadth (R^2= 0.7), weight and shoulder width (R^2= 0.6), shoulder sitting height and knee height (R^2= 0.5), buttock popliteal length and buttock knee depth (R^2= 0.5), popliteal height and knee height (R^2= 0.5), hip width and shoulder width (R^2= 0.5), stature and buttock knee depth (R^2= 0.6), stature and elbow fingertip length (R^2= 0.5), stature and knee height (R^2= 0.6), elbow fingertip length and knee height (R^2= 0.5), and elbow to elbow breadth and shoulder width (R^2= 0.5) of female anthropometric data. The correlation coefficient graphs of anthropometric parameters of male students' female students' which are having strong correlation are shown in Appendix C and Appendix D respectively.

Table 4.10: Correlation coefficient of students' anthropometric measurements- Male

Anthropetric Parameter	Stature (S)	Weight (kg)	Sitting Height (SH)	Eye Height (EH):	Shoulder height sitting (SHH)	Knee height (KH)	Popliteal height (PH)	Thigh thickness (TT)	Buttock-Knee Depth (BKD)	Buttock-Popliteal length (BPL)	Hip width (HW)	Elbow to Elbow Breadth (EB)	Elbow height sitting (EHS)	Subscapular height (SUH)	Elbow Fingertip Length (EFTL)	Shoulder width (SW)
Stature		0.4	0.3	0.3	0.3	0.5	0.3	0.2	0.3	0.3	0.2	0.3	0.2	0.1	0.2	0.3
Weight	0.4		0.2	0.3	0.3	0.3	0.1	0.4	0.2	0.2	0.6	0.7	0.2	0.1	0.1	0.5
Sitting height	0.3	0.2		0.3	0.1	0.1	0.0	0.1	0.1	0.2	0.1	0.2	0.1	0.0	0.4	0.1
Eye height	0.3	0.3	0.3		0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.0	0.1	0.1
Shoulder height sitting	0.3	0.3	0.1	0.2		0.2	0.0	0.2	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.1
Knee height	0.5	0.3	0.1	0.2	0.2		0.1	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.2
Popliteal height	0.3	0.1	0.0	0.1	0.0	0.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thigh thickness	0.2	0.4	0.1	0.1	0.2	0.2	0.0		0.0	0.1	0.2	0.3	0.1	0.1	0.0	0.2
Buttock-knee depth	0.3	0.2	0.1	0.1	0.1	0.3	0.0	0.0		0.3	0.1	0.1	0.0	0.0	0.2	0.1
Buttock-popliteal length	0.3	0.2	0.2	0.1	0.1	0.2	0.0	0.1	0.3		0.1	0.1	0.1	0.0	0.3	0.1
Hip width	0.2	0.6	0.1	0.2	0.1	0.2	0.0	0.2	0.1	0.1		0.3	0.1	0.0	0.0	0.3
Elbow to elbow breadth	0.3	0.7	0.2	0.1	0.2	0.2	0.0	0.3	0.1	0.1	0.3		0.1	0.1	0.2	0.4
Elbow height sitting	0.2	0.2	0.1	0.2	0.3	0.1	0.0	0.1	0.0	0.1	0.1	0.1		0.1	0.0	0.1
Subscapular height	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1		0.0	0.3
Elbow fingertip length	0.2	0.1	0.4	0.1	0.1	0.1	0.0	0.0	0.2	0.3	0.0	0.2	0.0	0.0		0.1
Shoulder width	0.3	0.5	0.1	0.1	0.1	0.2	0.0	0.2	0.1	0.1	0.3	0.4	0.1	0.3	0.1	

Table 4.11: Correlation coefficient of students' anthropometric measurements- Female

Anthropetric Parameter	Stature (S)	Weight (kg)	Sitting Height (SH)	Eye Height (EH)	Shoulder height sitting (SHH)	Knee height (KH)	Popliteal height (PH)	Thigh thickness (TT)	Buttock-Knee Depth (BKD)	Buttock-Popliteal length (BPL)	Hip width (HW)	Elbow to Elbow Breadth (EB)	Elbow height sitting (EHS)	Subscapular height (SUH)	Elbow Fingertip Length (EFTL)	Shoulder width (SW)
Stature		0.5	0.3	0.2	0.4	0.6	0.3	0.1	0.6	0.3	0.3	0.3	0.2	0.1	0.5	0.4
Weight	0.5		0.2	0.3	0.3	0.4	0.1	0.4	0.4	0.2	0.5	0.7	0.2	0.1	0.5	0.6
Sitting height	0.3	0.2		0.2	0.4	0.3	0.1	0.1	0.2	0.1	0.2	0.3	0.2	0.1	0.2	0.1
Eye height	0.2	0.3	0.2		0.4	0.2	0.1	0.3	0.1	0.0	0.1	0.2	0.3	0.2	0.2	0.1
Shoulder height sitting	0.4	0.3	0.4	0.4		0.5	0.2	0.3	0.2	0.1	0.2	0.3	0.4	0.3	0.3	0.3
Knee height	0.6	0.4	0.3	0.2	0.5		0.5	0.4	0.3	0.2	0.4	0.4	0.3	0.2	0.5	0.4
Popliteal height	0.3	0.1	0.1	0.1	0.2	0.5		0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.1
Thigh thickness	0.1	0.4	0.1	0.3	0.3	0.4	0.1		0.1	0.0	0.2	0.3	0.2	0.2	0.2	0.2
Buttock-knee depth	0.6	0.4	0.2	0.1	0.2	0.3	0.1	0.1		0.5	0.3	0.3	0.1	0.1	0.4	0.3
Buttock-popliteal length	0.3	0.2	0.1	0.0	0.1	0.2	0.1	0.0	0.5		0.3	0.1	0.0	0.0	0.2	0.3
Hip width	0.3	0.5	0.2	0.1	0.2	0.4	0.1	0.2	0.3	0.3		0.1	0.1	0.1	0.3	0.5
Elbow to elbow breadth	0.3	0.7	0.3	0.2	0.3	0.4	0.1	0.3	0.3	0.1	0.1		0.1	0.1	0.3	0.5
Elbow height sitting	0.2	0.2	0.2	0.3	0.4	0.3	0.1	0.2	0.1	0.0	0.1	0.1		0.2	0.2	0.1
Subscapular height	0.1	0.1	0.1	0.2	0.3	0.2	0.0	0.2	0.1	0.0	0.1	0.1	0.2		0.1	0.1
Elbow fingertip Llngth	0.5	0.5	0.2	0.2	0.3	0.5	0.2	0.2	0.4	0.2	0.3	0.3	0.2	0.1		0.4
Shoulder width	0.4	0.6	0.1	0.1	0.3	0.4	0.1	0.2	0.3	0.3	0.5	0.5	0.1	0.1	0.4	

4.6 Students' well-being qualitative data analysis

Table 4.12 shows the correlation between selected fields of students' well-being like having breakfast and doing physical activities regularly and students' weight and stature values were analysed.

Table 4.12: Average weight and stature values gender wise

	Gender	Average weight (kg)	Average stature (mm)	R^2
Having breakfast at home	Male	27.80	1367	0.3
	Female	32.12	1387	0.5
Not having breakfast at home	Male	28.70	1365	0.4
	Female	30.95	1379	0.6
Doing sports	Male	29.20	1374	0.4
	Female	31.50	1378	0.4
Not doing sports	Male	27.40	1348	0.5
	Female	32.43	1396	0.1

It was observed that no significant difference between weight of students who take breakfast at home before come to school and weight of students who do not take breakfast. Similar situation was observed in relation to stature values too. But average weight and average stature values of female students were slightly higher than male students. Also it was observed that there is no very strong correlation between weight and stature values in gender wise.

4.7 Furniture dimensions

Table 4.13 presents fourteen furniture dimensions measured in considered schools in Sabaragamuwa province. The notations which were used in the table; Rivisanda Maha Vidyalaya Mawanella, (S-1), Mayurapada Maha Vidyalaya Mawanella (S-2), Anura Vidyalaya Rathnapura (S-3), Saman Vidyalaya Rathnapura (S-4), Tholangamuwa Cebtral School Kegalle (S-5), and Morawaka Vidyalaya Kegalle (S-6). The descriptions of abbreviations used for furniture dimensions in the Table 4.13 were shown in the Figure 3.2. Additionally, A stands for SDC, B for UEB and C for BRH.

Table 4.13: Measured furniture dimensions of the considered schools in Sabaragamuwa province

School	Desk						Chair							
	DB	**DW**	**DH**	**V**	**W**	**A**	**SH**	**SD**	**B**	**SW**	**C**	**X**	**Y**	**Z**
S-1	470	660	730	390	470	250	460	320	370	385	225	145	245	305
S-2	465	660	640	385	465	200	440	240	430	300	290	150	210	260
S-3	450	590	560	370	460	194	354	310	366	330	226	146	290	310
S-4	460	580	760	390	500	145	445	295	400	380	250	150	240	290
S-5	460	580	750	385	495	120	430	280	450	350	290	160	245	250
S-6	450	590	600	390	510	240	360	280	330	340	180	150	300	280
Average	459	610	673	385	483	192	415	288	391	348	244	150	255	283

All dimensions are in mm

The average values of furniture dimensions were presented in the last raw of the table.

4.8 Determining most relevant values for furniture dimensions based on anthropometric measurements

From the literature it was found that seat surface height is determined by popliteal height (PH) of the students who use the chair. Both grade 6 male and female students' 5th and 95th percentile values of popliteal heights were considered for calculating suitable dimensions for school furniture desk and chair. Figure 4.6 shows the student PH which was measured when taking field data.

The lowest percentile value of students' popliteal height is 303.41 mm and the highest percentile value is 391.16 mm. Hence the furniture should be designed for both male and female students, anthropometric measurements of male and female were considered together to calculate furniture dimensions. On the other hand it is pragmatic to have common furniture. If the student seat is too high then they will be unable to rest their feet on the floor properly, thus causing compression of thigh muscles.

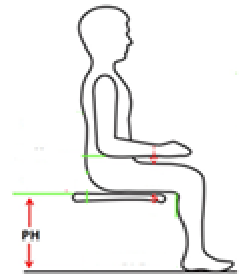

Figure 4.6: Student's popliteal height

If the seat is too low then it will increase the compression in the buttock muscles which leads to pain in buttock region during long hours of sitting. Therefore mid value of lowest of 5th percentile values and highest value of 95th percentile values were considered for the suitable height of the student's chair which is 347 mm.

Seat depth was determined from the values obtained for buttock popliteal length (BPL) of students. Minimum value of 5th percentile values was taken for the seat depth which is 321 mm. If the seat depth is too high compared to students' popliteal length, then students cannot lean their back against seat backrest causing back pain on long hours of sitting. Figure 4.7 shows the student BPL which was measured when taking field data.

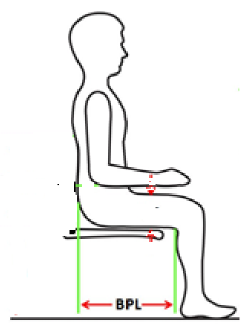

Figure 4.7: Student's buttock popliteal length

Seat width was determined from the values obtained for hip width (HW) of students. Maximum value of 95th percentile values was considered for seat width which is 324 mm. If the seat is too narrow, students will not be able to dissipate the pressure at the buttock, which will also cause for discomfort and restrict the mobility. Similarly backrest width of the seat also obtained from the maximum 95th percentile value of hip width. Figure 4.8 shows the student HW which was measured when taking field data.

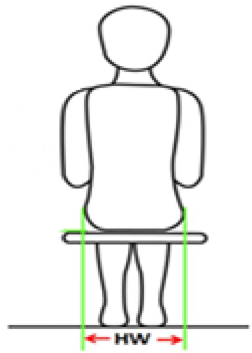

Figure 4.8: Student's hip width

Back rest height (upper) above seat and Back rest height (lower) above seat are determined by the Sitting shoulder height (SHS) and Subscapular height respectively. Misfit of backrest height to student trunk will lead to compression of scapula and reduction in the arm and trunk mobility, cause awkward posture in order to achieve task goal. Maximum value of 95th percentile values of Sitting shoulder height 478 mm and minimum value of 5th percentile values of Subscapular height 137 mm were taken for Back rest height (upper) above seat and Back rest height (lower) above seat respectively. Figure 4.9 shows the student SHS which was measured when taking field data.

Table height was calculated using Elbow height sitting (EHS), Knee height (KH), and shoe heel allowance. Students' anthropometric measurements were taken without wearing shoes. 20 mm was added for the value obtained from the addition of Elbow height sitting and Knee height. The value obtained for desk height is 591 mm.

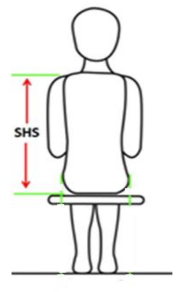

Figure 4.9: Student's sitting shoulder height

If the desk height is too low then it is affected to task performance and cause awkward posture in order to achieve the task goals. If the Table is too high, then students need to raise their shoulder and abduct upper arms and may results feel discomfort and pain in the shoulder region. If this is the case only one upper limb, it leads to asymmetrical spinal posture during sitting on the chair also may cause for muscular pain. Figure 4.10 shows the student EHS and KH which were measured when taking field data.

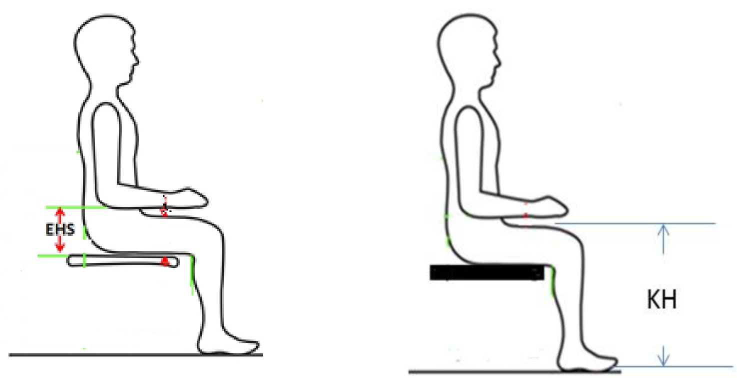

Figure 4.10: Student's elbow height sitting and knee height

Table depth 447 mm and Table width 554 mm are calculated using Elbow fingertip length and Hip width plus Elbow fingertip length multiply by $\cos 45^{o}$ respectively.

Seat desk clearance 244 mm is obtained from the difference between the calculated seat height and the desk height. It should be greater than highest value of 95th percentile values of thigh thickness 123.53 mm. If the seat desk clearance is too small, it restrains students' mobility because of the contact of thighs with the desk. Also chair cannot be pushed under the desk.

According to the above results the recommended furniture measurements for grade 6 students in Sabaragamuwa province are shown Table 4.14 and Figure 4.11.

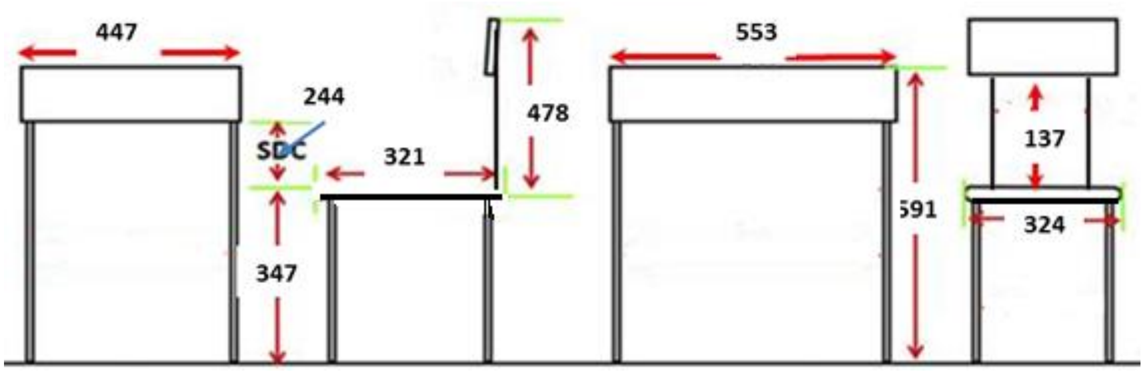

Figure 4.11: Recommended furniture measurements for grade 6 students in Sabaragamuwa province Sri Lanka

All dimensions are in mm

Table 4.14: Students' anthropometric measurements percentile data for school furniture dimensions

School furniture dimension (mm)	Relevant anthropometric measurement (mm)	Male		Female		Recom-mended value	Remarks
		05th percentile	95th percentile	05th percentile	95th percentile		
Seat surface height	Popliteal height (PH)	303.41	384.48	304.60	391.16	347	Midpoint of max and min
Seat depth	Buttock popliteal length (BPL)	321.47	438.74	322.15	448.27	321	Min value
Seat width	Hip width, sitting (HW)	198.19	300.22	194.79	323.91	324	Max value
Back rest width	Hip width, sitting (HW)	198.19	300.22	194.79	323.91	325	Max value
Back rest height (upper) above seat	Sitting shoulder height (SHH)	355.89	458.98	367.47	477.58	478	Max value
Back rest height (lower) above seat	Subscapular height (SUH)	136.6	253.9	149.35	249.91	137	Min value
Backrest angle to horizontal		110º	110º	110º	110º	110º	
Seat angle to horizontal		0º	0º	0º	0º	0º	
Table height	Elbow height sitting (EHS) +Knee height (KH) +shoe heel allowance	493.31	663.15	514.65	689.62	591	Midpoint of max and min
Table depth	Elbow fingertip length (EFTL)	275.07	446.98	326.19	426.30	447	Max value
Table width	Stature*0.4 (IS 4838:1990)	504.00	588.44	504.68	603.44	553.72	Mid point
Table angle to horizontal		15º	15º	15º	15º	15º	
Seat desk clearance	Thigh thickness (TT)	56.04	112.53	55.91	123.53	244	Max value

*All linear dimensions are in mm

*20mm allowance was kept for shoe heal clearance

The comparison of recommended students' desk and chair dimensions with Indian furniture standards specified in IS 4837:1990 were presented in the Table 4.15.

Table 4.15: Comparison of recommended furniture dimensions for grade 6 in Sabaragamuwa province and IS 4837:1990

Furniture Dimensions	Expected value as per IS 4837:1990	Recommended value	Percentage deviation
Desk breadth (DB)	450	447	0.7%
Desk width (DW)	450	554	-23.1%
Desk height (DH)	580	591	-1.9%
Seat height (SH)	340	347	-2.1%
Seat depth (SD)	330	321	2.7%
Upper edge backrest (UEB)	295	478	-62.0%
Back rest height (BRH)	145	137	5.5%
Seat width (SW)	320	324	-1.3%
Seat Desk clearance (SDC)	200	244	-22.0%

All dimensions are in mm

The percentage deviations from the recommended chair and desk dimensions for grade six students based on the anthropometric data of students in Sabaragamuwa province and the specified furniture sizes for students age for years 10-13 (size 3) in the Indian standard IS 4837:1990 were mentioned in the last column of the Table 4.17. The deviations were insignificant for desk breadth, desk height, seat height, seat depth, back rest height and seat width where as significant deviations were observed desk width, upper edge backrest, and seat desk clearance. The reasons for these significant deviations required to be identified.

4.9 Comparison of furniture dimensions in considered schools Sabaragamuwa province and IS 4837:1990 standard

Figure 2.3 shows a schematic diagram of school furniture which was considered in the research study. The measured grade 6 furniture dimensions in selected schools in Sabaragamuwa province were compared with the IS 4837:1990 Indian standard for school furniture, classroom chairs and table furniture Size 3 which is 10-13 years of children age category.

For children of age 11 years, mean stature data of Indian students and students in Sabaragamuwa province it is observed that there was no significant difference between stature values of two sample populations. Further, even though national standards are available in other countries such as UK, USA, Australia, Japan etc, it is fair to consider Indian standards for comparison of data measured in Sri Lanka because geographically both countries are situated very much closer to each other and it can be assumed that there is no significant difference of people living standards and food habits when compared to Western and Eastern countries. The comparison of data are shown in Table 4.16 which includes expected furniture dimensions as per the IS 4837:1990, existing furniture dimensions of considered schools and deviation from the expected values. Table 4.17 gives the percentage deviation of existing furniture dimensions from expected furniture values in IS 4837:1990. The percentage deviations which are highlighted were on safe side or deviations were insignificant while percentage values which were not highlighted were significant. Three furniture dimensions (desk width, upper edge backrest and back rest height) out of nine furniture dimensions have deviated significantly in all considered schools. Desk breadth values in all considered schools are within expected value in the standard and desk height, seat height, seat depth, seat width and seat desk clearance values of furniture in grade 6 in S-1 (Anura Vidyalaya Rathnapura) are also in par with the standard values. It is high time to have school children anthropometric database for Sri Lanka for the purpose of designing school furniture in the future because the country has not developed students' anthropometric database in the past, the available data also have been taken before 1979. It is evident that peoples living standards, food habits and work-life balance has changed significantly in the past causing changes in human anthropometric values.

Table 4.16: Comparison of furniture dimensions with expected furniture values in IS 4837:1990

Furniture dimensions (mm)	Expected value as per IS 4837:1990	Existing values						Deviation from IS 4837:1990					
		S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Desk breadth (DB)	450	470	465	450	460	460	450	-20	-15	0	-10	-10	0
Desk width (DW)	450	660	660	590	580	580	590	-210	-210	-140	-130	-130	-140
Desk height (DH)	580	730	640	560	760	750	600	-150	-60	20	-180	-170	-20
Seat height (SH)	340	460	440	354	445	430	360	-120	-100	-14	-105	-90	-20
Seat depth (SD)	330	320	240	310	295	280	280	10	90	20	35	50	50
Upper edge backrest (UEB)	295	370	430	366	400	450	330	-75	-135	-71	-105	-155	-35
Back rest height (BRH)	145	225	290	226	250	290	180	-80	-145	-81	-105	-145	-35
Seat width (SW)	320	385	300	330	380	350	340	-65	20	-10	-60	-30	-20
Seat desk clearance (SDC)	200	250	200	194	145	120	240	-50	0	6	55	80	-40

*All linear dimensions are in mm
*20mm allowance was kept for shoe heal clearance
*Abbreviation: Rivisanda Maha Vidyalaya Mawanella, (S-1), Mayurapada Maha Vidyalaya Mawanella (S-2), Anura Vidyalaya Rathnapura (S-3), Saman Vidyalaya Rathnapura (S-4), Tholangamuwa Cebtral School Kegalle (S-5), Morawaka Vidyalaya Kegalle (S-6)

Table 4.17: Percentage deviation of existing furniture dimensions from expected furniture values in IS 4837:1990

Furniture dimensions (mm)	Expected value as per IS 4837:1990	Existing values						% Deviation from IS 4837:1990					
		S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Desk breadth (DB)	450	470	465	450	460	460	450	-4%	-3%	0%	-2%	-2%	0%
Desk width (DW)	450	660	660	590	580	580	590	-47%	-47%	-31%	-29%	-29%	-31%
Desk height (DH)	580	730	640	560	760	750	600	-26%	-10%	3%	-31%	-29%	-3%
Seat height (SH)	340	460	440	354	445	430	360	-35%	-29%	-4%	-31%	-26%	-6%
Seat depth (SD)	330	320	240	310	295	280	280	3%	27%	6%	11%	15%	15%
Upper edge backrest (UEB)	295	370	430	366	400	450	330	-25%	-46%	-24%	-36%	-53%	-12%
Back rest height (BRH)	145	225	290	226	250	290	180	-55%	-100%	-56%	-72%	-100%	-24%
Seat width (SW)	320	385	300	330	380	350	340	-20%	6%	-3%	-19%	-9%	-6%
Seat desk clearance (SDC)	200	250	200	194	145	120	240	-25%	0%	3%	28%	40%	-20%

*All linear dimensions are in mm
*20mm allowance was kept for shoe heal clearance
*Abbreviation: Rivisanda Maha Vidyalaya Mawanella, (S-1), Mayurapada Maha Vidyalaya Mawanella (S-2), Anura Vidyalaya Rathnapura (S-3), Saman Vidyalaya Rathnapura (S-4), Tholangamuwa Cebtral School Kegalle (S-5), Morawaka Vidyalaya Kegalle (S-6)

CHAPTER 5

CONCLUSION

Conclusion

This research study was carried out to determine students' anthropometric data required for deciding dimensions of school furniture in grade six at Sabaragamuwa province Sri Lanka. According to the statistical analysis results, it showed that the behaviour of sample population data were closer to normal distribution curve, calculated kurtosis and skewness values of field data further supported this conclusion. However, according to kurtosis values of anthropometric data of thigh thickness and popliteal height of male data and sitting height of female data and skewness values of thigh thickness, popliteal height, and hip width of male data and sitting height, thigh thickness, and hip width of female data were not normally distributed. Further research studies can be carried out to in this regard.

Since there was a strong positive correlation between anthropometric data such as weight and elbow to elbow breadth, weight and hip width, weight and shoulder width, and stature and knee height (of male anthropometric data) and weight and hip width, weight and stature, weight and elbow fingertip length, weight and knee height, weight and elbow to elbow breadth, weight and shoulder width, shoulder sitting height and knee height, buttock popliteal length and buttock knee depth, popliteal height and knee height, hip width and shoulder width, stature and buttock knee depth, stature and elbow fingertip length, stature and knee height, elbow fingertip length and knee height, and elbow to elbow breadth and shoulder width (of female anthropometric data), further research study would be beneficial to consider developing anthropometric measurements prediction equations for future research studies. They would be very useful for minimizing the number of measurements needs to be taken per subject in the field, prediction equations can be used to calculate the anthropometric values using measured other anthropometric data. This minimizes time spent for collecting field data in a similar research study, specially, large sample population. The existing furniture of grade six classes in considered schools for the study needs immediate attention because of the deviations of the sizes compared to the standards. The recommended measurements for suitable desk and chair for grade six students is shown in Figure 4.11.

In the comparison of the recommended chair and desk dimensions for grade six students in Sabaragamuwa province and the specified furniture sizes for students age for years 10-13 (size 3) in the Indian standard IS 4837:1990, insignificant differences were observed for desk breadth, desk height, seat height, seat depth, back rest height and seat width. However, significant differences were observed for desk width, upper edge backrest, and seat desk clearance. Therefore all furniture sizes specified in Indian standard cannot be adopted. The reasons for these significant deviations required to be identified in future research studies.

However, comprehensive island wide anthropometric survey is recommended to be carried out covering all districts, including student categories from grade 1 to grade 12 and revisit the existing furniture sizes because no detailed study has been performed after 1979 in Sri Lanka and also students' anthropometry may have been changed with the change of living styles, food habits, intra-individual, inter-individual, and secular variation of measurements during the past 40 years. The past anthropometry data are no longer valid for future design of furniture and other equipment.

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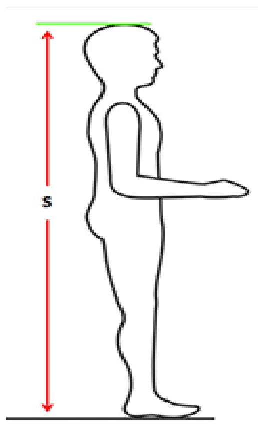
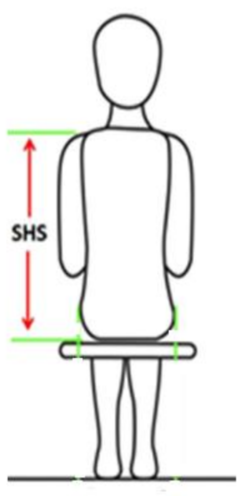
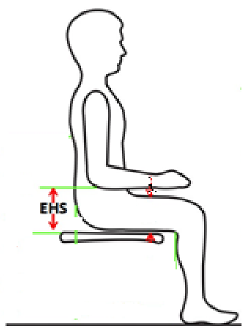
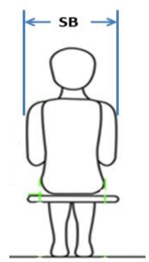
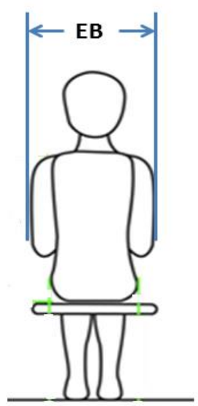
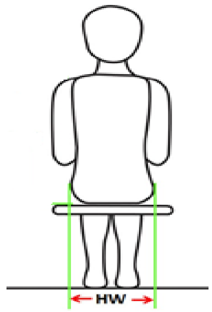
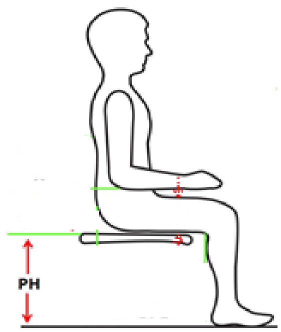
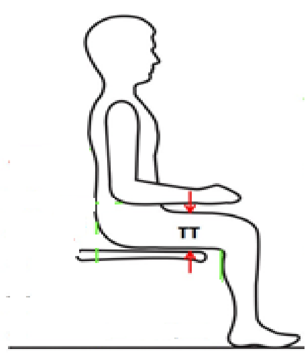
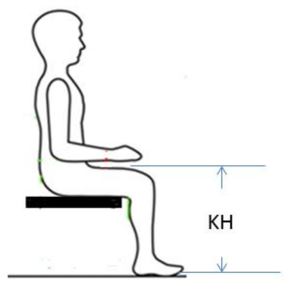
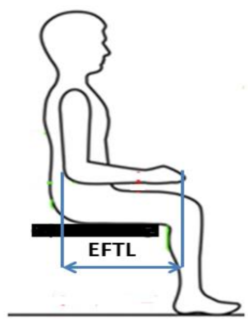
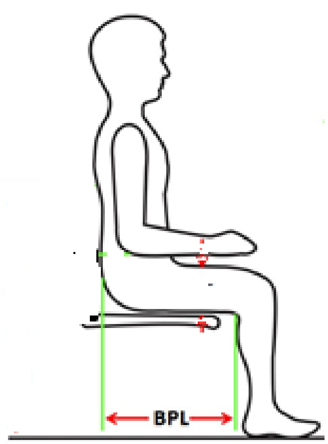
APPENDICES

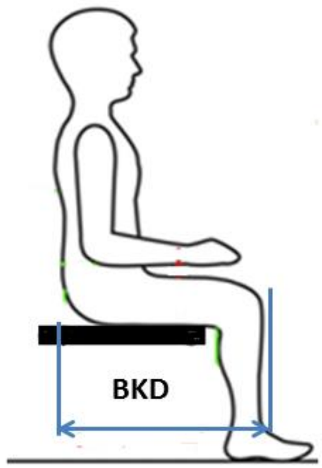
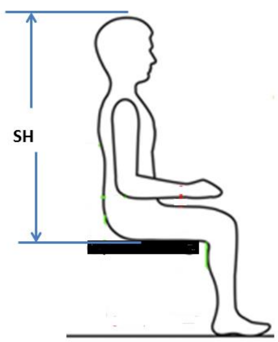
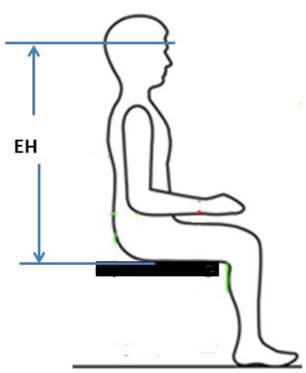
Appendix A: Guideline for taking selected anthropometric measurement which was used in the research study in compliance with ISO 7250-1:2008.

	Anthropometric measurement	
01	Body weight	**Description:** Total weight of the body **Method:** Student stands on the weighing scale (without shoes) **Instrument:** Weighing scale.
02	Stature  	**Description:** Vertical distance from the floor to the vertex (highest point of the head) **Method:** Student standing on the floor facing forward and arms hanging beside the body **Instrument:** Anthropometer
03	Shoulder height sitting (erect)  	**Description:** Vertical distance from student seated surface to the acromion **Method:** Students sits fully erect with thighs fully supported and lower legs hanging freely, shoulders are relaxed, and upper arms hanging freely **Instrument:** Anthropometer

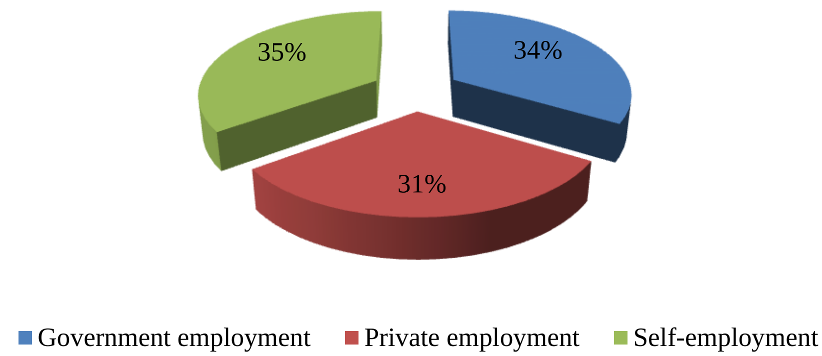
	Anthropometric measurement	
04	Elbow height sitting (EHS) 	**Description:** Taken with a 90° angle el-bow flexion, as the vertical distance from the bottom of the tip of the elbow (olecranon) to the student seated surface. **Method:** Students sits fully erect with thighs fully supported, lower leg hanging freely, upper arms hang freely downwards and forearms are horizontal **Instrument:** Anthropometer
05	Shoulder (bideltoid) breadth 	**Description:** Distance between the right and left deltoid muscles **Method:** Students sits fully erect with thighs fully supported, lower leg hanging freely **Instrument:** Large sliding caliper or large spreading caliper
06	Elbow-to-elbow breadth (EB) 	**Description:** Distance measured horizontally across the lateral surface of the elbows (standard writing position on the desk), spreading sideways was measured. **Method:** Student sits or stands erect with upper arms hanging down and lightly touching the sides of the body. Forearms are extended horizontally and parallel to each other and the floor. Measurement is taken without pressing into the flesh at the elbows. **Instrument:** Large sliding caliper or large spreading caliper

	Anthropometric measurement	
07	Hip width (HW) 	**Description:** The horizontal distance measured in the widest point of the hip in the sitting position. **Method:** Student sits with thighs fully supported and lowers legs hanging freely, knees together. Measurement is taken without pressing into the flesh of the hips **Instrument:** Large spreading caliper
08	Popliteal height (PH) 	**Description:** Measured with 90° knee flexion, as the vertical distance from the floor or footrest and the posterior surface of the knee (Popliteal surface). **Method:** Student holds thigh and lower leg at right angles during measurement. Student may sits with the foot placed on a raised platform. The movable arm of the measuring instrument is pushed gently against the tendon of the relaxed biceps femoris muscle. **Instrument:** Anthropometer.
09	Thigh thickness (TT) 	**Description:** The vertical distance from the highest uncompressed point of thigh to the student seated surface. **Method:** Student sits erect with knees bent at right angles, supporting the feet flat on the floor **Instrument:** Anthropometer

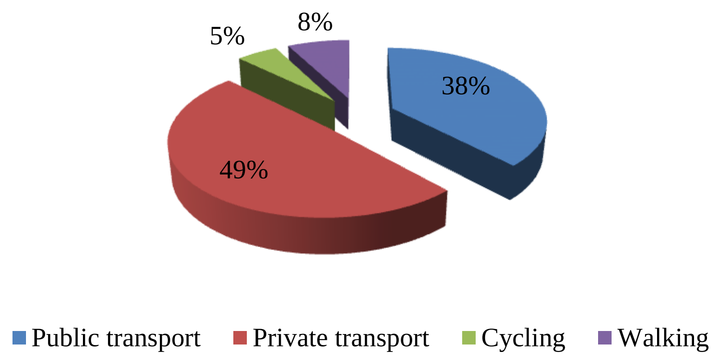
	Anthropometric measurement	
10	Knee height (KH) 	**Description:** Vertical distance from floor to the top of knee cap **Method:** Student sits erect with knees bent at right angles, supporting the feet flat on the floor **Instrument:** Anthropometer
11	Elbow length fingertip length (EFTL) 	**Description:** The horizontal distance from the back of the elbow to the tip of the middle finger at standard sitting position **Method:** Student sits erect with upper arm hanging downwards, forearm horizontal and hand extended. **Instrument:** Anthropometer or large sliding caliper
12	Buttock popliteal length (BPL) 	**Description:** Taken with a 90° angle knee flexion as the horizontal distance from the posterior surface of the buttock to the Popliteal surface **Method:** Student sits fully erect with thighs fully supported and the Student sitting surface extending as far as possible into the hollow of the knee, lower legs straight place on the horizontal floor or special height adjustable foot rest. Distance is measured from the rearmost point of the buttock to the forward edge of the sitting surface. **Instrument:** Anthropometer, Special height adjustable foot rest

	Anthropometric measurement	
13	Buttock knee depth (BKD) 	**Description:** Distance measured horizontally from the front of the knee cap to the back of uncompressed buttock. **Method**: Student sits fully erect with thighs fully supported and the Student sitting surface extending as far as possible into the hollow of the knee, lower legs straight place on the horizontal floor or special height adjustable foot rest. Distance is measured from the measuring block to the foremost point of the knee-cap. **Instrument:** Anthropometer, Special height adjustable foot rest
14	Sitting height (SH) 	**Description:** Vertical distance from the tip of the head to the surface of the student **Method:** Student sits fully erect with thighs fully supported and lower legs hanging freely. Head is oriented in the Frankfurt plane. **Instrument:** Anthropometer
15	Eye height (EH) 	**Description:** Eye height refers to the vertical distance from inner canthus of the eye to the sitting surface **Method:** Student sits fully erect with thighs fully supported and lower legs hanging freely. Head is oriented in the Frankfurt plane. **Instrument:** Anthropometer

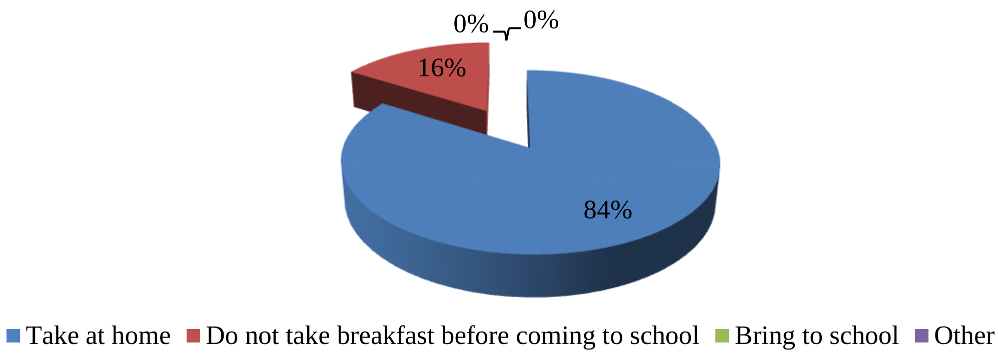
Appendix B: Students' well-being data analysis



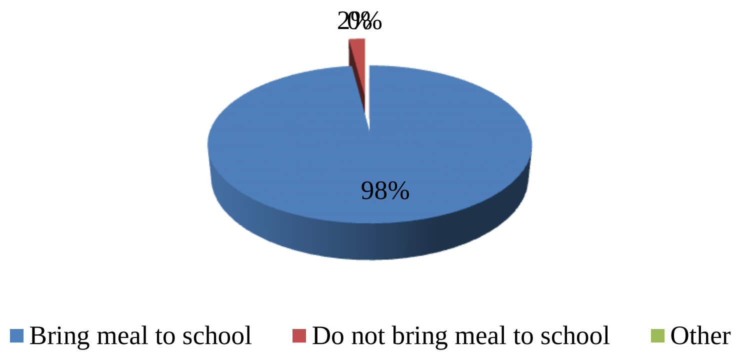
(G.1) Analysis of data related to family income of grade 6 students in Sabaragamuwa province



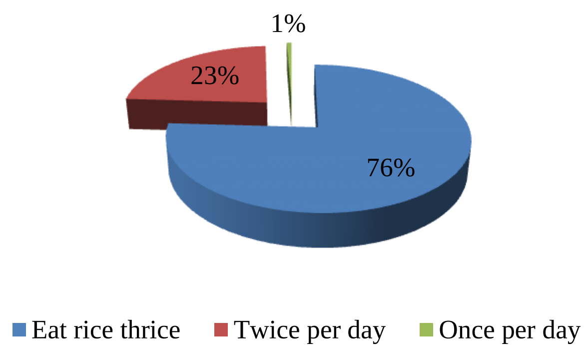
(G.2) Analysis of data related to mode of travel to school of grade 6 students in Sabaragamuwa province



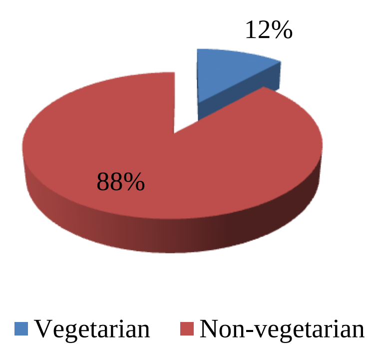
(G.3) Analysis of data related to pattern of having breakfast of grade 6 students in Sabaragamuwa province



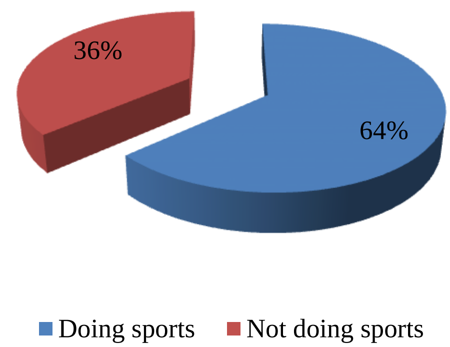
(G.4) Analysis of data related to students having their meals at school in Sabaragamuwa province



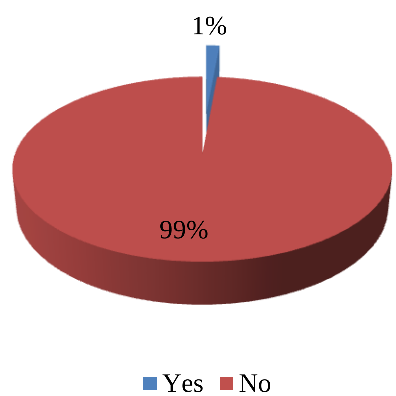
(G.5) Analysis of data related to students having their meals at school in Sabaragamuwa province



(G.6) Analysis of data related to students food styles in Sabaragamuwa province

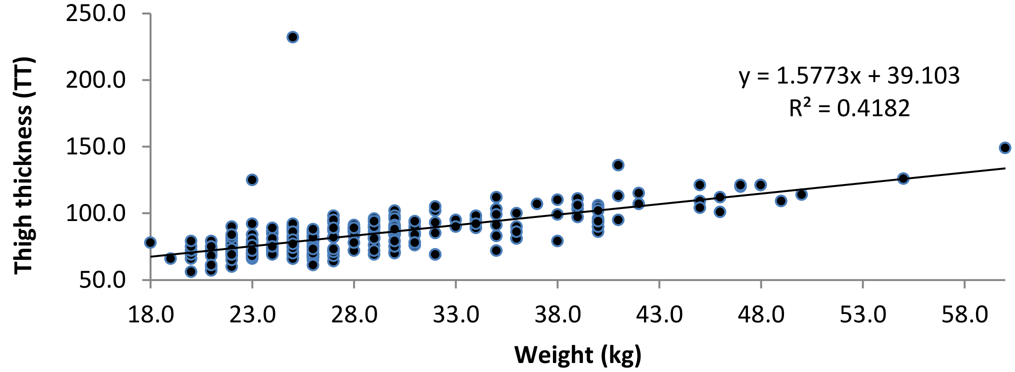


(G.7) Analysis of data related to students' physical activities in Sabaragamuwa province

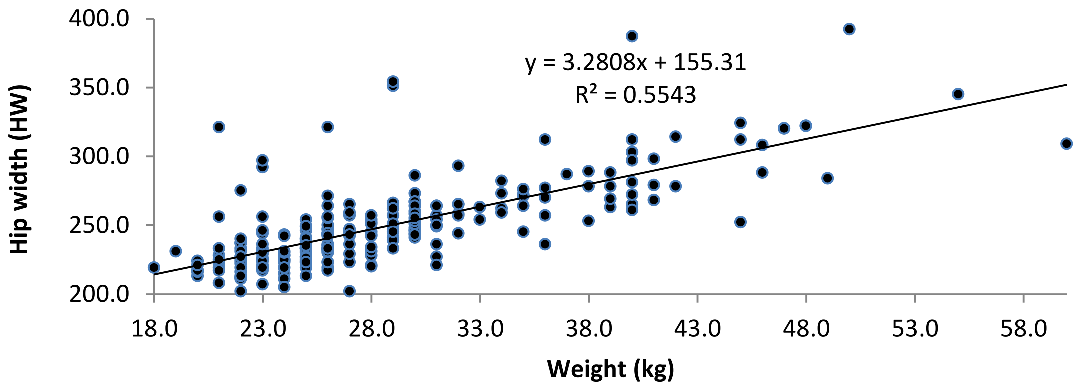


(G.8) Analysis of students’ data related to use of spectacles in Sabaragamuwa province

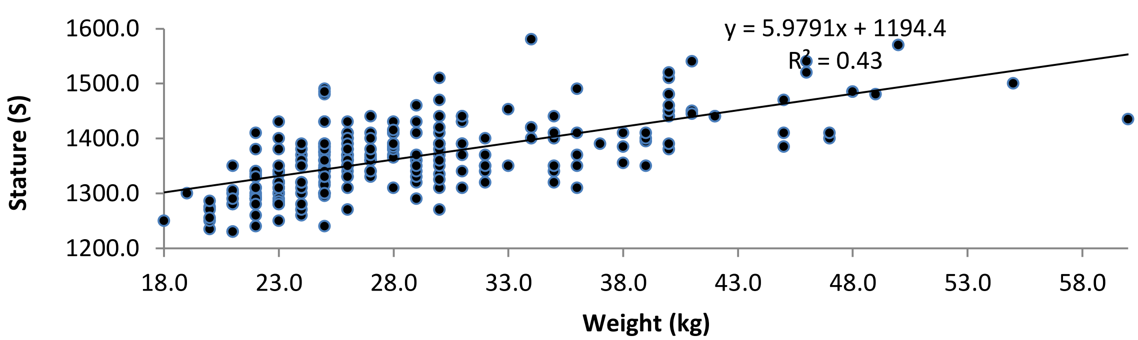
Appendix C: Correlation coefficient graphs for male anthropometric data



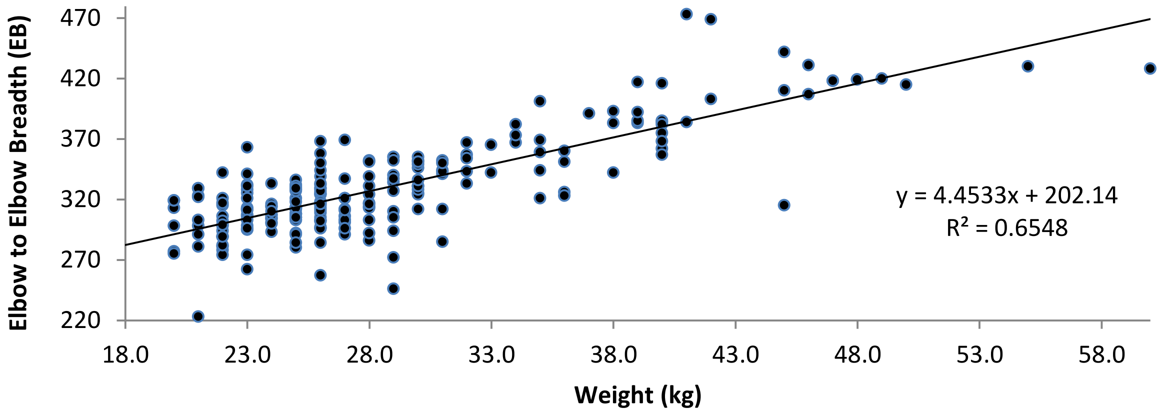
(H.1) Correlation of male anthropometric data weight vs thickness



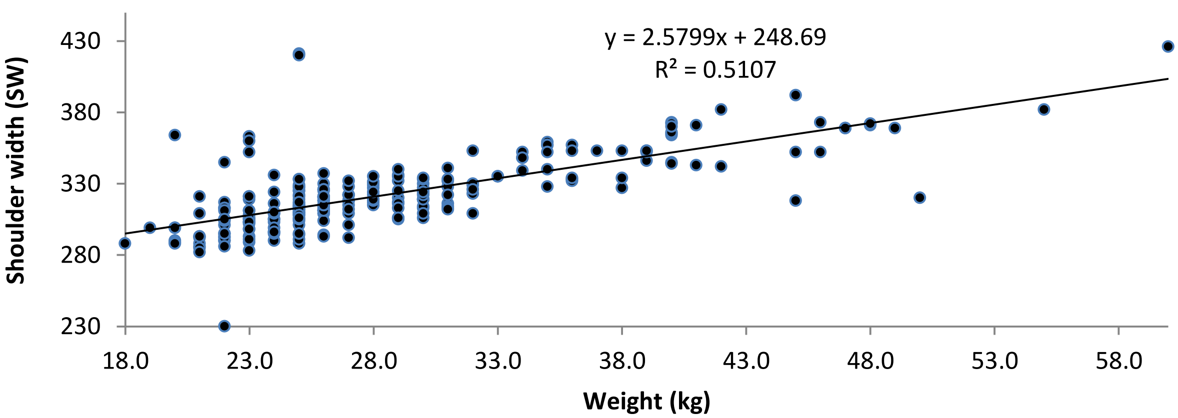
(H.2) Correlation of male anthropometric data weight vs hip width



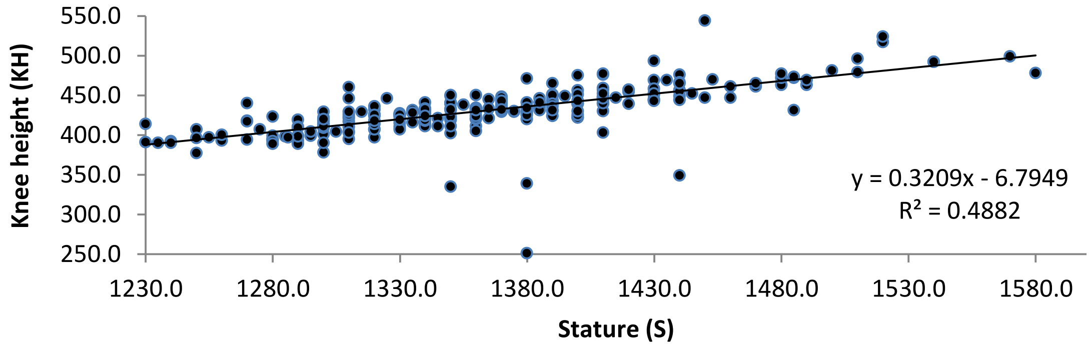
(H.3) Correlation graph of male anthropometric data weight vs stature



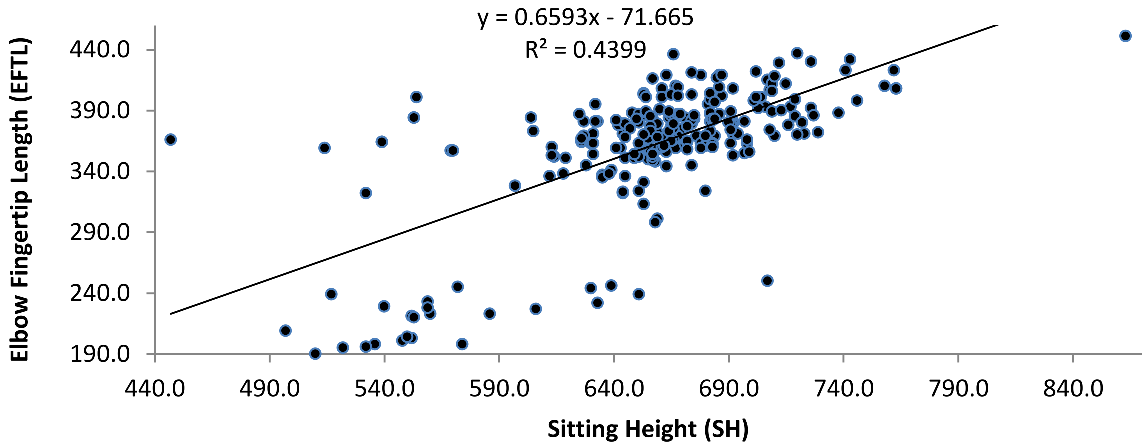
(H.4) Correlation of male anthropometric data weight vs elbow to elbow breadth



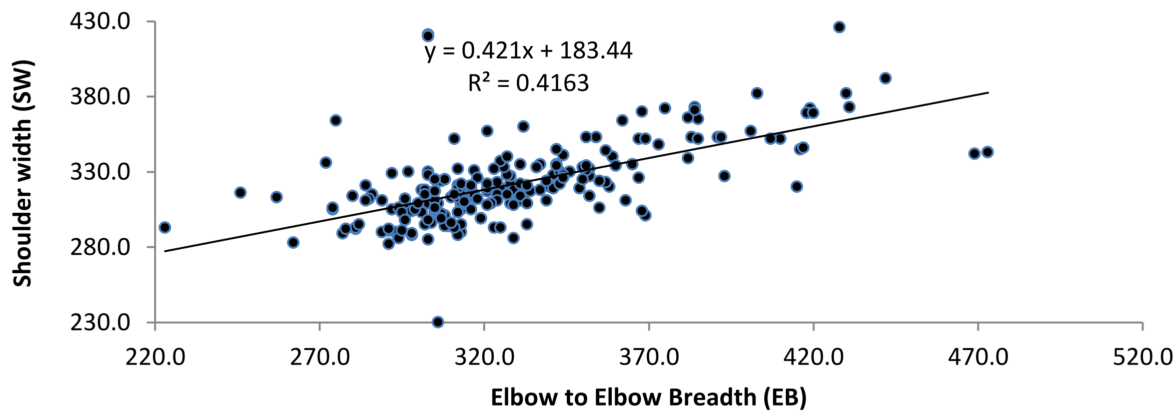
(H.5) Correlation graph of male anthropometric data weight vs shoulder wi



(H.6) Correlation graph of male anthropometric data stature vs knee height

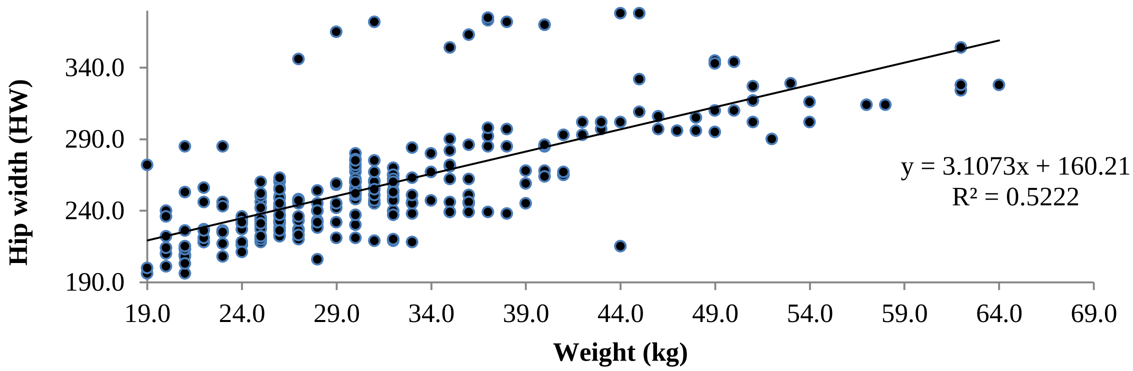


(H.7) Correlation graph of male anthropometric data sitting height vs elbow fingertip length

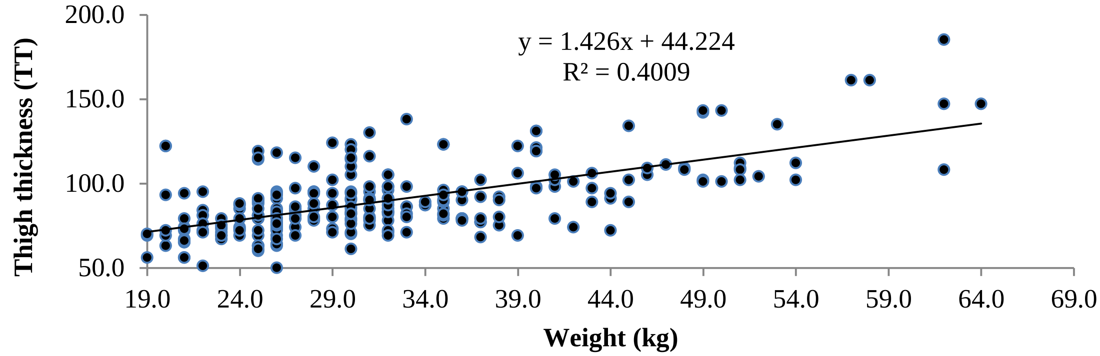


(H.8) Correlation graphs of male anthropometric data elbow to elbow breadth vs shoulder width

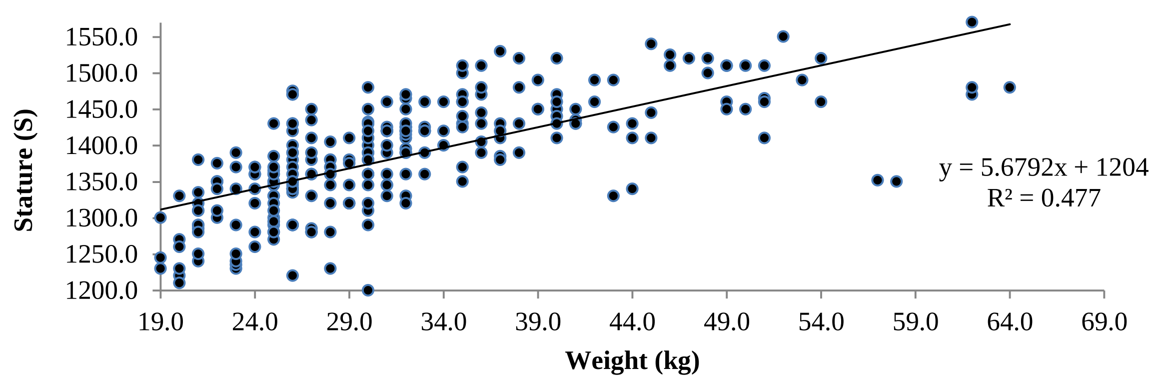
Appendix D: Correlation coefficient graphs for female anthropometric data



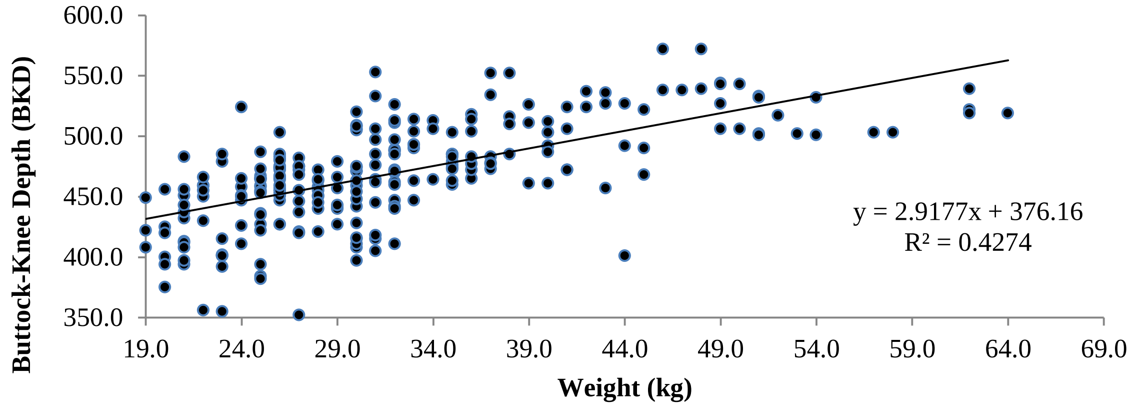
(I.1) Correlation graph of female anthropometric data weight vs hip width



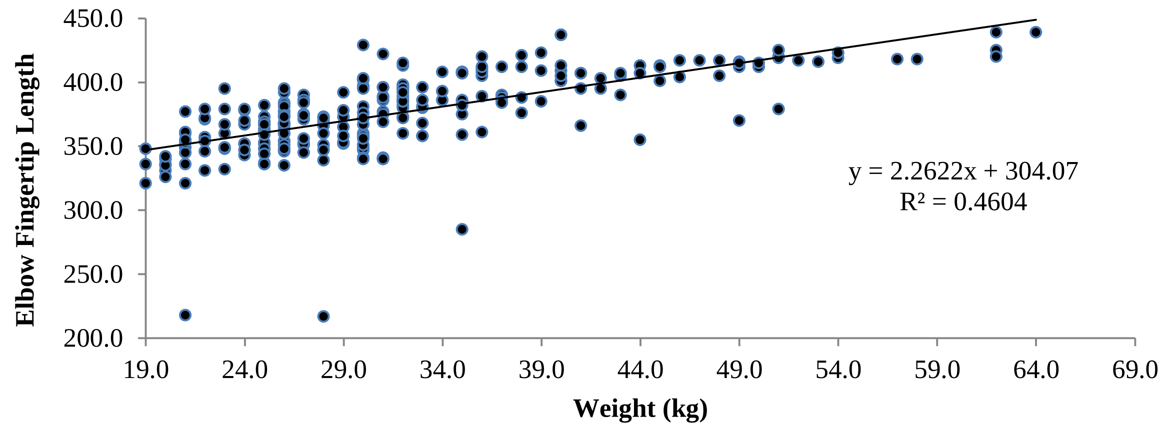
(I.2) Correlation graph of female anthropometric data weight vs thigh thickness



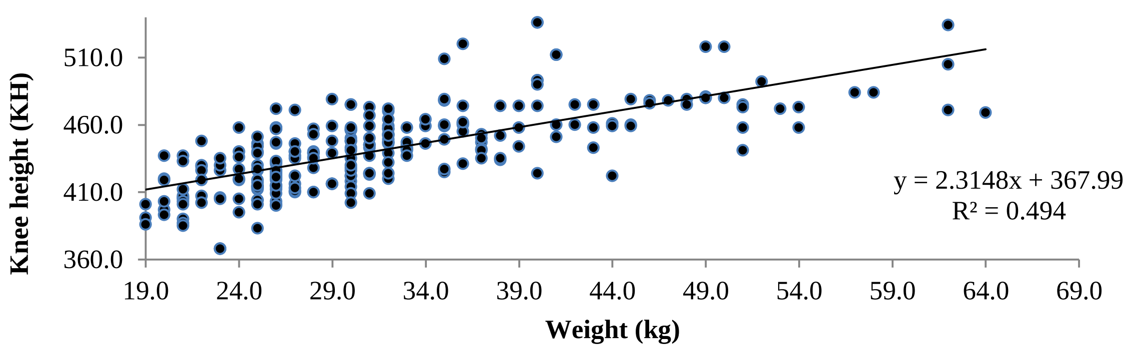
(I.3) Correlation graph of female anthropometric data weight vs stature



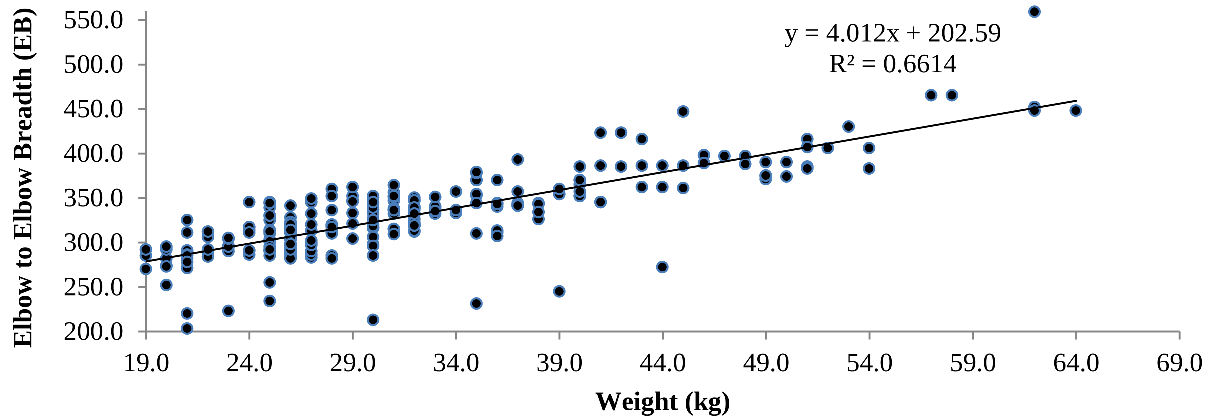
(I.4) Correlation graph of female anthropometric data weight vs buttock knee depth



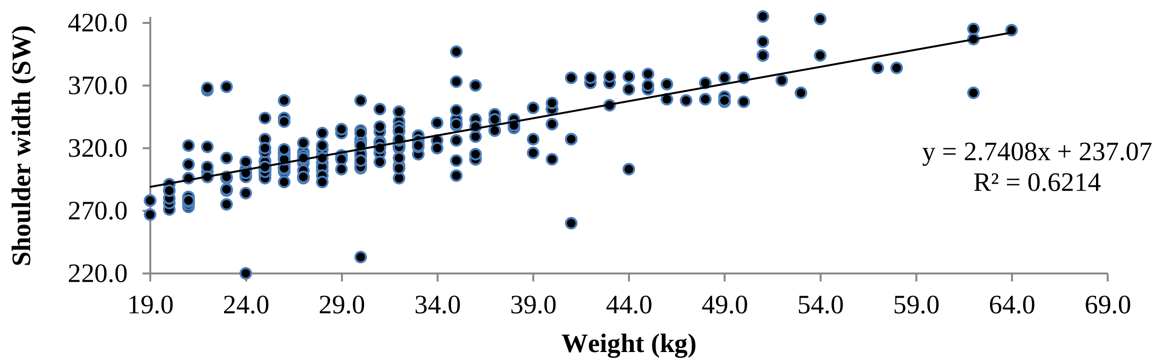
(I.5) Correlation graph of female anthropometric data weight vs elbow fingertip length



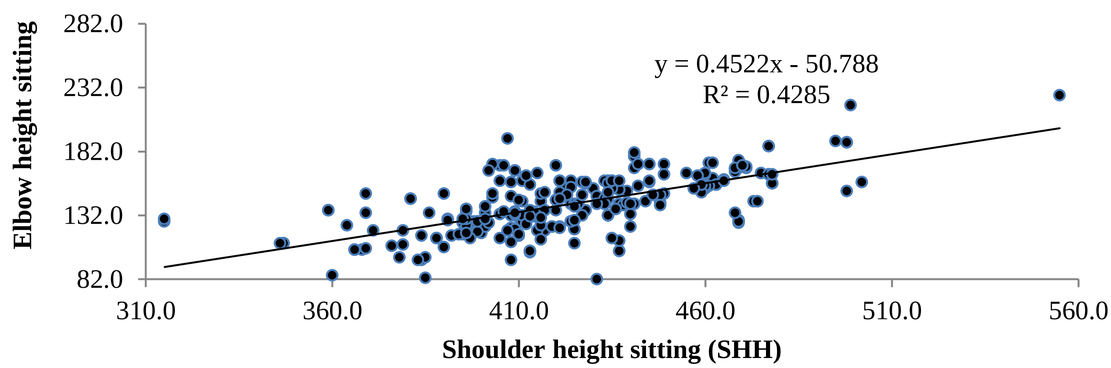
(I.6) Correlation graph of female anthropometric data weight vs knee height



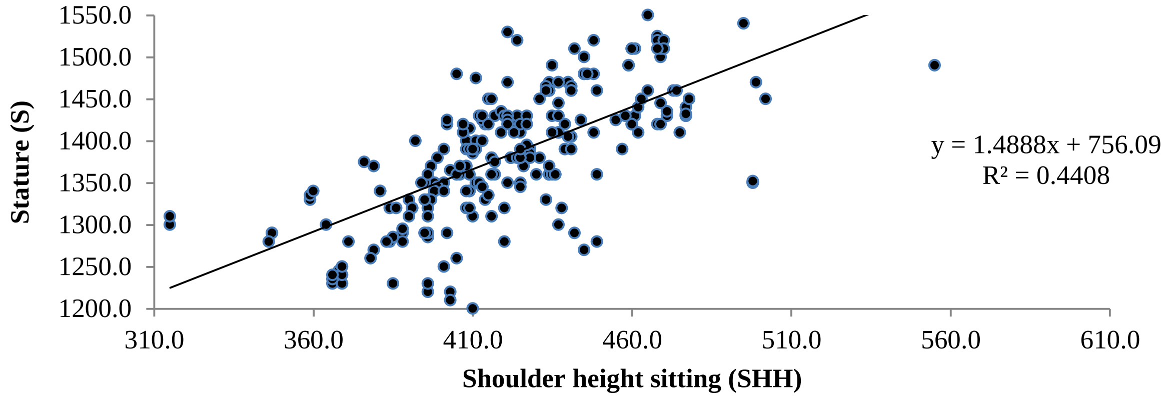
(I.7) Correlation graph of female anthropometric data weight vs elbow to elbow breadth



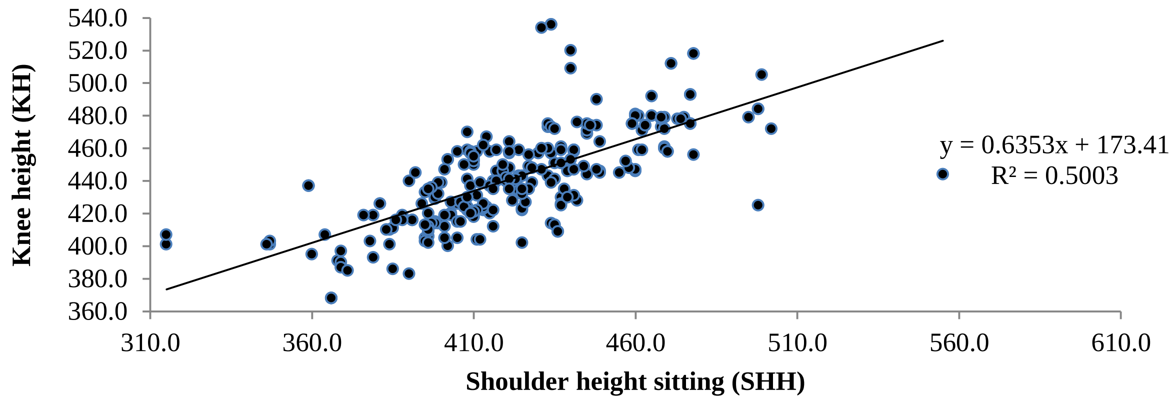
(I.8) Correlation graph of female anthropometric data weight vs shoulder width



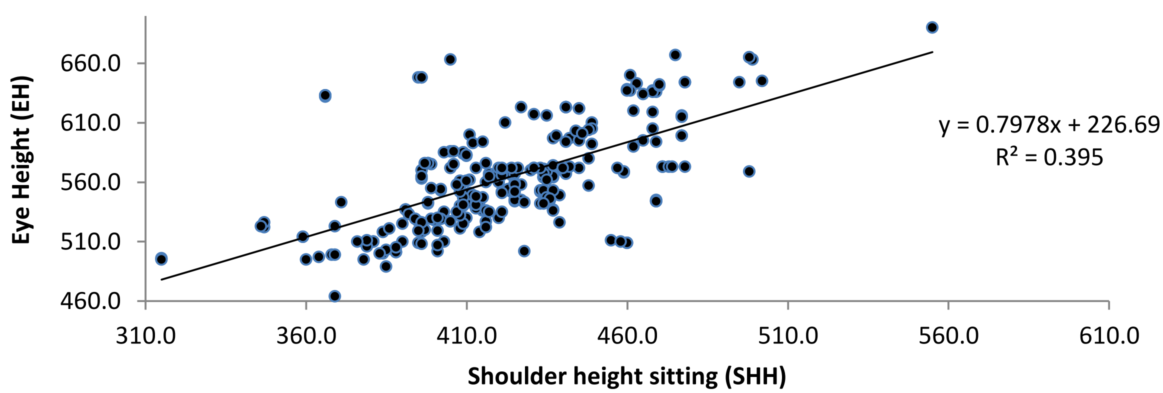
(I.9) Correlation graph of female anthropometric data shoulder height sitting vs elbow height sitting



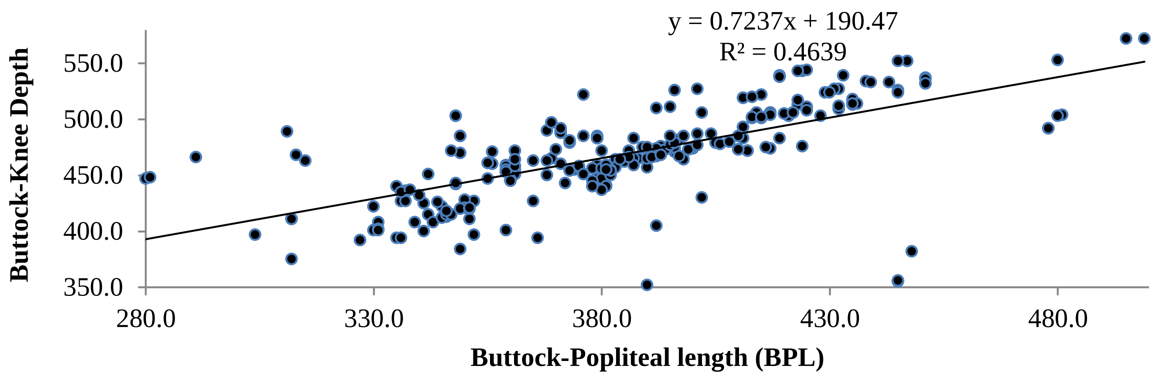
(I.10) Correlation graph of female anthropometric data shoulder height sitting vs stature



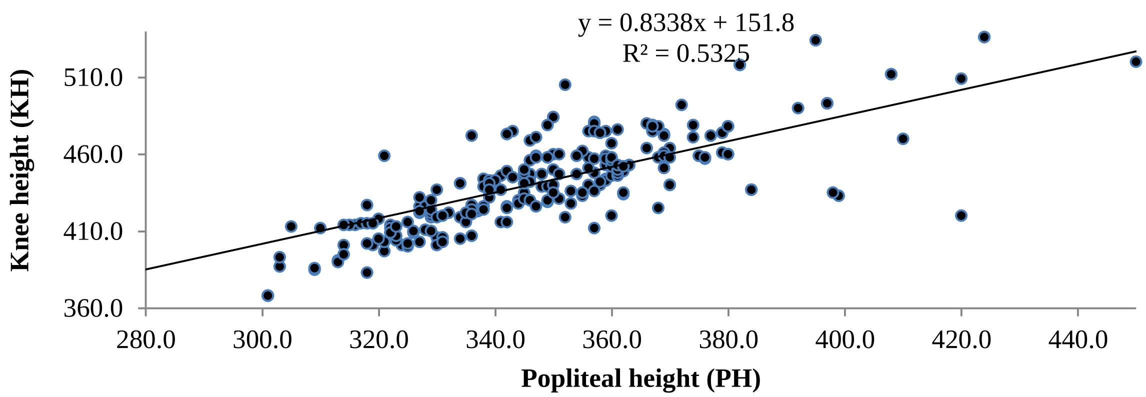
(I.11) Correlation graph of female anthropometric data shoulder height sitting vs knee height



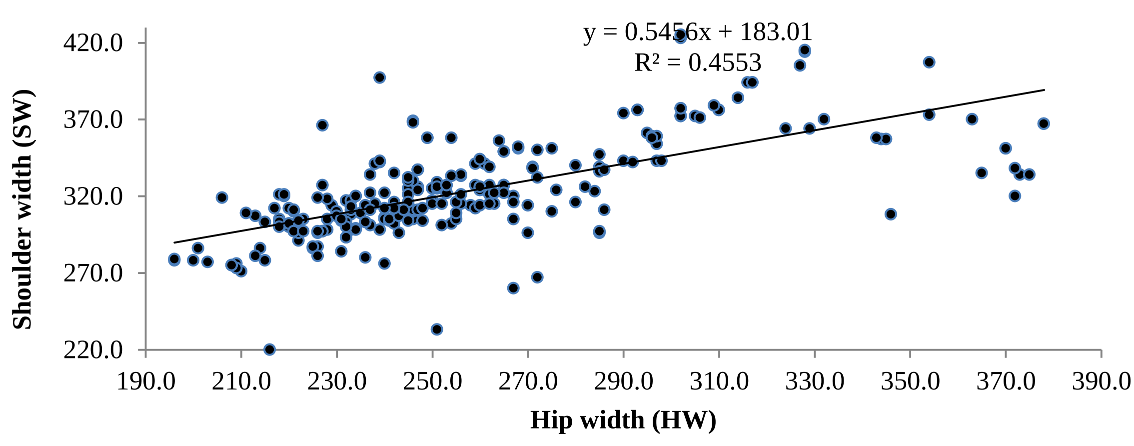
(I.12) Correlation graph of female anthropometric data shoulder height sitting vs eye height



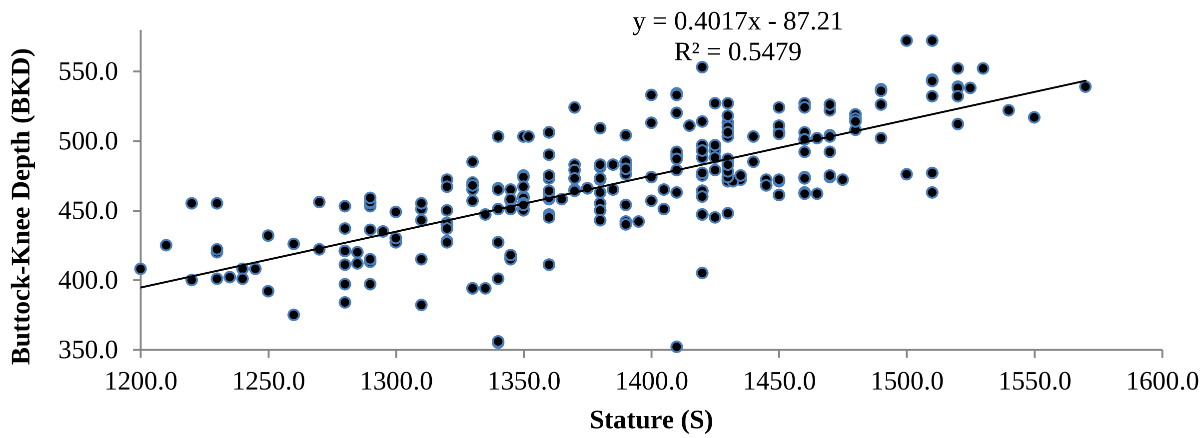
(I.13) Correlation graph of female anthropometric data buttock popliteal height vs buttock knee depth



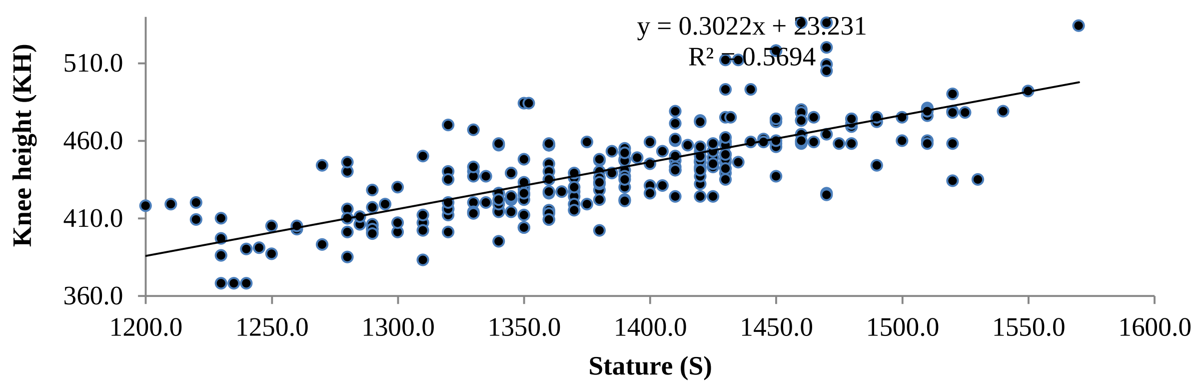
(I.14) Correlation graph of female anthropometric data popliteal height vs knee height



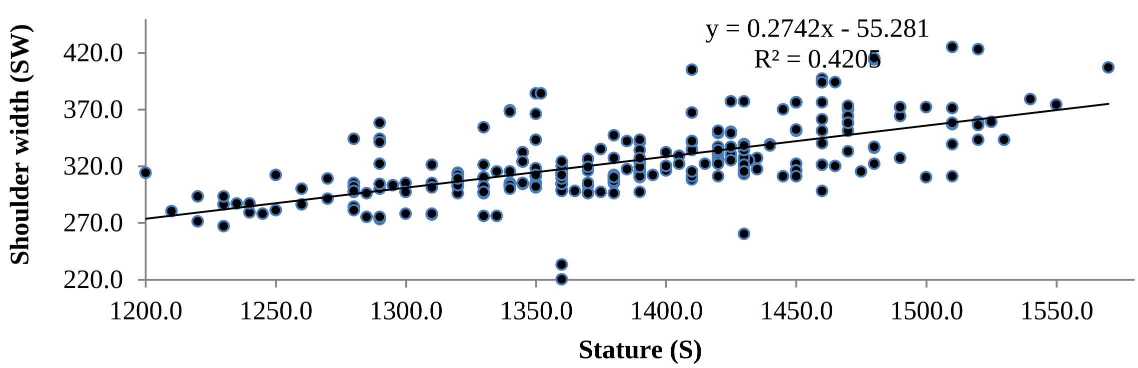
(I.15) Correlation graph of female anthropometric data hip width vs shoulder width



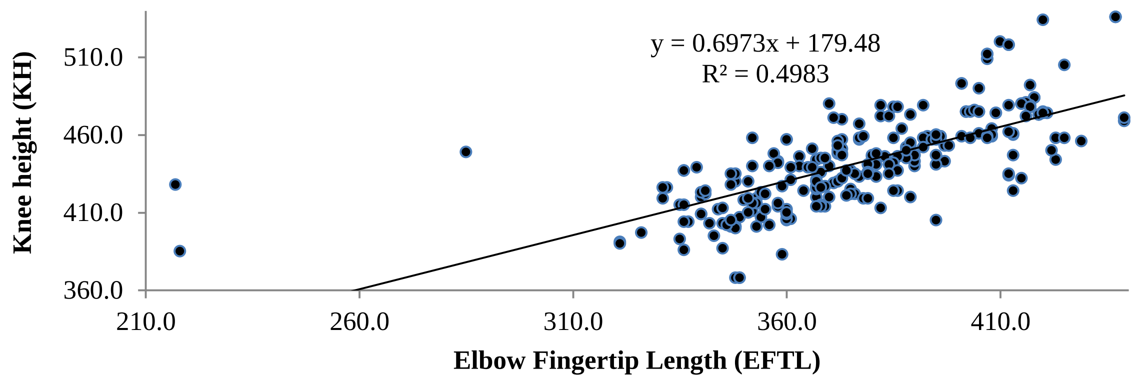
(I.16) Correlation graph of female anthropometric data stature vs buttock knee depth



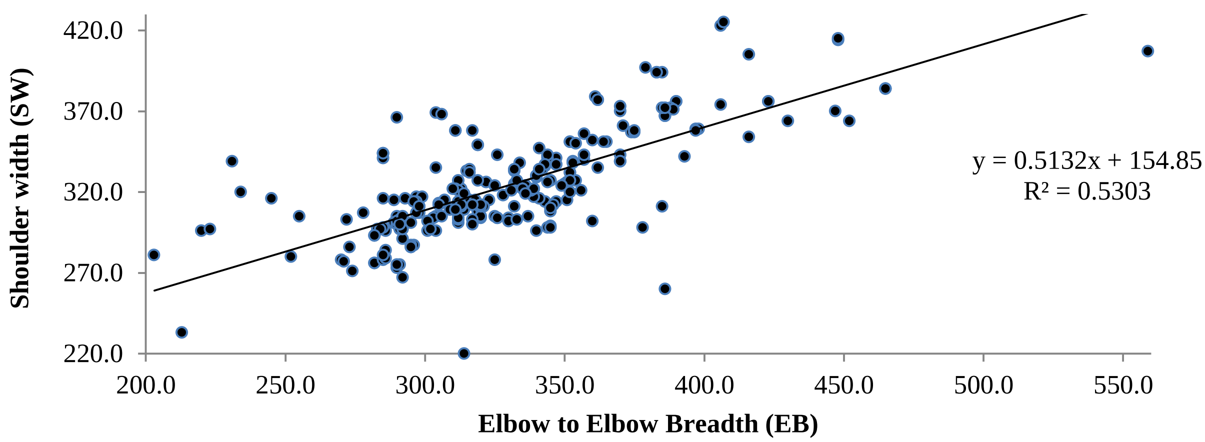
(I.17) Correlation graph of female anthropometric data stature vs knee height



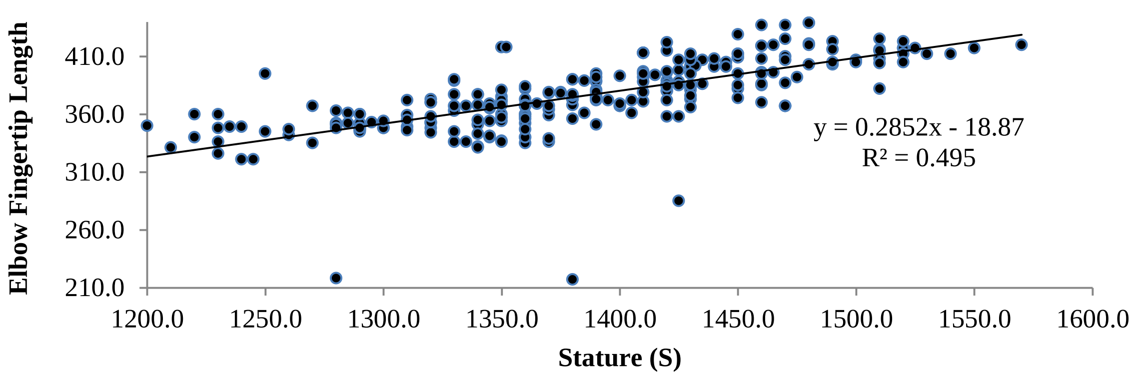
(I.18) Correlation graph of female anthropometric data stature vs shoulder width



(I.19) Correlation graph of female anthropometric data elbow fingertip length vs knee height



(I.20) Correlation graph of female anthropometric data elbow to elbow breadth vs shoulder width



(I.21) Correlation graph of female anthropometric data stature vs elbow fingertip length

Appendix E: Photographs taken during anthropometric field measurements taken at schools in Sabaragamuwa province

Appendix F: A letter from Ministry of Education

අධ්‍යාපන අමාත්‍යාංශය
கல்வி அமைச்சு
Ministry of Education

"Isurupaya", Sri Jayawardhanapura Kotte,
Battaramulla.

Telephone Nos.
Minister – 2784832, 2784807, 2785617
Secretary – 2784812
Office – 2785141-50, Fax: 2784846
E-mail : isurupaya@moe.gov.lk

Your No.

My No. – ED/07/08/101/01/ccI/II
Date – 2016.09.21

DEPARTMENT OF MECHANICAL ENGINEERING UNIVERSITY OF MORATUWA 23 .. 2016

Dr.Himan Punchihewa
Senior Lecturer
Department of Mechanical Engineering
University of Moratuwa

Anthropometric Data Collection to Determine Chair & Table Dimensions for School Children

This has to reference to your request by even No.UM/ME/CON/16/001-1, dated 09.09.2016 on the above.

02. I wish to inform you that your request to grant permission to Mr.H.R.D.R. Wijesinghe, teacher at Rivisada National School Mawanwlla to collect the Anthropometric data has been approved by the Secretary Ministry of Education.

03. We will request the Provincial / Zonal Directors to make arrangements to provide the services of a female teacher to assist with collecting the relevant data as you have requested.

04. Further Secretary MoE has requested that the copy of the research report be submitted to him for his information please.

Y.M.S.Gunasekara
Chief Accountant (Procurement)

Signed: Secretary
Ministry of Education

Copy:-01.Provincial Director of Education
Sabaragamuwa Province – for Necessary Action
02. Mr.H.R.D.R.Wijesinghe - for your information

Mr Kamal Meedeniya will collect the necessary data along with Mr Dimuthu Wijesinghe

Appendix G: A letter from Zonal Education office Mawanella

කලාප අධ්‍යාපන කාර්යාලය, මාවනැල්ල
வலயக் கல்விக் காரியாலயம் - மாவனல்லை
Zonal Education Office, Mawanella

මගේ අංකය
My No } කෑ/මාව/අධ්‍යා/පරි/ 1/9

දිනය
Date } 2016.10. ......

මාවනැල්ල අධ්‍යාපන කලාපයේ
විදුහල්පතිවරුන් වෙත,

<u>6 වසර සිසු දරු දැරියන්ගේ පාසල් ලී බඩු උපකරණ පිළිබඳ සමීක්ෂණය</u>

මොරටුව විශ්ව විද්‍යාලයේ අධ්‍යාපනය ලබන එච්. ආර්. ඩී. ආර්. විජේසිංහ යන අය 6 වසරට අදාළ සිසු දරු දැරියන්ගේ ලී බඩු උපකරණ පිළිබඳ සමීක්ෂණයක් සඳහා අවසර ලබා දෙන ලෙස ඉල්ලීමක් ඉදිරිපත් කර ඇත.

ඒ සඳහා අවශ්‍ය සහයෝගය ලබා දෙන ලෙස කාරුණිකව දන්වමි.

එස්.ජේ.යූ.බී.කෝරලේගෙදර
සහකාර අධ්‍යාපන අධ්‍යක්ෂ (පරිපාලන)
කලාප අධ්‍යාපන කාර්යාලය,
මාවනැල්ල.

එස්.ජේ.යූ.බී. කෝරලේගෙදර
ශ්‍රී.ලං.අ.ප.සේ. III
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මාවනැල්ල.

අ/කළේ :- පී.පී.ආර්.එස්. මාධවී වෙලගෙදර
කලාප අධ්‍යාපන අධ්‍යක්ෂ
කලාප අධ්‍යාපන කාර්යාලය,
මාවනැල්ල.

ක. අ. අ. Z. D. E.	035-2246034	ගණකාධිකාරී Accountant	035-2246034	පරිපාලන නිලධාරී Administrative Officer	035-2246034
සැලසුම් Planning	035-2246753	ඊ-මේල් E- mail	mawanellazone@gmail.com	ෆැක්ස් Fax	035-2246034

Appendix H: A letter from Zonal Education office Kegalle

කලාප අධ්‍යාපන කාර්යාලය - කෑගල්ල
Zonal Education Office –Kegalle
வலயக் கல்விக் காரியாலயம் - கேகாலை
Email: kegalleedz@gmail.com- Fax : 0352222520

මගේ අංකය : කෑ/අධ්‍යා/පරි/1/2/2017
My No :
ඔබේ අංකය :
Your No :
දිනය : 2017.06. 30
Date :

කෑගල්ල අධ්‍යාපන කලාපයේ
6 ශ්‍රේණිය සහිත පාසල්වල විදුහල්පතිවරුන් වෙත

<u>**6 ශ්‍රේණියේ සිසු දරු දැරියන්ගේ සහ මේස පුටු වල මිනුම් දත්ත ලබා ගැනීම**</u>

ඉහත සදහන් කරුණට අදාලව මොරටුව විශ්ව විද්‍යාලයේ කාර්මික ඉංජිනේරු දෙපාර්තමේන්තුවේ පශ්චාද් උපාධි පාඨමාලාව හදාරණ දිමුතු විජේසිංහ (ජා.හැ.අං:863432154 වී) මයා හා කමල් මීදෙනිය මයා (ජා.හැ.අං:680371342 වී) විසින් එවා ඇති 2017.06.30 දිනැති ලිපිය හා බැදේ.

02 ඒ අනුව තමන් විසින් අධ්‍යාපන අමාත්‍යාංශයේ ද එකගතාවය මත සිදු කරනු ලබන 6 ශ්‍රේණියේ අධ්‍යාපනය ලබන සිසු දරුවන්ගේ මිමි හා ඔවුන් පරිහරණය කරනු ලබන ඩෙස්/පුටු වල විස්තර ලබා ගැනීමේ සමීක්ෂණය සදහා කෑගල්ල කලාපයේ පාසල් වලින් තොරතුරු ලබා ගැනිමට අවසර ඉල්ලා සිටී.

03 මේ අනුව අනන්‍යතාවය තහවුරු කර ගෙන පාසලේ අධ්‍යාපන කටයුතු වලට බාධාවක් ඇති නොවන අයුරින් අවශ්‍ය තොරතුරු ලබා දිමට මෙයින් අවසර ලබාදෙමි. සිසු දැරියන්ගේ මිමි ලබා ගැනීමේ දී ගුරුමහත්මියකගේ සහාය ලබා ගැනිම අනිවාර්ය වේ.

ටී.එම්.සී.එච්.තෙන්නකෝන්
සහකාර අධ්‍යාපන අධ්‍යක්ෂ
කෑගල්ල කලාප අධ්‍යාපන අධ්‍යක්ෂ
වෙනුවට

කලාප අධ්‍යාපන අධ්‍යක්ෂ	ගණකාධිකාරී	පරිපාලන නිලධාරී	සැලසුම් අංශය	අධ්‍යාපන පරිපාලන
Zonal Education Director	**Accountant**	**A/O**	**Planning Section**	**Education Admin.**
0352222517	0352222202	0352222520	03522223021	0352222216

Appendix I: A letter from Zonal Education office Rathnapura

කලාප අධ්‍යාපන කාර්යාලය - රත්නපුර
வலயக்கல்வி அலுவலகம் - இரத்தினபுரி
Zonal Education Office - Ratnapura

...gmail.com

කලාප අධ්‍යාපන අධ්‍යක්ෂ
வலயக்கல்விப் பணிப்பாளர்
Zonal Education Director

සැලසුම් අංශය
திட்டமிடல் பிரிவு
Planning Section

දුරකථනය / தொலைபேசி / Tel/Fax - 045-2230905

කාර්යාලය / அலுவலகம் / Office

මගේ අංකය / எனது இல / My No: ර/ර-කලාප/අධ්‍යා.3/03

දිනය / திகதி / Date: 2017.07.07

රත්නපුර අධ්‍යාපන කලාපයේ
විදුහල්පතිවරුන් වෙත,

<u>6 වසර සිසු දරු දැරියන්ගේ සහ මේස පුටු වල මිනුම් දත්ත ලබා ගැනීම</u>

ඉහත කරුණට අදාලව මොරටුව විශ්ව විද්‍යාලයේ කාර්මික ඉංජිනේරු දෙපාර්තමේන්තුවේ පශ්චාත් උපාධි පාඨමාලාව හදාරණ දිමුතු විජේසිංහ මහතා (ජා.හැ.අ. 863432154V) හා කමල් මීදෙනිය මහතා (ජා.හැ.අ. 680371342V) විසින් එවා ඇති 2017.06.30 දිනැති ලිපියට අදාලවයි.

02.ඒ අනුව ඔවුන් විසින් අධ්‍යාපන අමාත්‍යාංශයේ අනුමැතිය මත සිදු කරනු ලබන 6 ශ්‍රේණියේ අධ්‍යාපනය ලබන සිසු දරුවන්ගේ මිනුම් හා ඔවුන් පරිහරණය කරනු ලබන මේස්/පුටු වල විස්තර ලබා ගැනීමේ සමීක්ෂණය සඳහා රත්නපුර කලාපයේ පාසල් වලින් තොරතුරු ලබා ගැනීමට අවසර ඉල්ලා සිටී.

03.මේ අනුව,අනන්‍යතාවය තහවුරු කර ගෙන පාසලේ අධ්‍යාපන කටයුතු වලට බාධාවක් ඇති නොවන අයුරින් අවශ්‍ය තොරතුරු ලබා දීමට මෙයින් අවසර දෙමි.ශිෂ්‍යාවන්ගේ මිනුම් ලබා ගැනීමේදී ගුරු මහත්මියකගේ සහය ලබා දීම අනිවාර්ය වේ.

කලාප අධ්‍යාපන අධ්‍යක්ෂ,
කලාප අධ්‍යාපන කාර්යාලය,
රත්නපුර.

ඊ. එස්. පී. රාජදාස
කලාප අධ්‍යාපන අධ්‍යක්ෂ (වැ. බ.)
කලාප අධ්‍යාපන කාර්යාලය
රත්නපුර