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Investigation of the anthropometric and ergonomic fitness of classroom chairs and desks in three selected primary schools in Dire Dawa, Ethiopia

A Thesis Submitted in Partial Fulfillment to the Requirements for the Degree of Masters in Wood Technology Management.

By: Zeyede Tekle

Id no MTR/806/13

Advisor- Dr. Anteneh Tesfaye

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Approval sheet 1

This is to certify that **Zeyede Tekle Ketema**, who worked under my supervision, submitted his master's thesis, titled "Investigating the anthropometric and ergonomic fitness of classroom chairs and desks in three selected primary schools in Dire Dawa, Ethiopia" in partial fulfillment to the requirements for the degree of Master of Science. No part of the thesis has been submitted elsewhere. The support and assistance obtained during the study have been properly recognized. Since it satisfies the requirements, I recommend that it be accepted.

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Name of Advisor	signature	date
_____	_____	_____
Name of co-advisor	signature	date
2. _____	_____	_____
Coordinator,	signature	date
Graduate program		

Approval sheet 2

We have read and evaluated Zeyede Tekle Ketema's thesis, titled "*Investigating the anthropometric and ergonomic fitness of classroom chairs and desks in three selected primary schools in Dire Dawa, Ethiopia*" as well as examined the candidate orally. We are the witnesses, members of the Board of Examiners for the final open defense. The purpose of this announcement is to inform you that the thesis has been accepted for partial fulfillment to the requirements for the *degree of Master of Science in Wood Technology management.*

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_____	_____	_____
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_____	_____	_____
Name of Internal Examiner	Signature	Date
_____	_____	_____
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Declaration

I, **Zeyede Tekle Ketema**, hereby affirm that the thesis I have submitted in partial fulfillment to the requirements for the *degree Master of Science in Wood Technology Management*, titled "Investigating the anthropometric and ergonomic fitness of classroom chairs and desks in three selected primary schools in Dire Dawa, Ethiopia" is my own original work that I carried out under the guidance of **Dr. Anteneh Tesfaye**. To the best of my knowledge, this thesis has not been circulated or submitted anywhere as a requirement for any degree program. The use of other authors' ideas or materials in this thesis has been appropriately acknowledged, and references are included at the end of the majority of the text.

Zeyede Tekle	_____	_____
Name of Student	Signature	Date

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Zeyede Tekle Ketema, 2014 /2022

Email= Zedjesus22@gmail.com

Abstract

In the classroom, students spend the majority of their time seated in school chairs. However, enough consideration has not yet been given to the design of chairs or chairs and desks in three selected primary schools utilizing the anthropometric data of the users. The main purpose of this study was proposed and carried out to measure the body size of primary school students, identify the cause of student discomfort in classrooms, if any, and determine the optimal relationship between body size measurement and classroom chair and desks ergonomics, in order to ensure the health and learning performance of primary school students in Dire Dawa. Two hundred and ninety-three (293) students were sampled for this study. Various body dimensions, such as S, SH, SEH, SShH, TC, KH, PH, BPL,HW, EH, BKL and FAHL of the students, and their respective chairs and desks dimensions, such as seat height (SH), seat depth (SD), seat width (SW), desk height (DH), and seat to desk clearance (SDC) were measured using a standard measuring tape, human caliper, and zigzag rule. The collected data were computed using an SPSS statistical package and excel as necessary and analyzed using mean, maximum, and minimum. The allowable chairs and desks design was determined using the 5^{th}, 50^{th}, and 95^{th} percentile. The results of the study showed a substantial level of mismatch between the anthropometric measures of students and the dimensions of the chairs and desks available to them for use in both age ranges. Therefore, it is clear that, the mean value and the percentiles of the anthropometric measurements of female students in both age categories are somewhat greater than those of male students except HW. This research was limited to primary school pupils aged 5 to 8 years, excluding those aged 9 to 12 years and beyond. As a result, it's critical to include the latter age group in future research. Furthermore, because of the reliance on several factors, this study needs to be replicated in other parts of Ethiopia in order to create full anthropometric data for each community, and these data should also be updated on a regular basis.

***Key words**- Anthropometric dimension, classroom chair and desks, Ergonomics and SPSS*

List of Acronyms

ANOVA	Analysis of Variance
BD	Bench Depth
BH	Bench Height
BL	Bench Length
BKL	Buttock Knee Length
BPL	Buttock Popliteal Height
DBDB	Distance between Desk and Bench
DD	Desk Depth
DH	Desk Height
DL	Desk Length
DS	Desk Slope
EH	Eye Height
FAHL	Forearm Hand Length
FRH	Footrest Height
HW	Hip Width
KH	Knee Height
KL	Knee length
PH	Popliteal Height
SH	Sitting Height
SEH	Sitting Elbow Height
SSHH	Sitting Shoulder Height
SPSS	Statistical Package for Social Science
S	Stature
TC	Thigh Clearance

Chapter one

1. Introduction

1.1 Background and justification

A school is a place far from home where children go to be educated and also to be socialized for the need of the world. For fulfilling these purposes, they need to stay at their schools for a long time (on an average of 4 to 6 hours for each day). While staying at school, children spend most of their time in doing different things; for instance, reading, writing, drawing, and other related activities, which lead them to sit on their seats constantly for a long time. Sitting for a long period of time in school causes low back pain (LBP) (Grimmer and Williams, 2006) and upper back pain (Murphy *et al*., 2004) for the school students.

The word ergonomics is derived from the Greek words ergo (work) and nomos (laws). The International Ergonomics Association (2000) provides the following definition: "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance." (Castellucci *et al*., 2017). It is the relationship between the human and the product. And also, it involves incorporating anthropometric data in designing products and environments. Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments, and systems to make them compatible with the needs, abilities, and limitations of people. Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments, and systems to make them compatible with the needs, abilities, and limitations of people also.

Physical ergonomics is concern with human anatomical, anthropometric, physiological, and biomechanical characteristics as they relate to physical activity. Ergonomics professionals apply an understanding of human factors to the design of equipment, systems and working methods to improve comfort, health, safety, and productivity and it also the study of the interaction between the human body, products, and the surround of the environment. It is a key factor in the design of all products from chairs to handhold devices (Kumar, 2005).

Furniture is one of the most essential physical amenities provided in a classroom setting where students spend the majority of their time focusing on various learning exercises. Students' workplaces should be designed to facilitate study and provide comfort. The physical plan of the student's classroom chairs and desks could be a result of its physical structure and biomechanics of the human body, resulting in its practical usability (Khanam *et al., 2006*). The anthropometric dimensions necessary for designing very good chairs and desks which will promote correct sitting posture and reduce the incidence of musculoskeletal disorders include popliteal height, buttock popliteal length, knee height, elbow-seat height, shoulder height, hip width, thigh thickness (Molenbroek *et al*., 2015).

Anthropometry is defined as the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body. In simple terms anthropometry can be defined as the study which deals with body dimensions, that is body size, shape, strength, and working capacity for design purposes and body composition. All engineering colleges, institutes, or universities have classroom chair and desks, but this chairs may be of low comfort level to students if anthropometric data are not considered in the initial stage of design chairs and desks (Parvez *et al*., 2019).

The anthropometric dimensions necessary for designing very good furniture which will promote correct sitting position and reduce the incidence of musculoskeletal disorders include popliteal height, buttock-to-knee length, popliteal length, knee height, elbow-seat height, shoulder height, hip width, thigh thickness (Castellucci *et al* ., 2015). The suitability or fitness of school chair and desks for the users is very critical since school children might spend 30% of their waking hours at school (Pynt *et al.*, 2001) and about 5 hours of their school days in sitting positions (Saarni *et al.*, 2007). Unfortunately, in most undeveloped countries school chair and desks is poorly designed (Marschall *et al.,* 2011). Poor classroom chairs and desks design may affect the studying process, lead to student discomfort and dissatisfaction, and aggravate some medical conditions such as back pains (Cram *et al,*2015; NIOSH, 2007; Proakis *et al,*2012). Therefore, proper chair-table design is essential to facilitate appropriate learning by providing a comfortable and stress-free studying station. The principal way to achieve good design is through the application of anthropometric fitness. In order to be effective, however, the data must not only be appropriate to

the design at hand but must also be descriptive of the target user population (Miller and Annis, 2004).

The main purpose of this study is to determine the agreement between anthropometric data of primary school students between ages 5 and 8 with selected parameters of school chairs and desks that are used in Dire dawa. With particular emphasis on anthropometric data of 5^{th} and 95^{th} percentile anthropometry of the children as described by *(*Yusoff *et al.*, 2016). Such work has never been done in Dire Dawa. Result of this study can be used to establish standard selection criteria and dimension that are essential for designing classroom chairs and desks for primary school in Dire Dawa. Therefore, the study was conducted to investigate the anthropometric and ergonomic fitness of classroom chairs and desks in three selected primary schools in Dire dawa.

1.2. Statement of the Problem

Due to the non-standard design of classroom chairs and desks that does not take into account the body dimension of a primary school student and bad-ergonomic fitness to classroom chairs and desks in Dire Dawa, one of Ethiopia's cities, the low quality and improper ergonomic fitness of classroom chairs and desks may have been causing health problems in primary school students (Ahamed *et al.,* 2015). Because body measurements from different regions of the world are used for design purposes. Body composition, size, and shape have been observed to differ among ethnic backgrounds and nations (Luke *et al.*, 1997). Classroom chairs and desks, locally manufactured and imported ones, are designed and developed based on anthropometry of alien population (Parvez *et al*., 2018). Designing classroom chairs and desks for Ethiopian primary school students based on anthropometric measurements collected from other areas of the world is not appropriate (Tesfaye and Abera, 2021). Basically, this problem can affect all students, but the age group of primary school is one of the most developmentally variable. As a result, this proposed research was focused on the primary school age ranges.

1.2.1 Gap of the study

The gap of this study were the age ranges of the pupils, un-adjustability and mismatches of classroom chairs and desks with student's body measurements (Milanese and Grimmer, 2004). And also such work has never been done in Dire dawa, Ethiopia.

Therefore, it is critical to conduct an anthropometry study in a Dire Dawa school and investigate how the measurements acquired are ergonomically compatible with the primary school chairs and desks in use in Dire Dawa.

1.3. Objective

1.3.1. General Objective

- ✓ The general objective of this study is to investigate the anthropometric and ergonomic fitness of classroom chairs and desks in three selected primary schools in Dire dawa, Ethiopia.

1.3.2 Specific Objectives

- ✓ To identify the cause of discomfort of primary school students in classrooms
- ✓ To measure body size of primary school pupils
- ✓ To determine the optimal relation between body size measurement toward ergonomics and anthropometric of classroom chairs and desks
- ✓ To determine health and nutrition status of students and income of the family

1.4 Research Questions

- ✓ What are the anthropometric data for primary school students in Dire Dawa?
- ✓ How ergonomics and anthropometrics are integrated into classroom chairs and desks for primary school students in Dire Dawa?
- ✓ What is the role and relationship between ergonomics and Anthropometry in primary schools?

1.5 Significance of the Study

This study will Improves the quality of education by helping to avail better agreement between anthropometric data of primary school students and the chairs and desks they are using in classes. And helps to improve comfort and health of primary school students thereby enhancing their learning ability. It will provide relevant information for designers and manufacturer about the fitness of classroom chairs and desks which they can use to design compatible and comfortable classroom chairs and desks. It will also contribute a great deal to the success of student by providing comfortable and healthy learning and teaching environment. The beneficiary of this study is pupils of primary schools and the manufacturer (designer).

1.6 Scope of the study

This study was conducted in Dire dawa city and focuses only on class room chairs and desks like school desk and chair or their combination and took into consideration age between 5-8 years as well as both male and female.

Chapter two

2. Literature review

2.1 General

Students are at special risk for suffering negative effects from badly designed and ill-fitting chairs and desks owing to the prolonged periods spent seated during school. It is for these reasons that public health concerns over the effects of bad posture with focus on the design of classroom chairs and desks. Several researchers have documented an increase in health problems related to poor sitting (Saarni *et al*., 2009). Neck, shoulder and back pain problems are common among school children and Neck, upper back, and lower back pain were significantly associated with school furniture features (Isapka *et al*., 2019) Students experience such problems due to low-quality design school tables and chairs (Troussier *et al.*,2014). Nonadjustable school chairs and desks forces the students to adapted poor sitting postures (Khalid *et al* ., 2013).

Researchers have conducted various studies on the evaluation of classroom ergonomic factors in relation to productivity, efficiency and comfort with regards to the design of classroom

chairs and desks based on the anthropometry data of the students. Khalid *et al.,* (2013), reported a significantly low discomfort rate for sitting on ergonomically adjustable school chairs compared to nonadjustable school chairs. Parcells *et al.,* (2010) and Samira, (2013) reported a substantial degree of mismatch between the bodily dimensions of the students and the classroom chairs and desks available to them. Also, Qutbuddin *et al.,* (2013) study showed that the existing classrooms furniture were far from compatible with the anthropometric measurements of the students which forced them to adopt unnatural postures.

Several factors, such as inappropriate desk height, lack of adequate space for the legs under the desks, lack of adjustability of the slope of the seat and seatback, high depth of chairs and their inappropriateness are among the factors responsible for a high percentage of musculoskeletal injuries facing Iran University Students (Zakeri *et al*., 2016). Although there are limited studies regarding furniture design for students in Nigeria schools, some researchers have reported a strong relationship between the workstation set up and development of musculoskeletal discomfort in classrooms and offices (Isapka and Omorodion, 2019). However, Continuation of such habit of procuring ready manufactured furniture without giving attention to anthropometric measurements of students can results to un comfortability, musculoskeletal disorders (MSDs) and can also reduce the performance of students (Dianat *et al*., 2013). Studies that provide empirical evidence on the extent and the nature of a possible mismatch between school furniture and student body dimensions are rare.

2.2 Concepts of Anthropometry

Anthropometry is the branch of the human sciences that deals with body measurements, particularly with measurements of body size, shape, strength and working capacity. Anthropometric data is used in ergonomics, to fit the workplace, and tools the man, rather than fit the man to the workplace. The aim is to create a conducive working environment for maximum work efficiency and maximum worker health and safety (Fernandez, 2010).

On the other hands, Anthropometry is a Grecian word which formed by two words ‘Anthropo’ amount to human (men) and ‘metry’ amount to measure. Dimensions of human’s body are far different and major factors that affect include difference of origin ethnic and economical,

sociological. However, other factors like age, gender, anatomy, job, diet and changes of time also are affecting on body. According to Sander (1998) one of application of anthropometry is to standardize tools and equipment for one or all community. Anthropometric dimensions of students vary based on age, gender and other related variables, as a result of which should the design of classroom chairs and desks should consider the variables separately and follow the ergonomic criteria, concentrating on students' adjustability and comfort. Any chair design needs to consider aesthetics, relaxation and comfort characteristics for students. A well-fitting chair used for students could be differentiated easily by the factors that are related to relaxation and comfort while she/he often finds it hard to differentiate between the features of ergonomics of chair. For example, most of the features of ergonomic furniture are assumed indistinguishable and discomfort in sitting cannot be perceived (Helander, 2003).

2.2.1 Review for Anthropometry

Parcells and Castellucci (2010) have evaluated the mismatches between classroom chairs and desks and the users (students) and consented on the fact that these mismatches may lead to increased pain and discomfort and tend to increase the risk of increasing musculoskeletal problems among school students (Parvez *et al*., 2018). Agha (2010), in his study, found that the mismatches in seat height, seat depth, and desk height occurred for 99% of the students in the Gaza strip. In Bangladesh, Biswas *et al*. (2014) found significant high and low mismatch between classroom chairs and desks and anthropometry of primary school students. The mismatches are the results of the fact that the majority of the administrations of educational institutions procure ready-made furniture which mostly for fewer users (students) with lack of ergonomic principles. Moreover, poor sitting posture on that ergonomically unfit chairs and desks negatively affects the musculoskeletal system of the school students (Biswas, 2014).

Smith-Zuzovsky and Exner (2004); in a laboratory setting, showed that all children scored higher on the intelligence test when they were seated in chairs that better suited their body sizes compared to school chairs and desks that was too large. Another paper (Smith-zuzosky, *et al* 2004) also revealed that students between 6 and 7 years old who were seated in chairs and desks that ft them well performed significantly better on an in-hand manipulation test (IMT), compared to those who were seated in chairs and desks that was too big for them. Hence, it is necessary to design

ergonomically fit classroom chairs and desks to decrease this mismatch and provide a better learning environment (Castellucci, *et al* 2016). Students receiving ergonomically designed chairs reported greater comfort and fewer musculoskeletal symptoms (Chung, *et al* 2007). Therefore, anthropometric data should be taken into consideration in designing school chairs to avoid all bad impacts due to poorly fitted chairs (Parvez *et al*., 2019). Hoque *et al., 2014*) designed ergonomically fit classroom chairs and desks for Bangladeshi university students. But the anthropometric dimensions of small children are different than the elders. Hence, classroom chairs and desks should be designed separately for them following ergonomic criteria and concentrating on user comfort and adjustability.

2.2.2 Anthropometric measurements

Anthropometrics refers to the study of human dimensions. Human dimensions include height, limb length and limb girth, as well as the physical capacities such as lifting carrying and grasping. Anthropometrics is fundamental to ergonomics and it applies to the design of different jobs, workplaces, equipment, tools and personal protective equipment (Sanders, 2004). According to Jacobs (2008) ergonomics is concerned with shaping the environment to optimize workers abilities to perform their jobs. An understanding of anthropometry is essential to the application of ergonomics (Jacobs, 2008). Anthropometric measurements are a series of quantitative measurements of the muscle, bone, and adipose tissue used to assess the composition of the body. The core elements of anthropometry are height, weight, body mass index (BMI), body circumferences (waist, hip, and limbs), and skinfold thickness (Casadei and Kiel, 2019).

Anthropometric information has been utilizing for a legitimate plan of workstation, hardware, and furniture. So on to decrease awkward postures and stresses on the human body due to improper design of furniture a mismatch with standards dimensions (Mirmohammadi *et al*., 2011). Anthropometry takes three major principles. These principles are mainly following in designing various products depending on the type of product. The primary principle is “design for extreme individual” which can be either design for the maximum population as commonly the 95^{th} percentile male or design for the minimum population value as commonly referred to as 5thpercentile female. The next principle is “designing for adjustable range” which put consideration of both 5th-percentile female and 95^{th} -percentile male to accommodate 90% of the population.

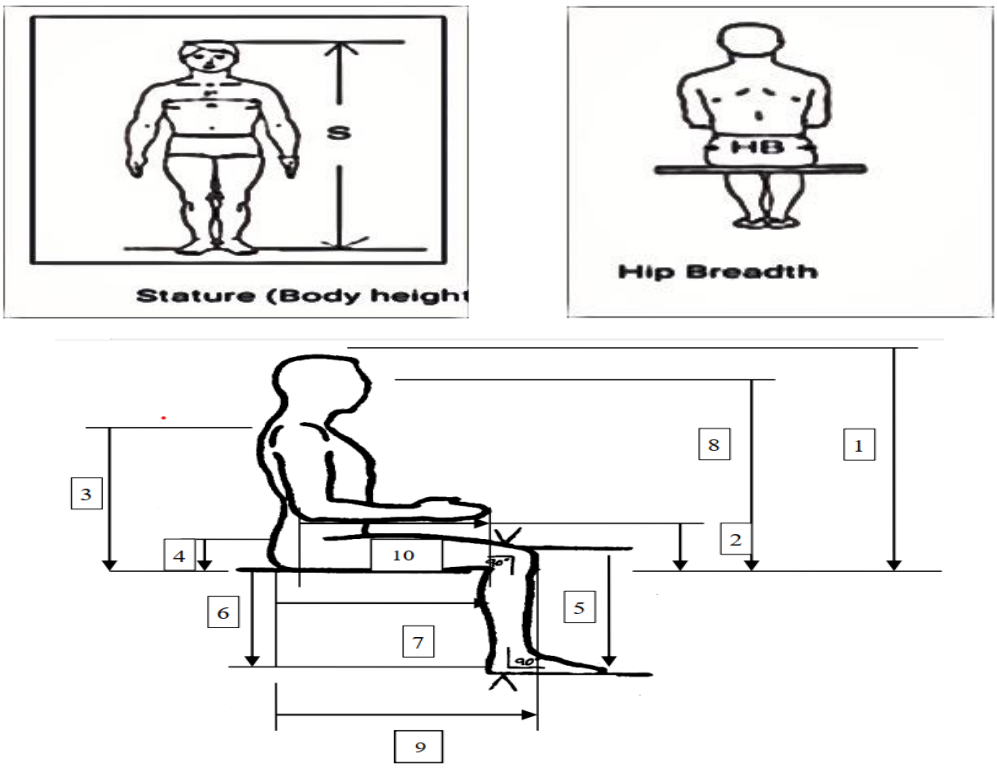
Adjustability principle has been much suggested by many researchers as the main ergonomics principles to be followed in designing furniture. The last principle is to "design for the average" that is mostly being used. However, design for the average user is not well-accepted as it accommodates only 50% of the population. It is not usually practical to design layouts for all users (100%). So, when setting dimensions for a workplace, 5^{th}-percentile female for minimum values and 95^{th}-percentile male for maximum values can make an effective solution. There are so many designs for average but fewer designs are based on the design for adjustability (Parvez *et al*., 2018). Sitting height: -Vertical distance between the top of the head and the surface of the seat surface that measured with the subject erect and looking straight ahead. Shoulder height sitting: - Vertical distance from the top of the shoulder at the acromion to seat surface. Elbow height sitting: - Vertical distance from the bottom of the tip of the elbow to the seat surface and taken with a 90° angle elbow flexion. Shoulder breadth: - Maximum horizontal breadth across the shoulders. Popliteal Height: - Vertical distance from the floor to the posterior surface of the knee with 90° knee flexion. Knee height: - Vertical distance from the floor to the top of the kneecap. Hip width: - Horizontal distance measured in the widest points of the hips in the sitting position. Elbow to elbow length: - Horizontal distance across the lateral surfaces of the elbows.

Elbow-fingertip length: - Horizontal distance from the outer surface of the elbow to the tip of the tallest finger. Buttock-popliteal length: - Horizontal distance from the posterior surface of the buttock to the popliteal surface. Buttock-knee length: - Horizontal distance from the back of the buttock to the front of the knee cap. Abdominal depth: - Horizontal distance from the vertical reference plate to the front of the abdomen in the standard sitting position. Forearm width: - Maximum width of the forearm when it is straight. Thigh thickness: -Vertical distance from the highest point of the thigh to the seat surface (Kapuria, 2018).

The 21^{st} century has seen a lot of interest in children, especially school children as it is well known that many postural problems, such as back pain and repetitive strain injuries, start at an early age. Therefore, ergonomics design for students is as important as designing for adults. Anthropometric data are essential for this design (Mokdad and Al-Ansari, 2009).

2.2.3 Anthropometric body dimensions

Body measurements gathered for anthropometric charts include static and dynamic dimensions. Static dimensions are measurements of specific anatomic structures (limb length, width and circumferences) as presented in Fig.1.



1. Sitting height
2. Sitting elbow height
3. Sitting shoulder height
4. Thigh clearance
5. Knee height
6. Popliteal height
7. Buttock popliteal length
8. Eye height
9. Buttock knee length
10. Forearm hand length

Figure 1 Anthropometric body dimension diagram

Static dimensions are used to design size-specific work station and tools (Sanders, 2004). The anthropometric dimensions of children such as stature, weight and body mass index

(BMI) have increased over the years and this is due to changes in their standard of living, eating habits and lack of adequate exercise (Kasovic *et al*., 2022). Anthropometric measures for children vary across different age groups, genders, cultures, races and ethnic backgrounds (Aziz *et al*., 2012).

2.2.4 Anthropometry in schools

The use of poorly designed chairs and desks, especially school desks and chairs, that fails to account for the anthropometric characteristics of its users has a negative influence on human health. Karwowski *et al* (2003) confirmed that being confined to awkward postures for specific task demands, at given situations or as influenced by poorly designed products over extended periods, provokes psycho-physiological stress and imposes negative effects on human mental and physical performance. Similarly, Bendix (1987) confirmed that University and school students constitute a large group of people who spend a lot of time on the chairs and desks in a static or awkward posture. Schlossberg (2004) also showed a high prevalence of neck and upper extremity complaints among university students. Cranz (2000) found that proper posture is an important factor for prevention of musculoskeletal disorders. So, designing usable and comfortable products has been the focal point of various academic and industrial projects over the last two decades. School and library furniture are decent examples in support of this matter. Some anthropometric studies revealed that there was mismatch between body dimensions and dimensions of furniture (Parvez *et al*., 2019). Besides, a large number of grade school children, industrial workers and adolescents are reported to have regular bouts of back, neck, shoulder, and headache pain due to poor design of furniture, equipment's and work space (Altaboli *et al*., 2014).

Paulsen and Hensen (1994) reported that Students use school chairs and desks extensively during the most important period of their physical development. Watson *et al.* (2002) also confirmed that in the developed countries, middle-aged people who suffer from backache often report that their backache started when they were in their twenties, the period when many of them are still attending university. Based on these reports, researchers discovered that school children suffer from backaches, and in recent years a considerable amount of research has been performed on this matter (Murphy *et al*., 2004). Anthropometric data have been used in the design of school desks and tables in almost all modern developed countries (Oyehole *et al*., 2010). In Africa as whole and in Ethiopia specifically, however, there is no significant study done on anthropometry

of school children and University students. There is no comprehensive anthropometric data for the design of school chairs and desks and it can be concluded that students are being affected with unfit chairs and desks.

2.2.5 Anthropometry in Africa

Appropriate use of anthropometry in design may improve the well-being, health, comfort, and safety of a product's users (Barroso *et al*., 2005). Anthropometric data of a country is vital database for clothing design, furniture design, equipment and machine design, work space design. Developing such databases is common in many countries of the world countries (Wibneh *et al*., 2020).

In Africa however, anthropometric study has been given limited attention though Africans body dimensions are significantly different from other continents. Products such as furniture, clothing, equipment's and machines are designed based on body dimensions of other nations. Due to this, African people are being challenged with unfit products, machines and equipment etc. So far attempts have been done to establish anthropometric data of Nigerian Paraplegics (Ayodeji *et al*., 2008), black South African women (Hattingh *et al*., 2008), Nasofacial anthropometry of adult Bini Trib in Nigeria (Omotoso et al., 2011), cephalic anthropometry of Ndi Igbo of Abia State of Nigreria (Esomonu *et al*., 2012). However, this is not enough and more research should be done on the subject. In Ethiopia, specifically, there is higher ethnic diversity and the research work made on anthropometry is negligible. Previously, attempts have been done to establish anthropometric measurements and Ergonomic fitness of some place in Ethiopia (Tesfaye and Abera, 2021). Hence, there is a need to do more research.

2.3 Concepts of Ergonomics

The IEA (International Ergonomics Association) defines Ergonomics, or Human Factors: "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. On the other hand, Ergonomics can be defined as the study of work. It is the science

of designing the job to fit the worker, rather than physically forcing the worker's body to fit the job.

Ergonomic is not a new science, for the first time it was used in 1857 by a polish scholar. However, it is still a new science for the most under developed countries including Iraq (Selki, 2017). Gavial (2006) argued that designers of fitness equipment not only should bind to adherence from law of fitness, but also is responsible to provide safety and comforting for users. According to Fiznet (1985), Word of Ergonomic is intermixture of two words of 'Ergo' (amount to work) and 'Nomos' (amount to law). Ergonomic is a mollified science which collect information about capacity of human and apply them to design jobs, products, systems related to human, work places and equipment by purpose of preventing occur problems and hurts related healthy and improvement efficiency. May be the best and briefer definition for ergonomic are science of conformity human and work place.

2.3.1 Review for Ergonomics

Qutbuddin *et al* (2013) noted that incompatible furniture forced the students to adopt unnatural postures (lateral bend, forward bend, twisting etc.) in the classroom for long period which imposes physical and mental strain on the students. Fatigue may also be caused by sitting for long duration of time in the classroom adapting to improper posture and May lead to operational uneasiness and musculoskeletal and some physiological disorders among children. Saleh *et al* (2013), the student posture analysis revealed that the new seats had better and comfortable angles when compared to the current sets in terms of neck, back and eye angles. In addition, subjective opinions showed that students were more comfortable using the new sets when compared to the current ones. Ismail *et al* (2017), on his work on anthropometric measurements for ergonomic design of student's furniture in India, recommends highly recommended to consider requirements from students in designing classrooms chairs and desks and conduct seminar or workshop to educate students regarding the negative impact towards adapting poor posture in the long usage of classrooms chairs and desks. Ahamed *et al* (2015), on his research on anthropometric evaluation of the design of the classroom desk for the fourth and fifth grades of Benghazi primary schools, finds there is considerable percentage of mismatch between the desk dimensions and students anthropometry. So, equation relating body dimensions

to desk dimensions must be utilized for recommendation of new design of chair and desks.

Adila Md Hasim *et al* (2012), in his work Kano Model and QFD integration approach for Ergonomic Design Improvement, they presented two methods of Kano Model and Quality Function Deployment to improve the school workshop's workstation design for adolescent in terms of ergonomic and users need. At the end, they were able to prioritize the modification elements to be implemented into the new ergonomically designed workstation. (Ivory, 2011) In his study on the impact of dynamic furniture on classroom performance, his study revealed that no one type of furniture provides the same effect for all elementary students, but rather than personal characteristics may dictate the best match for focus, work completion, and neatness. Hasan *et al* (2015) in his study on Ergonomics and structural analysis of classroom chair and desks in bartin, Turkey, recommended that studies should be focused on collecting more anthropometric data and share this information for furniture manufacturers for ergonomically designed desks.

Taifa and Desai (2018) did anthropometric measurements for the design of ergonomic furniture. They did the anthropometry by allowing participants to sit fully erect with thighs fully supported and the feet resting flat on the floor. The various anthropometric measurements suggested by them were popliteal height, sitting eye height, sitting height, sitting elbow height, Thigh clearance, Knee height, Buttock knee length, Elbow to elbow breadth, Hip breadth, sitting shoulder height, sitting lowest rib-bone weight, Sitting upper hip bone height, Fore arm fingertip length, Buttock popliteal length and Stature.

Al-Hinai *et al*. (2018) in their research on ergonomic students chair design and engineering for classroom environment, explored ways on how to improve the comfort of students in study environment. They stated an ergonomic chair must ensure and satisfy all basic needs of students in the classroom environment. According to Ernest Boampong *et al*. (2015), who studied the ergonomic functionality of classroom chairs and desks in senior high schools in Ghana, the prevalence rate of neck discomfort was strongly correlated with a student's class, age, sex, weight, and height. The study also found significant association between flexed postures and upper back pain. Static postures, neck pain and low back pain were also associated chronic back pain and sitting posture with rounded back, feet supported on another chair and crossed legs was associated

with neck pain. So, the anthropometric fitness of chairs and desks must be evaluated by considering age and gender.

Qutbuddin *et al.* (2013) in their work done on anthropometric consideration while designing desks engineering students of colleges revealed the extent of mismatch between different dimensions of school chairs and desks and the respective anthropometric measures of students of student's. Specifically, the study revealed that incompatible furniture forced the students to adopt unnatural postures in classroom for long period. It further recommended that establishing and maintaining of anthropometric database of students for the design and development of school chairs and desks.

2.3.2 Ergonomics in Schools

Ergonomics in Schools has focused on micro-ergonomics issues such as mismatch between student body sizes and their desks and chairs, the weight of schoolbags and the prevalence of musculoskeletal disorders amongst school students (Legg and Jacobs, 2008). The education process includes, among other things, providing sufficient conditions to be fulfilled, which allow the execution of assigned tasks, without violating the health of students these are: preservation of the health of students, creation of a comfortable working environment, and adjusting the process of education according to students' abilities (Zunjic *et al*., 2015).

Anthropometric estimations are a critical angle that ought to be taken into consideration in classroom chairs and desks designs. Particular estimations, such as popliteal stature, knee stature, buttock–popliteal length, and elbow stature are fundamental to school chairs and desks affecting the right sitting posture (Zunjic *et al*., 2015). The age range running between 5 to 8 years is one of the periods with the speediest physical, mental, and social improvement. Children pick up most of their fundamental motor skills and capacities as a portion of physical improvement within the preschool period. Starting successful educational spaces that will facilitate child development is a task that requires knowledge of children's needs, development process, and the educational program (Iivonen and Saakslahti, 2014).

2.3.3 Some ergonomics experiences of the countries in the world

In developing countries, most classroom chairs and desks has been found to have caused more distractions and injuries to the children than the provision of learning support. Hui Zhu *et al*. (1998) noted that most classroom chairs and desks in developing countries lacked quality and are often manufactured with woods which offer very rough writing and seating surfaces. It is therefore important to design classroom chairs and desks based on the necessary anthropometric measures. For the design of desks/ chairs, several researchers have incorporated measurements obtained from the elbow height in their designs (Parcells *et al*., 1999). If the elbow height exceeds the height of a desk or table, the users may tend to reach for the writing material or the computer keyboard by bending forward. As a result of this, spinal flexion occurs and the body weight is distributed to the arms, thereby leading to kyphotic spinal posture with round shoulders. Chaffin *et al*. (2006) recommends a shoulder flexion angle of 25 and a shoulder abduction angle of between 15 and 20 when performing deskwork on a workstation.

In developed European countries like England, Germany and France, several efforts have been made to introduce uniform classroom chairs and desks design guidelines and standards. For example, in England, the New British and European Educational Furniture Standard, also known as the New European Standards for Classroom Furniture (EN1729, Parts 1 and 2) was introduced in 2007 for the design of tables, chairs and workstation desks, based on the anthropometric measurements of over 1500 children in the United Kingdom in 2001. This New British and European Educational Furniture Standards have been considered as the only compelling standard for classroom chairs and desks, since they were results of over forty years of extensive research in which the anthropometric measurement database of school children in the United Kingdom was updated. According to the British Standard Institute (2007), the first part (Part 1) of the standard ensures that the size and dimensions of the furniture is in compliance with the set guidelines. This is necessary to prevent awkward seating postures which could lead to back pain. The second part (Part 2) of the standard ensures that the furniture is durable in terms of strength and stability. Since classroom chairs and desks is often used continuously, it is important to make sure that the product is capable of withstanding rigorous use.

And also, In Portugal there is no definite standard to design the appropriate furniture characteristics to be used by school children. This situation arises due to lack of anthropometric

knowledge by governmental authorities and the population (Castellucci *et al*., 2017). Thus, Portuguese school children are using school chairs and desks designed without any ergonomic consideration (Castellucci *et al*., 2010).

In addition, in Hong Kong, Lee *et al*. (2001) pursued an investigation of 26,111 students aged between 10-19 years and showed that among the top 10 health problems, muscular skeletal symptom was considered as major one which happened due to improper design of furniture. Recently, Murphy (2007) pursued a study of British and New Zealand school children aged between 11- 14 years and reported that poor school chairs design was significantly associated with neck, upper back and low back pain.

Milanese and Grimmer (2004) also showed the mismatch between work furniture and anthropometric dimensions of American children aged 11-13 can produce some musculoskeletal disorders, such as low back pain, wrist, and neck shoulder pain. Choobineh, (1997) showed in Iran and Korea, the importance of varying the design of school furniture with differing sizes in body's dimensions caused by age and gender. Thus, it is necessary to design the furniture appropriately considering gender and age dependent anthropometry and ergonomics. Since the beginning of history, anthropometric measurements of human body had been developed to eliminate harmful postures and minimize the design-imposed stresses on the user (Hoque *et al*., 2014). Parcells *et al* (2006) also investigated the effect of incompatibility between school chairs and desks and anthropometric dimensions on students' health.

Furthermore, Chung and Wong (2007) conducted a survey with 214 school children to determine whether the design of their school chairs and desks was appropriate for their anthropometry. As a result, the girls' BMI was lower than that of the boys. The girls had longer lower limbs and wider hip breadth measurements in the standing position. This was similar in the sitting position. Almost none of the subjects had a chair with an appropriate seat height. Seat depth was found appropriate for large groups of students whether or not a large or small chair was used. Thus, the design of work place furniture and user anthropometric characteristics is the most important factors in designing ergonomically appropriate furniture.

Among the important factors for the prevention of musculoskeletal problems, correct standing and sitting posture was considered as major ones (Cranz, 2000). Anthropometric data are

applied to specific design problems for different situation considering three basic principles: Design for extreme individuals, designing for adjustable range, and designing for the average. Since the early 1960s, adjustability had been considered as a primary criterion in many designs. By the early 1990s, the mass production of the modern furniture, especially chairs of different sizes and dimensions, was done by several manufacturers based on the anthropometric data available to the designers. Jeong (1997) reported that gender differences are another consideration for designing classroom chairs and desks. The anthropometric measurements revealed that differences in gender cause a corresponding significant difference between measures of stature, Body Mass Index (BMI), and other body dimensions. The standard dimensional specifications are based on body dimensions of the 5^{th} percentile (small) female to the 95^{th} percentile (large) male. Furthermore, Sanders (1999) reported that Design for Adjustable Range as a suitable method of design chairs and desk height (DH) considering the 5^{th} percentile female to the 95^{th} percentile male of the relevant population characteristics (sitting height, arm etc.). Thus, Design for Adjustable Range principle was also considered in previous studies.

And also, in case of higher education, students usually spend approximately one third of the day at university. Almost 80% of that time is spent sitting on university furniture to do university work. Several studies have showed the importance of designing ergonomically fit work place and furniture that is suitable to university students (Thariq *et al*., 2010). Thus, it is necessary to take into consideration ergonomics and anthropometry in the design of university furniture to maintain students' comfort and ensure healthy learning. Indeed, several researchers had incorporated anthropometric fitness criteria in the designs of school chairs and desks so as to improve the classroom learning environment (Parcel, 1999). In developed European countries like England, Germany, and France, several efforts have been made to introduce uniform classroom chairs and desks design guidelines and standards. The study further asserted that there was no anthropometric consideration for designing classroom chairs and desks as the furniture-maker was the designer who was at the same time illiterate with no knowledge about anthropometry.

2.4 Body size and furniture design

When designing products, it is necessary to know body dimensions of potential users. Relevant reasons for this are that accidents may occur due to incorrect product dimensions and sizes that do not meet student's dimensional requirement and health problems such as musculoskeletal, visual and circulatory may be caused (Kayis and Ozok, 1991)

Parcell *et al.* (1999) had some comments on design of school chairs and desks in USA after personal communication with two school chairs manufacturers which they did in 1996. They found that classroom chairs and desks from manufacturers is typically not designed to accommodate the dimensions of individual users. While a few desks offer an overall height adjustment and chairs of different sizes are available, individual adjustment for the seat, arm and back are not offered. Instead, a one-size-fits-all philosophy has been adopted in the industry, because such furniture is less costly to manufacture and easier to sell at a lower price, and lessens the inventory problems for manufacturers and schools. Lane and Richardson, (1993) also asked the five major school chairs and desks manufacturers in the United States, regarding what research they relied on for their furniture designs, and the responses they got was that there was no any reliance. Instead, each company based their designs on specifications from the American Furniture Manufacturers Association and the national standards board to decide "seat width, belly room, and prohibited combustible materials". Existing designs have basically been unaltered for years. While manufacturing and inventory costs are important concerns, there are also costs involved in products that do not reflect designs based on properly selected anthropometric data and ergonomics. Without proper design, sitting will require greater muscular force and control to maintain stability and equilibrium.

Most important for school children, musculoskeletal stress resulting from efforts to maintain stability and comfort of seating may make for a fidgety individual, a condition not conducive to focused learning (Parcell *et al*., 1999). The education of children in developing countries has long been regarded as an important element of economic development. Although well-designed school chairs and desks has been shown to contribute to the learning process, school chairs and desks used in these countries often detracts rather than facilitate education. Often the furniture is of low quality, with rough writing surfaces, falling apart quickly, and does not fit the

children, yet it is relatively costly and consumes a disproportionate amount of limited educational budgets (Diep, 2003).

2.5 School furniture and school children's sitting position

School children spend most of their wake hours at school (approximately a quarter of the day) mostly in the sitting position doing their school work activities such as reading and writing (Castellucci *et al*., 2010). Besides activities performed in the classroom, school children' s sitting posture is influenced by their anthropometric measures such as Stature (S), Popliteal Height (PH), Buttock-Popliteal Length (BPL), Elbow Height Sitting (EHS), Hip Width (HW), Thigh Thickness (TT) and Sub scapular Height (SUH) as well as by design features and measures of school chairs and desks including Seat Height (SH), Seat Depth (SD), Seat Width (SW), Upper Edge of Backrest (UEB), S Point (SP), Lower Edge of Backrest (LEB), Desk Height (DH) and Seat to Desk Clearance (SDC).

Considering the amount of time spent by children in the sitting posture, school chairs has a significant role in the maintenance of good sitting position and should be designed to promote it. Use of the furniture that promotes correct posture is more important to children than to adults, because young age is the period when sitting habits are developed. Non-ergonomically dimensioned furniture, unsuited to body dimensions may lead to bad posture habits which may have a direct impact on the growth process because they are likely to remain unchanged into adolescence or adulthood (Gligorovic *et al*., 2018). Poor sitting position in students using school chairs is considered as one of the factors that may increase the risk of developing musculoskeletal disorders Grimes and Legg (2004) resulting in pain in back, leg, arm, neck, shoulder and feet. Additional impacts are loss of concentration and restlessness which arise due to the constant attempt made to find a better position. The design of school furniture is guided by national and regularity standards. Unfortunately, these standards do not always comply with the anthropometric reality of the users.

2.6 Classroom Desks and chairs in primary school

The classroom desks and chairs plays a very important role in the maintenance of good sitting position. Yeats (1997) indicated that classroom chairs and desks design serves a vital part in the long-term sitting position of children. Unlike adults, proper sitting posture is found to be

more important to children since sitting habits acquired at this stage may be extremely difficult to change later in life. Knight and Noyes (1999) identified the major functions of the school furniture in their research. Classroom chairs and desks is known to provide support to the children when during class activities or when writing on the table. In addition to ensuring that distractions are minimized, comfortable classroom chairs and desks have been noted to enhance effective learning, since the performances and behaviors of children can be easily monitored when seated. When designing classroom chairs and desks, easy mobility of children should be considered since localized muscle fatigue could set in due to prolonged immobility (Laville, 1985).

Classroom desks and chairs can make learning easier or harder for students. Ergonomic classroom chairs and desks makes learning easier by removing physical hindrances, large and small, to allow the student to concentrate on the day's lesson. The classroom is a formal environment for learning. A conducive and comfortable classroom environment motivates students to perform better and encourage the learning process (Abdullah *et al*., 2012). Ergonomic furniture grows with your child as children grow; all classroom chairs and desks can be adjusted to their current height and proportions, which makes them ergonomic at all times. Be able to adjust the position of the backrest and the seat depth is as important as adjusting the height of the desk and chair (Salvador *et al*., 2014). Ismail *et al*. (2010) have evaluated the ergonomics intervention to reduce the ergonomics risk factors the musculoskeletal disorder among children. During the classroom's lessons, the children will experience bad posture of sitting where the head, back and neck rotate and flex for a long duration of time.

In an early childhood classroom, furniture like tables and low-rise shelving creates spaces that help manage the students. Again, the furniture has to be appropriately scaled, so that the teacher can see students throughout the room. Breaking up the room into zones not only gives a sense of ease to the environment, but the smaller spaces also exert a passive form of control and prevent running and rough play.

Overall, these findings confirmed that the majority of students had a mismatch with university or school chairs and desks. By obtaining more anthropometry data in various age groups and generalizing it to any educational place may help the design ergonomic furniture. As developing a comfortable posture, educational furniture should also support the learning activities of the students (Baharampour *et al*., 2013).

2.7 School chairs and desks dimensions

Students are often exposed to fixed-dimension furniture throughout their school life, with little opportunity for adjustability to suit their own changing anthropometry. This concern is rendered clear by the large number of studies published worldwide in which a clear mismatch between anthropometric characteristics and dimensions of the furniture under study had been identified (Arezes *et al*., 2015).

To avoid the mismatch problem, one of the best possible solutions is adjustability. Yeats (1997) argued that it is difficult to encourage proper posture early in life without the support of adjustable chairs, desks and tables in the classroom. However, scalability became a more realistic and cheaper solution and is somehow reflected in the increase in the number of published standards regarding school chairs and desks in various countries, including Chile (INN 2002), Colombia (ICONTeC 1999), the European Union (CeN 2012), Japan (JIS 2011) and the United Kingdom (BSI 2006). As mentioned, to define school chairs and desks dimensions (Standard) or quantify the level of mismatch, it is important to consider students' features. For example, age is important not only because of growth rate but also because of the manner of growth; before puberty, the legs grow more rapidly than the trunk, and in adolescence, the growth spurt is largely in the trunk (Bass *et al*. 1999). Furthermore, students' growth appears to be influenced by their socio-economic status. It has previously been observed that children of higher socio-economic status are, on average, taller than students of lower and medium socio-economic status (Kormos and Kiddle, 2013). Regarding gender differences, it can be observed that until the onset of puberty, males and females have similar rates of growth and that after puberty, male's present greater anthropometric values than females, with exceptions in some variables such as hip width. For example, Oxford (1969), that was cited by Grimes and Legg (2004) wrote that school children are repetitively exposed to the hazards of abnormal or awkward postures because of classroom chairs and desks that is often too large or too small. Such size variations may also affect their academic performance, affecting learning, because uncomfortable and awkward body postures can decrease students' interest in learning, even during the most stimulating and interesting lessons (Hira, 1980).

Physically, when the SH is higher than the popliteal height (PH), the majority of students are unable to properly rest their feet on the floor, compressing vascular and neural structures along the popliteal space (Milanese & Grimmer, 2004). However, an SH significantly lower than PH,

more than 4 cm (UNESCO 2001), increases the compression in the buttock region (García-Molina *et al*., 1992). In the case of seat depth (SD), the support of at least 80% of buttock-popliteal length (BPL) is required to avoid the extra pressure on the back of the thighs, which could cause discomfort (Pheasant, 2003). However, the SD cannot be greater than 95% of the BPL because the student will not be able to use the backrest of the seat and, consequently, will not be able to support the lumbar spine without compression of the popliteal surface (Milanese and Grimmer, 2004).

To avoid this situation, students will generally move their buttocks forward towards the edge of the seat, as suggested by Panayiotopoulos *et al*. (2004). This improper use of the backrest causes kyphotic posture (Geldhof *et al*., 2007). According to some authors, students who use narrow seats are not be able to relieve the pressure on the buttocks and cannot avoid discomfort and mobility restrictions (Castellucci *et al*., 2017). Students who use a higher than recommended desk height are forced to flex and abduct their arms as well as elevate their shoulders. This posture may cause more muscle work load, discomfort and pain in the shoulder region (Hagberg, 1981). If such a posture occurs in only one upper limb, an asymmetrical spinal posture will result. Despite the large amount of research regarding school chairs and desks, it is not clear whether the application of the different size and/or design of school chairs and desks improves the students' performance and physical responses. Furthermore, Legg and Jacobs (2008) indicated that longitudinal case-controlled ergonomic intervention studies are required if the musculoskeletal discomfort, pain and injury problems experienced by schoolchildren identified in epidemiological studies are to be addressed. Therefore, considering the developed literature review, this study seeks to determine whether the design and/or dimensions of school chairs and desks affect the students' physical responses and/or their performance.

2.8. A method for evaluating ergonomic and Anthropometric fitness

Anthropometric match (or mismatch) was established using the equations presented by Parcells *et al*. (1999) and Castellucci, *et al.* (1999). It refers to the state of fitness (or unfitness) between the anthropometric measurements of a person and chairs dimensions. Therefore, it is anticipated that the popliteal height will be greater than the seat height.

Odunaiya *et al.* (2014) claim that a mismatch exists when the seat height is 95% or 88% of the popliteal height. The match criteria will thus be derived using an equation modified from related investigations.

$$(PH + 3)\cos 30 \leq SH \leq (PH + 3)\cos 5 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In the equation above, the shoe correction factor, or 3, is represented by the number 3. In millimeters, PH stands for popliteal height, and SH for seat height (in centimeters).

As described by Parcells *et al*. (1999), the range of angles between 50 and 300 allows a user to sit on a chair that is high enough so that both feet are well supported on the floor and prevents a slumped, hypnotic posture, and low enough to prevent an extension of more than 300 relative to the vertical in the knee joint as described by Castellucci *et al* (2014).

Additionally, Castellucci *et al.* (2010) suggested that the fifth percentile of buttock-popliteal length be defined as the seat depth. Equation 2 will be used to derive the match criteria, using inspiration from Parcells *et al.* (1999).

$$80\%BPL \leq SD \leq 95BPL \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

SD stands for seat depth, while BPL is the buttock-popliteal length (in cm) (in centimeters).

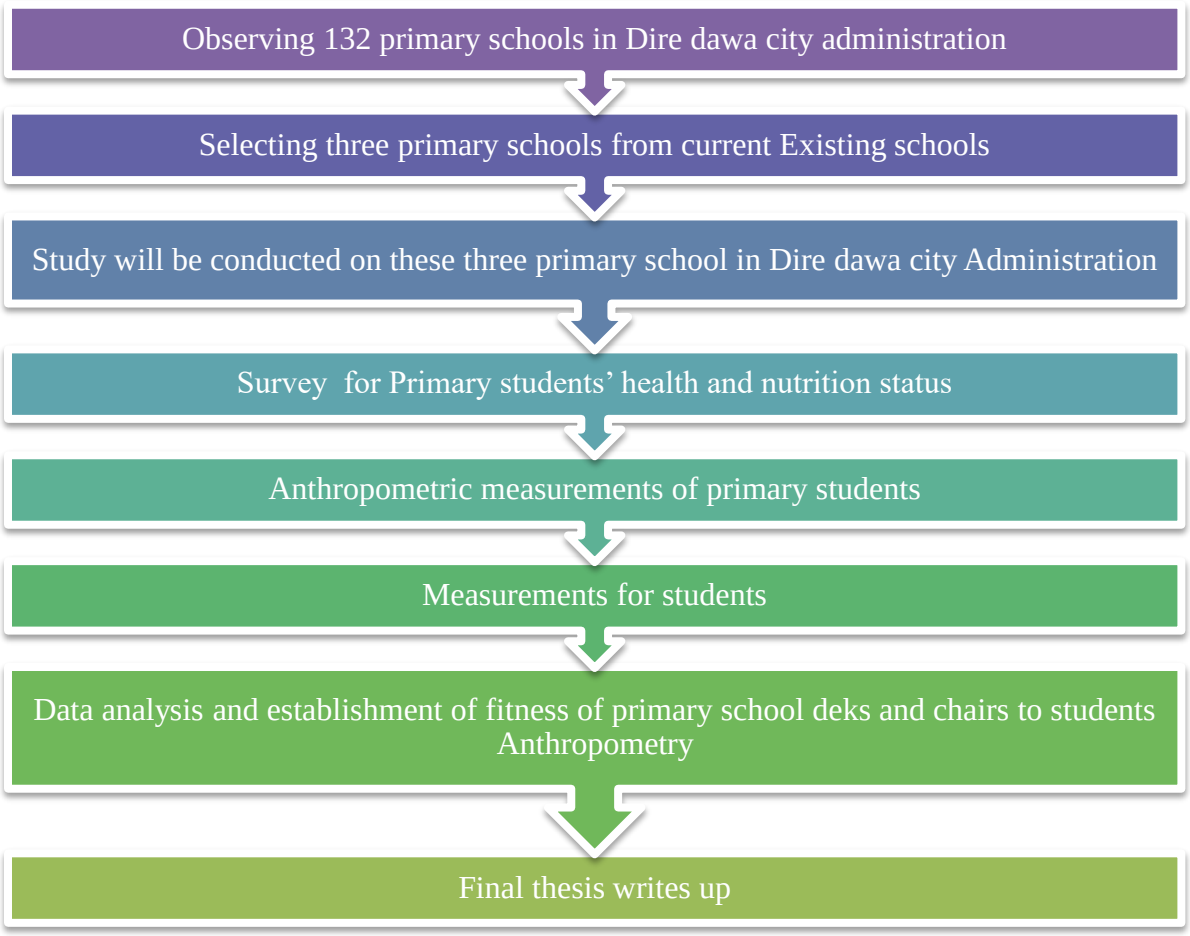
According to Gouvali *et al.* (2006), the seat width should be sufficient to support hips with the widest ranges, therefore the 95th percentile of hip width is the target.

Equation 3 will provide the match criteria, which was taken from Castellucci *et al.* (2010).

$$HW < SW \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

HW stands for hip width (in millimeters), SW for seat width (in centimeters).

2.9 Conceptual frame work for the graduate research



Source; own data

Figure 2 conceptual framework of the research

Chapter Three

3. Materials and Methods

3.1 The Study area

The study was conducted in Dire Dawa city. Dire Dawa is one of the two chartered cities in Ethiopia, the other being Addis Ababa and from which it is 515km far away. It is precisely located between 9^0 28.1" N and 9^0 49.1" N latitude and between 41^0 40.0" E and 42^0 8.0" E longitude. The city administration has an estimated area of 128,802 hectares.

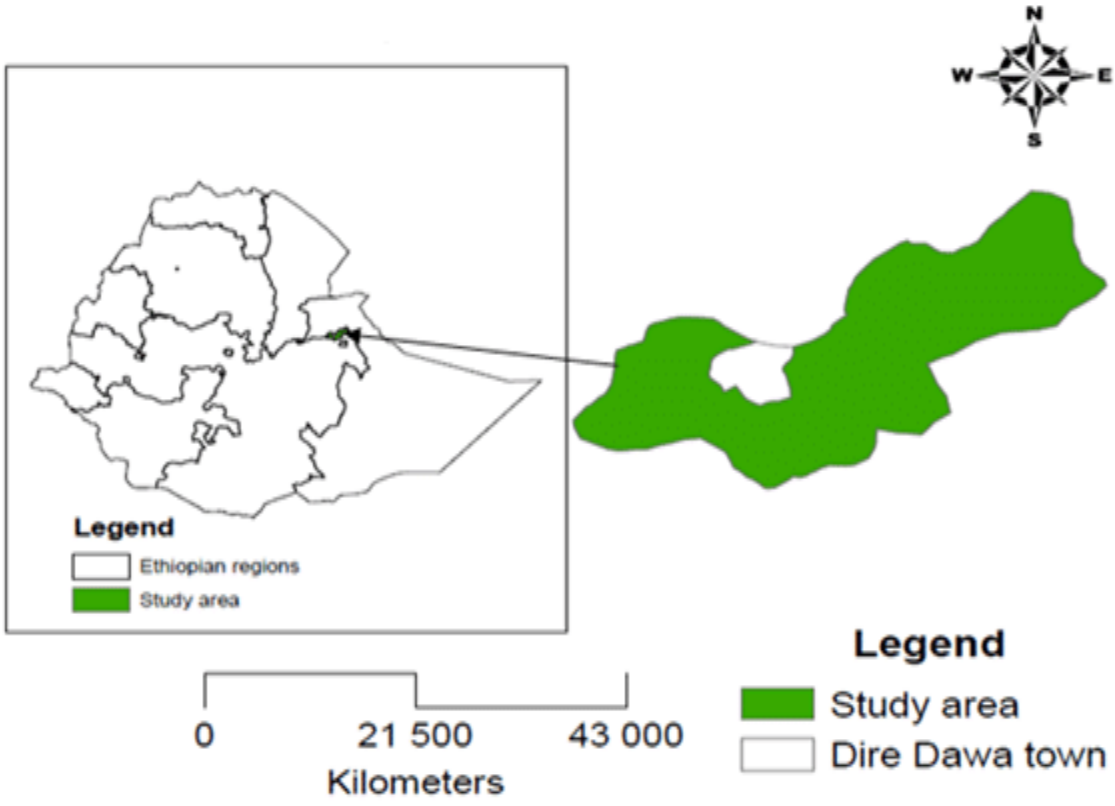


Figure 3 Map and Location of Dire Dawa city

(Source- google map**)**

3.2 Study population and sampling

In Ethiopia, students aged five to eight years old are divided into two groups: KG2 and primary. In Dire Dawa were enrolled 20323 primary school students in 132 government and private primary schools in the school year of 2014/15 as presented in Table 1, Three primary schools were chosen at purposive from the total of 132 primary schools of the Dire Dawa city administration. Because the primary schools in the city are similar in terms of conditions. From the three primary schools were included in this study those children grade levels ranged from KG2 to Grade 2, or who had age ranges from 5 to 8 years.

A total of **293** students were participated in this study in the investigation of the anthropometric and ergonomic fitness of classroom desks and chairs in the three selected primary school students aged 5 to 8 as presented in table 3 of section 3.2.3.

3.2.1 Total number of public and private primary schools in Dire Dawa city

Table 1 Population of students aged 5 to 8 years old in Dire Dawa city

Private			Government		
Number of schools = 49			Number of schools = 83		
Total = 132					
Male	Female	**Total**	Male	Female	**Total**
7599	6782	**14302**	3124	2897	**6021**

Source- Dire Dawa Education bureau

3.2.2 Sample of the study population in the three selected primary schools in Dire dawa city

Table 2 Total number and gender of students in the three selected study schools

No	Name of schools	Location of schools	Number of teachers	Number of students		
				Male	Female	Total
1	Saint Tereza (Private)	03 kebele	13	347	275	622
2	Sabian No1 (Public)	02 kebele	20	194	207	401
3	Goro (Public)	02 kebele	5	74	60	134
Total			38	615	542	1157

Source- Administration of three selected schools

3.2.3 Sample selection for this study

Table 3 Sampling plan of students in the three study schools

No	**Name of schools**	**Number of Teachers**	**Number of parents**	**Number of students with age ranges in three selected primary schools**					
				5-6 ages			**7-8 ages**		
				Male	**Female**	**Total**	**male**	**female**	**Total**
1	Saint Thereza	13	**45**	20	35	**55**	25	20	**45**
2	Sabian No 1	20	**50**	30	21	**51**	25	25	**50**
3	Goro	5	**40**	16	27	**43**	25	24	**49**
	Total	**38**	**135**	**66**	**83**	**149**	**75**	**69**	**144**

3.2.4 Selecting sample students and data collection

In this research data were collected and used both qualitative and quantitative methods. First, the study was clearly explained to the participants and an informed consent was obtained from each participating student before the collection of primary and secondary data.

A. Primary Sources

i. Anthropometric dimensions:

The first primary quantitative data were the anthropometric measurements taken from male and female children of 5 to 8 years old. The qualitative data were observations**,** interviews, pictures and audiovisual recordings.

A purposive sampling methodology was used to choose each sample student at purpose and entirely by chance, with each having the same chance of being chosen.

The following anthropometric dimensions were measured as defined by ISO 7250, 1996.

- ✓ **Stature (body height**) - the vertical distance from the floor to highest point of the head (vertex)
- ✓ **Sitting height** - is a segment length measure of the vertical distance from the crest or top of the head to the base of a seating surface.
- ✓ **Sitting elbow height**- Vertical distance from the seat surface to the underside of the elbow or the vertical distance from a horizontal sitting surface to the lowest bony projection of the elbow bent at a right angle with the forearm horizontal.
- ✓ **Sitting shoulder height-** the vertical distance from the horizontal sitting surface to the acronym.
- ✓ **Thigh clearance-** the vertical distance from the sitting surface to the highest point on the thigh.
- ✓ **Knee height -** vertical distance from the floor to the upper surface of the knee (usually measured to the quadriceps muscle rather than the kneecap).
- ✓ **Popliteal height-** vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the bicep's fem or muscle inserts into the lower leg.

- ✓ **Buttock popliteal length-** it is horizontal distance from the back of the uncompressed buttocks to the popliteal angle, at the back of the knee, where the back of the lower legs meets the underside of the thigh.
- ✓ **Hip width**- horizontal distance of the body measured across the widest portions of the hips.
- ✓ **Eye height** - Vertical distance from the floor to the inner canthus (corner) of the eye.
- ✓ **Buttock knee length** - Horizontal distance from the back of the uncompressed buttock to the front of the kneecap.
- ✓ **Forearm hand length-** the distance from the tip of the middle finger to the midline of the distal wrist crease.

The anthropometric dimensions of the students were taken from the right side of each based on gender and age, while they are sitting in an erect position on a height-adjustable chair with a horizontal surface and had no shoes on them. The knees and elbow fixed flexed at 90^{o}.

ii. Chair/ desk Dimensions:

The second sets of data were chair and desk dimensions of the following types:

Legend

1. Bench length
2. Bench height
3. Distance between desk and bench
4. Desk depth
5. Desk length
6. Desk slope/ angle
7. Seat Desk height
8. Bench depth
9. Footrest height
10. Thickness

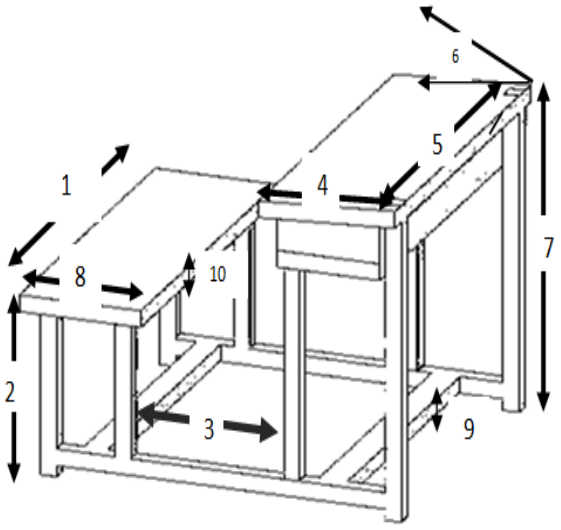


Figure 4 Parts of Classroom Furniture/School desk

iii. Comfort/ Discomfort and health data

The second primary data were collected based on a survey regarding student's feel for classroom comfort/ discomfort.

3.2.5. Measuring instruments

Human caliper was used to measure the vertical anthropometric dimensions of:

i. Sitting height,
ii. Sitting elbow height,
iii. Sitting shoulder height,
iv. Knee height,
v. Popliteal height.

Measuring tape and zigzag rule were used to measure the following dimensions of chairs:

i. Seat Height,
ii. Seat Depth,
iii. Seat Width,
iv. Backrest Height

Caliper was used to measure the following horizontal dimensions:

i. Buttock-Popliteal Length,
ii. Buttock-knee Length.

Additionally, the following instruments were used for the respective activities:

i. Digital cameras and video to take the pictures and record,
ii. Pencils for recording raw data on papers,
iii. Voice recorders for interviews,

iv. Laptops to record data,

v. Observation checklists and Questionnaires.

B. Secondary sources

Secondary data were obtained from Education Bureau of the Dire dawa city administration, published peer reviewed reports from library search**,** and web search (SCI- HUB, Google scholar and Research gate) Used in this study was from SPSS.

3.2.6. Ethics

Before going to collect data, the researchers obtained permission from the following concerned actors before the commencement of this study:

i. Dire dawa Education Bureau

ii. Administrations of the study school's administration and

iii. Parents

Students and their parents were also assured that the data obtained from this study will be kept confidential and only be used for the purposes of this study.

3.3. Data Analysis

The collected data were analyzed using Statistical Package for Social Science (SPSS) software. Descriptive statistics were used to examine the data, and the means, standard deviations (SD) and the percentiles of the 5^{th}, 50^{th} and 95^{th} by differentiating boys and girls by gender and ages. Pearson correlation was used to assess relationships of anthropometry between age, gender, income and family size.

The following equations were used to investigate anthropometric fitness of the classroom chairs and desks as described by Osquei-Zadeh *et al*. (2012);

Chair seat height (CSH) and

popliteal height ---------- (PH + 2) cos 30≤ (PH + 2) cos 5……. Eq 1

Chair seat depth (CSD) and

Buttock-popliteal length (BPL) --------0.80 BPL ≤ CSD ≤ 0.99 BPL……Eq 2

Chair seat width (CSW) and

Hip Breadth (HB) ----------1.1 HB ≤ CSW ≤ 1.3 HB……Eq 3

Chapter four

4. Results and Discussions

4.1 Results

4.1.1 Environmental conditions of three selected primary schools

In each of the three selected primary schools, just one type of school bench or classroom chairs/desks was observed, and each one's measurements were nearly the same. Even though the classroom desks and chairs in these schools had the same seat and surface slope angles. And also, the proportions of school bench/combination chairs in three schools were nearly the same. Of the three selected primary schools, Saint Teresa primary school, which is located in the 03 kebele of Dire Dawa, has a better learning environment and a more conducive classroom than the others. The rest of the two, which are Goro and Sabian No 1, have the same environment and proportions and both of them are located in 02 kebele of Dire Dawa.

In subsequent parts are presented first, results of demography and health conditions of the students, followed by anthropometry and fitness.

4.1.2 Summary for demographic profile and responses of Questionnaires

Figure 5 shows the gender distribution of teachers in all three schools. At Kidist Teresa schools, there were 13 teachers, with the number of males and females being 7 and 6, respectively, while at Goro, there were a total of 5 teachers, with the number of males and females being 2 and 3, respectively. The total number of students at Sabian No 1 was 20, with the number of males and females being 11 and 9, respectively.

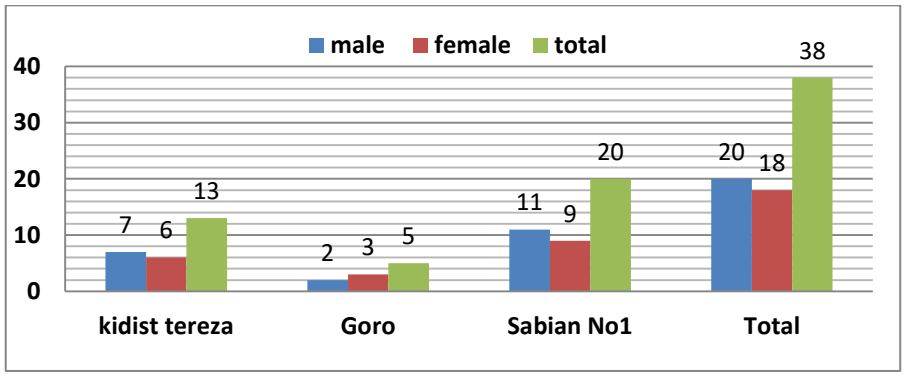


Figure 5 Demographic profile of student's teacher's gender in three selected primary schools

Fig. 6 shows that, of the total number of teachers in the three study primary schools that were chosen, 18.4% (n = 7) were single, 78.9% (n = 30) were married, and the remaining 2.6% (n = 1) were divorced. As a result, majority of the teachers were married.

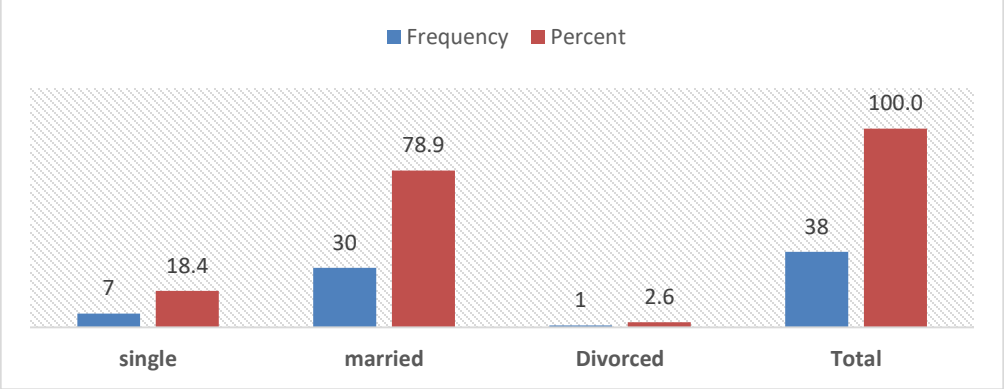


Figure 6 Marital status for primary school Teachers

Figure 7 shows the age variation of teachers. Of the total number of teachers, 36.8 % (n = 14) were between the ages of 31 and 35, while 18.4 % (n = 7) were between the ages of 26 and 30. And also, 28.9 % (n = 11) were between the ages of 36 and 40, 13.2 % (n = 5) were between the ages of 41 and 50, and the remaining 2.6 % (n = 1) were between the ages of 46 and 50. Compared to this, the majority of teachers were in the 31 to 35 age group.

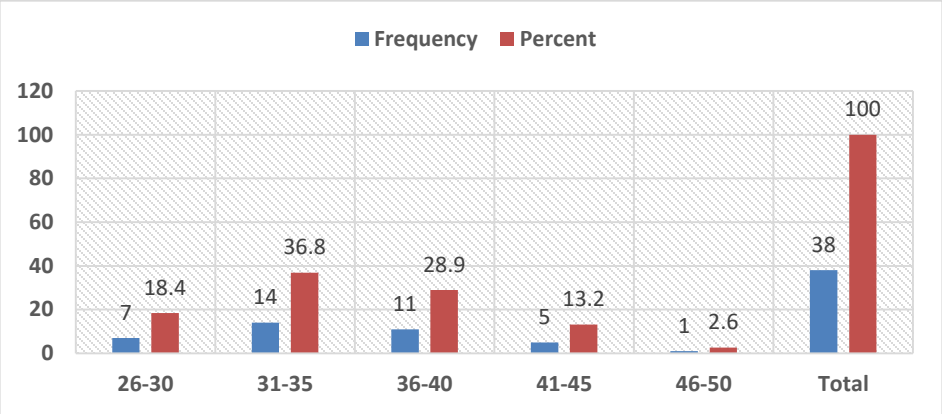


Figure 7 Age variation of primary school teachers

Figure 8 shows the educational background of teachers in primary schools. Out of the total, 44.7% (n = 17) had diplomas, and 55.3% (n = 21) had degrees. The proportion of degree-holding teachers is therefore higher than the proportion of diploma-holding teachers.

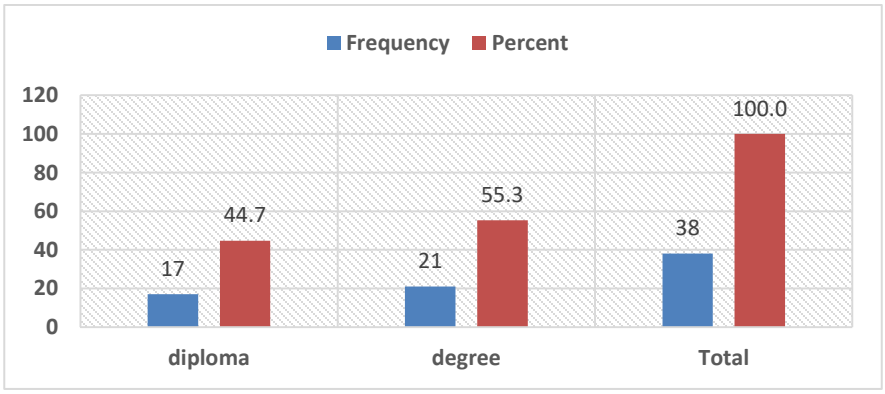


Figure 8 Education Qualification of Primary school teachers

Figure 9 shows the subjects/educational programs that teachers attended at universities or other institutions. 42.1 % (n = 16) of them were with primary school's teachers' education, 5.3 % (n = 2) attended developmental psychology, and furthermore, 26.3 % (n = 10) were graduates from

social science, and 26.3 % (n = 10) were with applied natural sciences background. As a result, the three study schools' teachers tend to have primary school teachers' education.

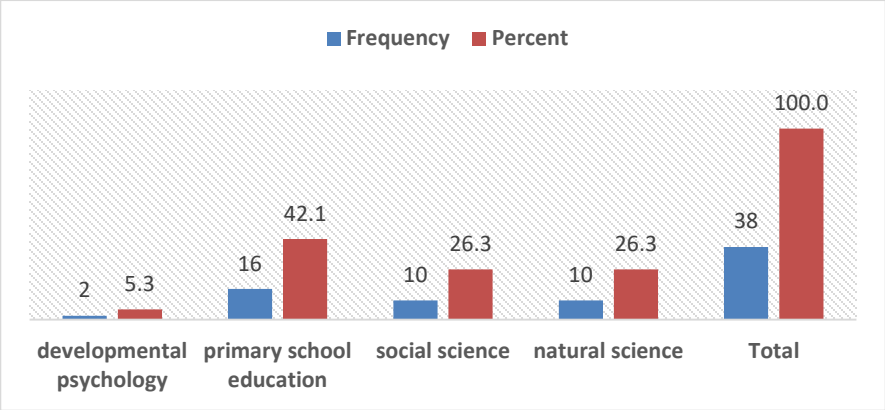


Figure 9 Subjects they applied at University/Institution

Table 4 presents summary of the results obtained on ergonomics, anthropometry, and classroom chairs and desks. The result of question 1 showed that 23.8% (n = 19) of respondents are not aware of the significance of ergonomics in classroom desks and chairs, while 76.3% (n = 61) are aware As a result, 23.8% of respondents are not aware of the significance of ergonomics in classroom chairs and desks.

The result of question 2 showed that 15.0% (n = 12) of respondents did not comprehend anthropometric measurements and fitness of classroom chairs and desks, while 85.0% (n = 68) did comprehend. As a result, 15% of respondents did not comprehend anthropometric measurements and the fitness of classroom chairs and desks.

The result of question 3 showed that the reasons of discomfort among primary school students are about 70.0 % (n = 56) classroom furniture, 20.0% (n = 16) climate of the classroom, 5.0% (n = 4) body size of students, and 5.0% (n = 4) nutrition of food, respectively. As a result, 70% of the reasons for discomfort among primary school students are classroom chairs and desks.

The result of question 4 showed that 20.0% (n = 16) of primary school students do not find the classroom furniture comfortable, while 80.0% (n = 64) will find. As a result, 80% of students find comfortable classroom chairs and desks, which is the majority.

The results of question 5 showed that 6.3 % (n = 5) of respondents said that dietary nutrition not only impacts the body size and classroom comfort of primary school students, while 93.8% (n = 75) said that it is the only impact Dietary nutrition will also impact on the body size and classroom comfort of primary school students.

The result of question 6 showed that 41.3% (n = 33) of respondents did not know the role of ergonomics and anthropometric fitness in classroom chairs and desks/school, while 58.8% (n = 47) did. As a result, 41.3% of respondents do not know the role of ergonomics and anthropometric fitness in classroom chairs and desks/school.

The result of question 7 showed that 45.0% (n = 36) of respondents said that classroom desks and chairs are ergonomically suited and anthropometrically measured, while 55.0% are not. As a result, 55% of classroom desks and chairs are not ergonomically suited and anthropometrically measured.

The result of question 8 showed that 91.3% (n = 73) of students will be affected by the lack of ergonomic and anthropometric measurements on classroom chairs and desks, while 8.8% (n = 7) will not. As a result, 91.3% of students are affected by the lack of ergonomic and anthropometric measurements on classroom chairs and desks.

The result of question 10 showed that 53.8% (n = 43) of students' discomfort in the classroom is not related to their weight gain or loss, while 46.3% (n = 37) is related. As a result, 46.3% of students' discomfort in the classroom is related to their weight gain or loss.

Table 4 Frequency and percentages of respondents regarding with Ergonomics, Anthropometry and Classroom furniture

No	Questions	Response			
		Yes		No	
		n	%	N	%
1	Aware of the significance of ergonomics in classroom chairs and desks	61	76.3	19	23.8
2	Comprehend Anthropometric measurements and fitness of classroom chairs and desks	68	85.0	12	15.0

		Classroom chairs		Climate of classroom		Body size of student		Nutrition of food	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**

3	The reasons of discomfort among primary school students	56	70.0	16	20.0	4	5.0	4	5.0
4	primary school students will find the classroom chairs and desks comfortable	Yes				No			
		n		%		n		%	
		64		80.0		16		20.0	
5	Dietary nutrition only impacts the body size and classroom comfort of primary school students	75		93.8		5		6.3	
6	Know the role of ergonomics and Anthropometric fitness in classroom chairs/school	47		58.8		33		41.3	
7	Classroom chairs that most primary schools use for student seats are ergonomically suited and anthropometrically measured	36		45.0		44		55.0	
8	Students will be affected by the lack of ergonomic and anthropometric measurements on classroom chairs and desks	73		91.3		7		8.8	
9	Classroom furnishings fulfill ergonomic and anthropometric requirements	7		8.8		73		91.3	
10	Students' discomfort in the classroom is related to their weight gain or loss	37		46.3		43		53.8	

Source; field survey

Table 5 presents the results of the respondents concerned with primary school students. The results of question 1 showed that 77.5% (n = 224) of students do not feel comfortable when sitting at a school desk in a classroom, while 22.5% (n = 65) feel comfortable. As a result 77.5% of students report not feeling comfortable when sitting at the school desk in the classroom.

The results of question 2 showed that 90.0% (n = 260) of students feel tired when sitting on a chair in a classroom, while 10.0% (n = 29) do not. As a result, 90% of students feel tired when sitting on a chair in the classroom.

The results of question 3 showed that 68.5% (n = 198) of students do not feel comfortable on their back when sitting at a school desk in the classroom, while 31.5% (n = 91) of students feel comfortable. As a result, 68.5% of students are not comfortable on their backs when sitting at a school desk in a classroom.

The results of question 4 showed that 89.6% (n = 259) of students had pain or discomfort in their necks, while 10.4% (n = 30) did not. As a result, 89.6% of students had pain or discomfort in their necks. The result of question 5 showed that 74.7% (n = 216) of students had pain or discomfort in their shoulder, while 25.3% (n = 73) had not. As a result, 7% of students had pain or discomfort in their shoulders.

The results of question 6 showed that 65.4% (n = 189) of students did not have pain or discomfort in their elbows, while 34.6% (n = 100) of students had pain or discomfort. As a result, 34.6% of students had pain or discomfort in their elbows.

The results of question 7 showed that 65.1% (n = 188) of students did not have pain or discomfort in their wrists/hands, while 34.9% (n = 101) had pain or discomfort. As a result, 34.9% of students had pain or discomfort in their wrists or hands. The results of item 8 showed that 75.4% (n = 218) of students did not have pain or discomfort in their hips/thighs, while 24.6% (n = 71) of students had pain or discomfort. As a result, 24.6% of students had pain or discomfort in their hips or thighs.

The results of question 9 showed that 84.8% (n = 245) of students had pain or discomfort in their knees, while 15.2% (n = 44) did not. As a result, 84.8% of students had pain or discomfort in their knees. The results of question 10 showed that 79.6% (n = 230) of students had pain or discomfort in their ankles/feet, while 20.4% (n = 59) did not. As a result, 79.6% of students had pain or discomfort in their ankles or feet. The results of question 11 showed that 77.9% (n = 225) of students have noticed pain or discomfort recently, during this study, while 22.1% (n = 64) have not. As a result, 77.9% of students have noticed pain or discomfort recently.

The results of question 12 showed that 80.3% (n = 232) of students who noticed the pain or discomfort months ago during this survey, while 19.7% (n = 54) of students did not. As a result, 80.3% of students notice the pain or discomfort within 3 months.

The results of question 13 showed that 58.5% (n=169) of students had pain or discomfort in the last 7 days, during this survey, while the rest, 26.3% (n=76), did not. As a result, 58.5% of students had pain or discomfort within 7 days. The results of question 14 showed that 73.7% (n = 213) of students' pain is related to the school chairs design, while 26.3% (n = 76) are not related. As a result, 73.7% of students' pain is related to the school chairs design.

The results of question 15 showed that 73.0% (n=211) of students are feeling pain in their knees when sitting at the school desk in the classroom, while 27.0% (n=78) are not. As a result, 73% of students are feeling pain in their knees when sitting on a school bench in the classroom. The results of item 16 showed that 78.9% (n = 228) of students do not feel comfortable with their sore joints when sitting on a chair in the classroom, while 21.1% (n = 61) are comfortable. As a result, 78.9% of students report feeling uncomfortable with their sore joints when sitting in chairs in the classroom.

The results of question 17 showed that 86.5% (n = 250) of students feel fatigued during class work, while 13.5% (n = 39) do not. As a result, 86.5% of students are feeling fatigued during class work. The results of question 18 showed that 57.8% (n = 167) of students' backs straight are not supported by the chair back when sitting in a classroom, while 42.2% (n = 122) are supported by the chair back. As a result 57.8% of students' backs straight are not supported by the chair back when sitting in a classroom.

The results of question 19 showed that 55.4% (n = 160) of students' shoulders are relaxed when sitting on a chair in a classroom, while 44.6% (n = 129) are not. As a result, 44.6% of students' shoulders are not relaxed when sitting on a chair in a classroom. The results of question 20 showed that 55.0% (n = 159) of students do not complain to their teachers about the discomfort of the classroom furniture they use in the classroom, while 45.0% (n=130) of students have complained to their teachers. As a result, 45% of students have not complained to their teachers about the discomfort of classroom chairs and desks. The results of question 21 showed that 50.2% (n = 145) of students complained to their classmates about the discomfort of the classroom furniture they use in the classroom, while 49.8% (n = 144) of students did not. As a result, 49.8% of students do not complain to their classmates about the discomfort of the classroom chairs and desks.

Table 5 Frequency and Percentages of Respondents concerned with primary school students

No	Questions	Response			
		Yes		No	
		n	%	N	%
1	Feel comfortable when sitting at school desk in classroom	65	22.5	224	77.5
2	Feel tired when sitting on a chair in classroom	260	90.0	29	10.0
3	Feel comfortable on your back when sitting at school desk in classroom	91	31.5	198	68.5
4	Had pain or discomfort in your neck	259	89.6	30	10.4
5	Had pain or discomfort in your shoulder	216	74.7	73	25.3
6	Had pain or discomfort in your elbows	100	34.6	189	65.4
7	Had pain or discomfort in your wrists/ hands	101	34.9	188	65.1
8	Had pain or discomfort in your hips/ thighs	71	24.6	218	75.4
9	Had pain or discomfort in your knees	245	84.8	44	15.2
10	Had pain or discomfort in your Ankles/feet	230	79.6	59	20.4
11	Notice the pain or discomfort Recently	225	77.9	64	22.1
12	Notice the pain or discomfort months ago	232	80.3	57	19.7
13	Had this pain or discomfort in the last 7 days	169	58.5	120	41.5
14	Pains are related to the school furniture design	213	73.7	76	26.3
15	Feel pain on your knee when sitting at school desk in classroom	211	73.0	78	27.0
16	Feel comfortable on your sore joints when sitting at chair in classroom	61	21.1	228	78.9
17	Feel fatigue during class work	250	86.5	39	13.5
18	Back straight supported by the chair-back when sitting in classroom	122	42.2	167	57.8
19	Shoulders relaxed when sitting on a chair in classroom	160	55.4	129	44.6

20	Complained to the teacher about the discomfort of the furniture you use in the classroom	130	45.0	159	55.0
21	Complained to the classmate about the discomfort of the furniture you use in classroom	145	50.2	144	49.8

Source; field survey

Table 6 presents the results of the respondents regarding the students' academic performance and behavior. The results of question 1 showed that about 4.4% (n = 2) of them respond almost all when asked whether they pay enough attention to the class, and 48.9% (n = 22) of them respond half. About 40.0% (n = 18) of them are more than half, and 6.7% (n = 3) of them respond to almost all, respectively. Nearly 52% of students are not paying attention in class.

The results of question 2 showed that about 4.4% (n = 2) or less than half of students are putting forth sufficient effort to comprehend the teacher's explanation, and 20.0% (n =9) or half and 75.6% (n = 34) or more than half of students are putting forth sufficient effort to comprehend the explanation of the teacher, respectively.

The results of question 3 showed that about 71.1% (n = 32) of them are respond more than half the time when asked whether they are well disciplined in the classroom, and 28% (n = 13) of them are respond almost all. As a result, nearly 45% of students are not well disciplined in the classroom. The results of question 4 showed that about 66.7% (n = 30) of students respond positively half, when asked whether they participate in class regularly, and 33.3% (n = 15) of them are more than half. As a result, more than half of students do not participate in class regularly. The results of item 5 showed that about 40.0% (n = 18) of them are respond less than half the time when asked whether students complete their home work on a regular basis; 46.7% (n = 21) of them are respond more than half; and the remaining 13.3% (n = 6) respond almost all, respectively. Nearly 53.5% of students do not complete their homework on a regular basis.

The results of question 6 showed that about 62.2% (n = 28) of them are respond positively half, when asked whether students participate actively in class, and 37.8% (n = 17) of them respond more than half the time. As a result, nearly 61% of students are not asking more questions during the learning process. The results of item 8 showed that about 31.1% (n = 14) or less than half of

students are tired or sick in class, and about 53.3% (n = 24) or half , and 15.6% (n = 7) of students are tired or sick in class, respectively.

The results of question 9 showed that about 44% (n=2) of them were respond less than half, when asked whether students are able to sit comfortably in classroom while they are teaching and 28.9% (n=13) or half, 57.8% (n=26) or more than half and 8.9% (n=4) or almost all, of students are able to sit comfortably in classroom while they are teaching. The results of question 10 showed that about 2.2% (n=1) of them are respond less than half, when asked whether students are seat comfortably in the classroom, and 17.8% (n=8) or half, 60.0% (n=27) or more than half and 20.0% (n=9) or almost all, respectively.

Table 6 Frequency and percentages of Respondents regarding with students' academic performance and behavior

No	Questions	Response							
		Less than Half		Half		More than half		Almost all	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1	Students pay enough attention to the class	2	4.4	22	48.9	18	40.0	3	6.7
2	Students put out sufficient effort to comprehend your explanation	2	4.4	9	20.0	34	75.6		
3	Students are well disciplined in the class room					32	71.1	13	28.9
4	Students regularly participate in class			30	66.7	15	33.3		
5	Students complete their homework on a regular basis	18	40.0			21	46.7	6	13.3
6	Students who participate actively in class			28	62.2	17	37.8		
7	Students ask more questions during learning process			33	73.3	12	26.7		

8	Report of being tired or sick in class	14	31.1	24	53.3	7	15.6		
9	Students are able to sit comfortably in classroom while you are teaching	2	4.4	13	28.9	26	57.8	4	8.9
10	Students are seat comfortably in the classroom	1	2.2	8	17.8	27	60.0	9	20.0

Source; field survey

Table 7 presents the results of the respondents regarding parents of primary school students. The results of question 1 showed that about 27.4% (n = 37) of children slept from 2 pm–12 am during the nighttime, while 72.6% (n = 98) of children slept from 3 pm–12 am. The results of question 2 showed that about 72.6% (n=98) of children are feeling pain in their knee joint, 11.9% (n=16) in their shoulder, 5.9% (n=8) in their elbow, and the remaining 9.6% (n=13) of children are feeling pain in the other parts of their body. As a result, 72.6% of children are feeling pain in their knee joints.

The results of question 3 showed that the causes of pain for item 1 were: 11.1% (n = 15) is nutrition of food, 64.4% (n = 87) is classroom chairs and desks, 15.6% (n = 21) are the climate of the classroom and the remaining 8.9% (n = 12) are the others. 64.4% of the cause of the pain is classroom furniture.

The results of question 4 showed that the solution to the pain for item 2 responds to about 7.4% (n=10) adjusting their diet/nutrition, 70.4% (n=95) adjusting classroom chairs and desks, 10.4% (n=14) are physical activities, and the remaining 11.8% (n=16) are treatments and others. As a result, 70.4% of the solution for the pain in the knee joint is adjusting classroom chairs and desks.

The results of question 5 showed that about 11.9% (n = 16) of them responded most of the time when asked whether the child experienced physical pain or discomfort, and 74.8% (n = 101) responded some of the time, and the remaining 13.3% (n = 18) of respondents were not sure. The results of item 6 showed that about 1.5% (n=2) of them are responding most of the time when asked whether the feelings of their child have a family relationship, and 26.7% (n=36) respond more than half, 63.0% (n=85) more than half, and 8.9% (n=12) respond almost all, respectively.

The result of question 7 showed that about 30.4% (n = 41) of them responded most of the time when asked whether children participate in physical activities, and 69.6% (n = 94) of them responded some of the time. The result of question 8 showed that about 2.2% (n = 3) of them respond 'most of the time" when asked whether the child is cheerful after class, while 71.1% (n = 96) respond 'some of the time' and the remaining 26.7% (n = 36) are not sure. The results of question 9 showed that about 49.6% (n = 67) of them responded "most of the time" when asked whether they had been informed about the illness and diagnosis of their child for at least three years. While the remaining 50.4% (n = 68) of them are not sure. The results of item 10 showed that about 17.8% (n = 24) of them respond "most of the time" when asked whether children have enough time for school work or social activities, and 71.9% (n = 97) of them respond 'some of the time', and 10.4% (n = 14) of them are not sure.

Table 7 Frequency and percentages of respondents regarding with parents of primary school students

No	Questions	Responses							
		2pm- 12am				3pm-12 am			
		n		**%**		**n**		**%**	
1	Hours does child sleep at night	37		27.4		98		72.6	
		Knee joint		Shoulder		Elbow		Others	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
2	Part of the body do they feel pain in	98	72.6	16	11.9	8	5.9	13	9.6
		Nutrition of food		Classroom chairs		Climate of classroom		Others	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
3	The cause of this pain	15	11.1	87	64.4	21	15.6	12	8.9
		Adjust their diet/ nutrition		Adjust classroom chairs		Physical activities		Treatments and others	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
4	The solution of this pain	10	7.4	95	70.4	14	10.4	16	11.8

		Most of the time		Some of the time		Not sure		
		n	**%**	**n**	**%**	**n**	**%**	
5	Child experienced physical pain or discomfort	16	11.9	101	74.8	18	13.3	
		Less than half		Half		More than half		Almost all
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
6	Feeling of your child with his or her family relationships	2	1.5	36	26.7	85	63.0	12	8.9
		Most of the time		Some of the time				
		n	**%**	**n**	**%**			
7	Child participate in physical activities	41	30.4	94	69.6			
		Most of the time		Some of the time		Not sure		
		n	**%**	**n**	**%**	**n**	**%**	
8	Child is cheerful after class	3	2.2	96	71.1	36	26.7	
9	Child become ill, and has there been any diagnosis for at least three years	67	49.6			68	50.4	
10	Child have for schoolwork or social activities	24	17.8	97	71.9	14	10.4	

Source; field survey

Table 8 presents the results of respondents' eating habits and dietary information. The results of question 1 showed that 0.5% (n = 1) of students eat one meal a day, while 8.0% (n = 16) eat two meals a day, 80.0% (n = 160) eat three meals a day, and 11.5% (n = 23) eat more than three meals on a daily basis. As a result, 80% of students are eating three meals a day.

The results of question 2 showed that about 50.0% (n = 100) of students eat their breakfast daily, while 45.5% (n = 91) sometimes and the remaining 4.5% (n = 9) never eat breakfast. The results of question 3 showed that about 68.0% (n=136) of students eat their lunch daily, while 26.5% (n=53) of them eat sometimes, and the remaining 5.5% (n=11) of students never eat their lunch.

The results of question 4 showed that 17.5% (n=35) of students eat their snacks daily, while 74.5% (n=149) of them eat sometimes, and the remaining 8.0% (n=16) of students never eat their snacks. The results of question 5 showed that 92.0% (n = 184) of students eat their dinner daily, while the remaining 8.0% (n = 16) eat sometimes. The results of question 6 showed that 7.0% (n = 14) of students eat fast food daily, while 84.5% (n = 169) of them eat it sometimes, and the remaining 8.5% (n = 17) of students never eat fast food. The results of item 7 showed that about 11.5% (n = 23) of students are sleeping less than six hours a day, while 82.0% (n = 164) of them are sleeping six to nine hours a day, and the remaining 6.5% (n = 13) of students are sleeping more than nine hours a day. The results of item 8 showed that 48.5% (n = 97) of parents have a low level of income, while 49.0% (n = 98) have a middle income and the remaining 2.5% (n = 5) of parents have a high level of income. As a result, 48.5% of parents have a low level of income.

Table 8 Frequency and percentages of respondents regarding with Eating habits and Dietary Information

No	Questions	Responses							
		One meal a day		Two meal a day		Three meal a day		More than three meals	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1	Eat on a daily basis	1	0.5	16	8.0	160	80.0	23	11.5
		Daily				Sometimes		Never	
		n		**%**		**n**	**%**	**n**	**%**
2	Eat Breakfast	100		50.0		91	45.5	9	4.5
3	Eat Lunch	136		68.0		53	26.5	11	5.5
4	Eat Snack	35		17.5		149	74.5	16	8.0

5	Eat dinner	184	92.0	16	8.0		
6	Eat fast food	14	7.0	169	84.5	17	8.5
		Less than six hours a day		Six to nine hours a day		Greater than nine hours a day	
		n	**%**	**n**	**%**	**n**	**%**
7	Hours spent with sleeping	23	11.5	164	82.0	13	6.5
8	Level of Income	Low		Middle		High	
		n	**%**	**n**	**%**	**n**	**%**
		97	48.5	98	49.0	5	2.5

Source; field survey

4.1.3 Anthropometric Dimension of the Students

The anthropometric data of the students is presented in Tables 9 to 12 as means, standard deviations (SD), and 5^{th}, 50^{th}, and 95^{th} percentiles. Furthermore, the minimum and maximum dimensions are included. In anthropometry, percentiles of various body dimensions are used to determine design values for an application. For seat height, the 5^{th} percentile (lower percentile) of the popliteal height of the population is usually recommended so that a larger percentage of the population is accommodated and thus allows a short person to use the chair.

Similarly, the 5^{th} percentile of buttock-popliteal length is considered for seat depth. However, the 95^{th} percentile (larger percentile) of the hip breadth is usually recommended in the design of the seat and desk widths to accommodate as many people in the population as possible, thus allowing an obese person to use the chair.

Seat desk height, seat desk depth, and desk slope are the important dimensions for the design of a desk, while bench height, bench length, and bench depth are the dimensions that are essential for the design of a school bench. And also, footrest height, distance between desk and bench, and thickness are the other components of the school desk.

Table 9 Summary of anthropometric dimensions for primary school students (N=149), age group-on 5- 6 years

Anthropometric dimension		Gender	5th	50th	95th
S	No = 149	Male(n=66)	108.00	118.00	122.00
		Female(n=83)	116.00	118.00	121.00
SH	No = 149	Male(n=66)	54.00	57.00	68.00
		Female(n=83)	55.20	58.00	67.00
SEH	No = 149	Male(n=66)	39.00	55.00	68.25
		Female(n=83)	40.00	50.00	64.00
SSHH	No = 149	Male(n=66)	42.00	46.00	55.00
		Female(n=83)	42.00	43.00	52.00
TC	No = 149	Male(n=66)	6.00	8.00	9.50
		Female(n=83)	6.00	7.00	9.00
KL	No = 149	Male(n=66)	35.00	41.00	44.30
		Female(n=83)	35.00	38.00	42.00
PH	No = 149	Male(n=66)	25.00	30.00	33.00
		Female(n=83)	24.00	28.00	32.00
BPL	No = 149	Male(n=66)	28.00	34.00	36.65
		Female(n=83)	28.00	30.00	35.00
HW	No = 149	Male(n=66)	20.00	22.00	25.00
		Female(n=83)	20.00	23.00	25.00
EH	No = 149	Male(n=66)	48.00	55.00	59.00
		Female(n=83)	50.00	55.00	59.00
BKL	No = 149	Male(n=66)	34.35	42.00	45.00
		Female(n=83)	40.00	42.00	45.00
FAHL	No = 149	Male(n=66)	26.35	30.00	34.00
		Female(n=83)	27.00	29.00	34.00

Source; field survey, 2022

Table 10 Summary of anthropometric dimensions for primary school students (N=144), age group-on 7- 8 years

Anthropometric dimension		Gender	5th	50th	95th
S	No = 144	Male(n=75)	118.00	120.00	123.20
		Female(n=69)	118.00	121.00	124.00
SH	No = 144	Male(n=75)	55.00	65.00	70.00
		Female(n=69)	55.00	65.00	70.00
SEH	No = 144	Male(n=75)	55.00	60.00	63.00
		Female(n=69)	55.00	60.00	63.00
SSHH	No = 144	Male(n=75)	45.00	46.00	48.00
		Female(n=69)	45.00	47.00	48.00
TC	No = 144	Male(n=75)	7.00	8.00	9.50
		Female(n=69)	7.50	9.50	11.00
KH	No = 144	Male(n=75)	38.00	42.00	45.40
		Female(n=69)	42.00	45.00	48.00
PH	No = 144	Male(n=75)	30.00	31.00	33.20
		Female(n=69)	32.00	33.00	35.00
BPL	No = 144	Male(n=75)	33.00	34.00	36.00
		Female(n=69)	34.00	36.00	37.00
HW	No = 144	Male(n=75)	28.00	30.00	32.20
		Female(n=69)	28.00	29.00	31.00
EH	No = 144	Male(n=75)	55.00	60.00	62.20
		Female(n=69)	56.50	60.00	62.00
BKL	No = 144	Male(n=75)	39.00	43.00	45.00
		Female(n=69)	39.00	41.00	43.00
FAHL	No = 144	Male(n=75)	28.00	30.00	33.20
		Female(n=69)	29.00	29.00	34.00

Source; field survey

Table 11 Ergonomic fitness of Classroom desks and chairs with Anthropometry of male's students

Anthropometric Variables		Percentile	Value	Minimum	Maximum	Mean	Remarks
S	5-6 years N=66	5th	116	108	122	117.36	M
		50th	120	109	122.5	117.5	M
		95th	124	111.5	124	118	M
SH+ BPL+ KH+ 5 ≥ DH	7-8 years N= 75	5th	118	118	125	120.44	LM
		50th	122	119	126.5	121	LM
		95th	126	121	127	121	LM
SH	5-6 years N= 66	5th	54	54	*68*	57.85	HM
		50th	60	56	69.5	57.7	HM
(PH + 2)cos 30° ≤ SH ≤)PH +2) cos 5°		95th	68	57	70	58	HM
	7-8 years N= 75	5th	55	55	*70*	64.75	LM
		50th	62	56.5	72	65	LM
		95th	70	62.3	72.1	65.5	LM
SEH	5-6 years N= 66	5th	39	39	65	49.98	LM
		50th	55	41	65	50.01	LM
		95th	70	42.5	66.3	51	LM
SEH ≤ DH ≤ SEH + 5.	7-8 years N= 75	5th	55	55	65	59.51	LM
		50th	62	56.5	66.01	61	LM
		95th	70	58	75	62	LM
SSHH	5-6 years N=66	5th	49	39	*55*	44.48	HM
		50th	50	41.07	56.02	45	HM
		95th	54	43.01	58	46.04	HM
0.6SH < BH <0.8 SH	7-8 years N= 75	5th	43	43	*50*	46.62	LM
		50th	47	44.5	52.01	47	LM
		95th	52	46	53.5	47.06	LM
TC	5-6 years N=66	5th	4	6	*10*	7.43	HM
		50th	6	7.1	11.01	8.5	HM
		95th	9.5	8.2	12.00	8.6	HM
TC + 2 < SD	7-8 years N= 75	5th	6	6	11	9.21	HM
		50th	7.5	8	11.07	9.05	LM
		95th	10	9.2	12	10	LM
KH	5-6 years N=66	5th	32	35	43	38.58	HM
		50th	35	36.01	44.03	39	HM
KH+2 ≤ UND ≤ (PH cos5 +(0.8517 EH) + (0.1483 SHH)		95th	45	39.05	48	39.5	HM
	7-8 years N= 75	5th	38	40	50	45.04	LM
		50th	45	42	52.02	46	LM

		95th	52	43.5	53.5	46	LM
PH (PH + 3) cos 30∘ ≤ SH ≤ (PH + 3) cos 5∘.	5-6 years N=66	5th	24	24	33	27.12	LM
		50th	30	28.6	34	28	M
		95th	35	32	35.02	28.5	M
	7-8 years N= 75	5th	30	31	35	33.36	LM
		50th	32	32.5	36. 8	35	LM
		95th	35	33.05	38	36	M
BPL 0.80BPL ≤ SD ≤ 0.95BPL.	5-6 years N=66	5th	26	26	37	31.28	LM
		50th	30	27.5	37.08	32	LM
		95th	38	30.4	38	32	LM
	7-8 years N= 75	5th	33	33	38	35.54	M
		50th	35	34.5	39.1	38	M
		95th	38	36.02	40	39	M
HW 1.10HW ≤ SW ≤ 1.30HW.	5-6 years N=66	5th	20	20	26	22.87	HM
		50th	23	25.3	29.9	23	HM
		95th	26	28.6	33.8	24	HM
	7-8 years N= 75	5th	28	28	32	29.39	HM
		50th	30	29.02	33.05	30	HM
		95th	34	31	35	30.06	LM
EH EH ≤ DH ≤ SEH + 5.	5-6 years N=66	5th	48	50	65	54.67	LM
		50th	58	52.2	66.05	55	LM
		95th	65	54	68	55	LM
	7-8 years N= 75	5th	55	55	62	59.57	M
		50th	60	56.07	63.08	60	M
		95th	65	58	65	60	M
BKL SD + DBDB ≥ BKL	5-6 years N=66	5th	34	35	46	41.70	HM
		50th	40	36.06	47.02	42	HM
		95th	46	37.08	48.07	42	HM
	7-8 years N= 75	5th	38	38	44	41.28	LM
		50th	42	39.5	45.08	41.45	LM
		95th	46	40	47	42	LM
FAHL BD ≤ FAHL	5-6 years N=66	5th	26	26	35	29.61	HM
		50th	30	28	35.05	30	HM
		95th	35	29	36.02	30	HM
	7-8 years N= 75	5th	28	28	35	31.36	LM
		50th	32	29.5	36	32	LM
		95th	35	30	37.02	32	LM

Source; field survey

- **Note; M**- match, **LM**- low mismatch, **HM**- high mismatch,

Table 12 Ergonomic fitness of Classroom desks and chairs with Anthropometry of female's students

Anthropometric Variables		Percentile	Value	Minimum	Maximum	Mean	Remarks
S SH+ BPL+ KH+ 5 ≥ DH	5-6 years N= 83	5th	116	108	122	117.72	M
		50th	120	109	122.5	118.5	M
		95th	124	112.5	125	119	M
	7-8 years N=69	5th	118	118	125	120.99	LM
		50th	122	119	126.5	122	LM
		95th	126	121.5	127	122	LM
SH (PH + 2) cos 30° ≤ SH ≤) PH +2) cos 5°	5-6 years N= 83	5th	54.5	54	*68*	58.42	LM
		50th	65	56	69.5	59	LM
		95th	68	58	70	59	LM
	7-8 years N=69	5th	56	55	70	64.75	M
		50th	65	58.023	72.08	65	M
		95th	70	62.4	73.123	65.5	M
SEH SEH ≤ DH ≤ SEH + 5.	5-6 years N= 83	5th	38	39	70	53.77	M
		50th	55	41.02	73	54	M
		95th	70	42.06	75.3	54	LM
	7-8 years N=69	5th	55	55	63	59.19	LM
		50th	64	56.5	66.01	61	M
		95th	70	58	75.02	62	M
SSHH *0.6SH < BH <0.8 SH*	5-6 years N= 83	5th	52	42	*58*	47.57	LM
		50th	55	44.07	60.02	48	LM
		95th	58	46.01	62	48	LM
	7-8 years N=69	5th	50	43	*50*	46.25	M
		50th	55	44.5	52.01	47	M
		95th	58	46	53.5	48.06	M
TC TC + 2 < SD	5-6 years N= 83	5th	6	6	10	8.19	HM
		50th	8	7.1	11.01	8.5	HM
		95th	9.5	8.2	12.00	8.6	HM
	7-8 years N=69	5th	7.5	6	11	8.35	LM
		50th	8	8	12.07	9.05	LM
		95th	10	9.2	13.05	10	LM
KH KH+2 ≤ UND ≤ (PHcos5 + (0.8517 EH) + (0.1483 SHH)	5-6 years N= 83	5th	32	32	45	40.38	HM
		50th	42	34.01	46.23	41	HM
		95th	45	37.05	48	41.5	HM
	7-8 years	5th	38	38	48	42.07	LM
		50th	45	42	52.02	46	LM
		95th	52	43.5	53.5	46	LM

	N=69						
PH *(PH+3) cos 30≤ SH≤ (PH+3) cos 5*	5-6 years N= 83	5th	25	24	34	29.58	HM
		50th	28	26.846	35.08	30	HM
		95th	35	32	37.8	30.02	M
	7-8 years N=69	5th	28	30	35	31.52	M
		50th	30	32.5	36. 8	33	M
		95th	35	33.05	38	33	M
BPL *0.8BPL ≤ SD ≤ 0.95BPL*	5-6 years N= 83	5th	32.5	26	38	33.02	LM
		50th	34	27.5	37.08	34	LM
		95th	38	30.4	39.05	34	M
	7-8 years N=69	5th	34	33	38	34.01	LM
		50th	36	34.2	39.1	38	M
		95th	38	36.01	40	39	M
HW *HW < SW* 1.10HB ≤ SW ≤ 1.30HB.	5-6 years N= 83	5th	19	20	26	22.39	HM
		50th	20.5	22.5	28	23	HM
		95th	23	25	30	24	HM
	7-8 years N=69	5th	26	28	33	29.68	HM
		50th	28	29.02	34.25	30	LM
		95th	32	35.2	36	30.06	LM
EH EH<SDH<EH+5	5-6 years N= 83	5th	48	48	60	54.95	LM
		50th	55	52.2	63.05	55	LM
		95th	65	54	66	55	LM
	7-8 years N=69	5th	55	55	65	59,61	M
		50th	58	63.07	67.08	60	M
		95th	65	70	72	60	M
BKL SD + DBDB ≥ BKL	5-6 years N= 83	5th	34	34	46	41.06	HM
		50th	40	36.06	47.02	42	HM
		95th	46	37.08	48.07	42	HM
	7-8 years N=69	5th	40	38	46	42.57	LM
		50th	42	39.5	46.78	43	LM
		95th	46	40	48	43	LM
FAHL BD ≤ FAHL	5-6 years N= 83	5th	26	26	35	29.97	LM
		50th	30	28	36.05	30	LM
		95th	35	29	38.02	30	M
	7-8 years N=69	5th	28	28	34	30.59	LM
		50th	32	29.5	36	32	M
		95th	35	30	37.02	32	M

Source; field survey, 2022

4.2 Discussions

4.2.1 Percentiles of Anthropometric measurements of three selected primary school students

An anthropometry study was carried out to study the anthropometric dimensions of the student population and generate data on the students, to measure the dimensions of the various desks available in the class rooms, to compare the dimensions of the desks with the anthropometric measures of students, to find out any mismatch between the anthropometric dimensions and the student desks used and to suggest suitable corrective measures in the design.

The design of the school desk for use by students in primary school was based on the following computation criteria:

Hip Width

The mean hip width while sitting is 22.39 for males and 22.87 for females for the age ranges of 5–6 and for which the percentile values calculated were 20,00 for males and 20,00 for females for the age ranges of 5–6 (5^{th} percentile) and 25,00 for males and males (95^{th} percentile). And also, for the age ranges of 7-8—mean 29.68 for male and 29.39 for female, 5^{th} percentiles of 28,00 for male and female, 95^{th} percentiles of 32,20 and 31,00 for male and female, respectively. This measurement is required to determine the width of the seat (Kahya, 2018).

Seat Desk height

For non-adjustable seats, the 5th percentile may be utilized as the maximum permitted seat height, as indicated in (Parcells *et al*., 1999) and (Kahya, 2018). The 5th percentile in the case of Dire Dawa primary school students was 54, 00 for male and 55.20 for female for 5–6 years and 55, 00 for male and 60, 00 for female for 7-8 years.

Desk depth

The buttock-popliteal length is proportional to the seat depth. According to Ismaila *et al*. (2013) and Engineering *et al*. (2013), the seat depth should not exceed the buttock-popliteal length of the shortest user. As a result, the seat depth should be determined using the 5th percentile of buttock-popliteal length.

In this study, the 5th percentile of the buttock-popliteal length is thus equivalent to the seat depth, which is 33, 00 for males and 34, 00 for females for 7-8 age ranges and 28, 00 for males and 28, 00 for females age ranges of 5–6-year-old students.

Bench height

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 (Parcells *et al*., 1999). The 5th percentile in the current student is age range 5-6 for males at 25.00 and females at 24.00. For the age ranges 7-8 for males at 30.00 and females at 32.00.

Bench seat depth

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 (Bridger, 2000), and as such, the 5th percentile of the buttock popliteal length should be used to determine the seat depth. In this study, the 5th percentile of the buttock-popliteal and thus the seat depth is 33,00 for males and 34,00 cm for females for 7-8 age ranges and 28,00 for males and 28,00 for age ranges of 5-6-years old students.

Bench length

Buttock knee length should be considered in the design of bench length; the 5th percentile may be used as the maximum allowable bench length (Perez, 2017). The 5th percentile in the present student is age ranges 5-6 for male 34.35 and female 40, 00. Age ranges 7-8 for male 39, 00 and female 39, 00.

Distance between desk seat and bench

The anthropometric dimension to be considered in the design of buttock popliteal length is related to the distance between the desk seat and bench. Most of the students feel pain in the knee joint when they sit in the classroom. Similarly, with bench seat depth, the distance between desk seat and bench should not exceed the buttock popliteal length of the shortest user (Bridger, 2000), and as such, the 5th percentile of the buttock-popliteal length should be used to determine the seat depth. In this study, the 5th percentile of the buttock-popliteal and thus the seat depth, which is 33,00 for male and 34,00 cm female for 7-8 age ranges and 28,00 for males and 28,00 for age ranges of 5-6-years old students.

This study focused on the age ranges of students since the classroom furniture in the three primary schools chosen had nearly the same dimensions. By separating the participants' ages into two categories (5–6 and 7-8), the anthropometric dimension and ergonomic fitness were assessed.

Tables 11 and 12 show how to compare the values of chosen percentiles (5^{th}, 50^{th}, and 95^{th}) and corresponding allowable design variables with measured mean values, as well as how to assess ergonomic and anthropometric fitness using the provided equation and remarks on the match and mismatch of student anthropometric measurements with classroom chairs and desks.

4.3. Recommended dimensions of school bench/ combination chairs

Table 13. The recommended dimensions of school bench/ combination chairs (unit, CM)
(Taifa and Desai, 2017*)*

Features	Anthropometric Measures	Proposed Design Dimension		Criteria
		5-6 years	7-8 years	
Desk/bench Height	Seat height +Elbow height +Shoe heel allowance	92.5 cm	109,00 cm	Maximum bench height=5th percentile of seat height+5th percentile of functional elbow height(sitting)+shoe heel allowance
Desk depth	Forearm hand length	34,00 cm	35,00 cm	95th percentile of fore arm-hand length
Desk length	Hip width	33.5 cm	37.5 cm	95th percentile of hip width + 15% allowance as clearance (5.4 cm is taken as clearance)
Desk slope	15 degrees			
Bench/seat height	Popliteal height	33.5 cm	38,00 cm	5th percentile of popliteal height+2cm shoe heel allowance
Bench length	Hip width	30,00 cm	36.25 cm	95th percentile of hip width sitting
Bench depth	Buttock popliteal length	36,00 cm	37,00 cm	95th percentile of buttock popliteal length

Source, field survey and Chair and Table Height Guidelines (European standard EN1729 Part 1)

4.4. Match and mismatch of school bench for primary schools

It is crucial to know whether or not classroom desks and chairs and body measurements are compatible while developing and analyzing ergonomic school chairs and desks. The range in which each furniture dimension is recognized as fitting was described using relevant anthropometric measurements and ergonomic criteria.

Different kinds of compatibility metrics, such as "Match" and "Mismatch," were established to compare anthropometric measurements of students with chair and desk dimensions in two-way models. The discordance between the chairs dimensions and the student anthropometric measurements is referred to as a mismatch if the equation is not satisfied. For two-way models, three outcome categories were developed.

- 'Match' means the anthropometric measure is between the limits,
- 'High mismatch' means the criteria model's minimum limit is greater than the anthropometric measure, and
- 'Low mismatch' means the criterion model's maximum limit is lower than the anthropometric measure.

Tables 11 and 12 show how to compare the values of chosen percentiles (5th, 50th, and 95th) and corresponding allowable design variables with measured mean values, as well as how to assess ergonomic and anthropometric fitness using the provided equation and remarks on the match and mismatch of student anthropometric measurements with classroom chairs and desks.

4.4.1. Mismatch of Classroom desks and chairs and Body Dimensions

The term "mismatch" refers to the disparity between the size of classroom chairs and the anthropometric measures of students. When it comes to creating and analyzing classroom chairs and desks, determining whether something is a match or a mismatch is critical. Anthropometric measurement and ergonomic criteria can be used to define the range in which each furniture dimension is considered suitable. Many relationships have been constructed to determine if a match or mismatch exists. Below is a list of the most frequent relationships.

Popliteal Height (PH) against Seat Height (SH)

The seat height (SH) must be balanced in relation to the popliteal height (PH), allowing the knee to be flexed to form a maximum of a 30-degree angle with regard to the vertical. The PH should be greater than the SH. The lower leg constitutes a 5–30-degree points with respect to the vertical, and furthermore, the lower leg edge is in the proximity of 95 and 120 degrees. The PH usually has an esteem of little more than 4 cm. When the seat stature is >95% of the popliteal tallness, PH and SH are identified. Usually, this body dimension is used to determine the seat height and is expected to be higher than the seat height. The fifth percentile of popliteal height should be used to determine seat height. The popliteal height used as the anthropometric standard for the seat height dimension in this study. The 5^{th} and 95^{th} percentiles of popliteal height were used to determine a standard chair's seat height.

For this evaluation, a 3 cm shoe height adjustment is applied to the popliteal height. As a result, a match dimension is created, as demonstrated by the condition below.

$$(PH + 3) \cos 30\circ \leq SH \leq (PH + 3) \cos 5°.$$

Buttock Popliteal Length (BPL) against Seat Depth (SD)

Seat depth should be at least 5 cm but not more than the buttock popliteal length. In any event, the hypothesis would not be sufficiently supported if the SD differed greatly from the individuals' BPL. According to many experts, the seat depth should be assessed for the 5^{th} percentile of the BPL appropriation so that the seat's backrest can support the lumbar spine without putting pressure on the popliteal surface. Mismatch between seat depth and BPL of users can cause bending of the neck and head and forward extension of the arm, which can cause pain in the back, shoulders, and arms over time as well as difficulty utilizing the backrest. According to Heidarimoghadam *et al*. (2015), a high seat depth puts strain on the thighs and disrupts the circulatory system, while a low seat depth puts pressure on the back and knees in order to prevent accidents. The seat's front edge is curved to protect the thighs underneath, and the user in front of it shields various portions of the feet from pressure.

In this vein, a crossover between SD and BPL is defined as SD being greater than 95% of BPL. As a result, a match dimension is recommended, as indicated by the condition:

$$0.80BPL \leq SD \leq 0.95BPL.$$

Hip Width (HB) against Seat Width (SW)

To achieve stability and enable space for horizontal advancements, the seat width must be sufficient to accommodate the user with the largest hip expansibility. Various investigations have revealed that the HW should be narrower than the SW in order to provide a proper fit in the seat, and an optimal seat width is determined for the 95^{th} percentile of HW conveyance or the largest HW. For the optimum seat width design, the hip width 95th percentile is considered. The lower hip breadth will fit into the seat width that allows the larger hip breadth.

The SW that is purchased must be no less than 10% larger than the hip expansiveness (to ensure hip breadth) and no more than 30% larger (for space economy). Similar to this, the following criterion determines a match rule:

$$1.10HW \leq SW \leq 1.30HW$$

Sitting Elbow Height (SEH) against Desk Height (DH)

Several studies have shown that the center point for the work area stature is assessed at the elbow height. The arms are upheld on the desk as the pressure on the spine diminishes, and the desk height is influenced by the 5^{th} percentile of shoulder flexion and shoulder snatching edge. According to Grimes *et al*., (2004) mismatch between the sitting elbow height and desk height can lead to pain in the shoulders and neck.

As a result, the height of the work area should be 3–5 cm above the SEH. Following that, a match measure is established with a modified condition that recognizes the SEH as the DH's most minimum stature and that the DH's extraordinary height should not exceed 5cm over the SEH.

$$SEH \leq DH \leq SEH + 5.$$

Thigh Clearance (TC) against Seat to Desk Clearance (SDC) or the distance between desk and bench

To facilitate leg health, an appropriate seat in the work area should take precedence over thigh flexibility. The ideal seat-to-desk clearance is higher than the thigh clearance. The following conditions are used to interpret a matching paradigm in this way:

$$TC + 2 < SD$$

4.5. Correlation between family size, age, income and Genders

Table 14 shows that the correlation between families' sizes, income, age, and gender. The family size/incomes of students do have a direct influence on the body size of students. The results of this study indicated that 48.5% of the families were of low income, 49.0% medium while the remaining 2.5% were of high income.

The size of the family will impact the amount of advantage or disadvantage that an individual or family will experience. Better levels of education, wealth, health, and quality of life may be advantages for smaller family sizes. Higher family sizes will ultimately result in lower levels of income, welfare, health, and economic standing (Arthur, 2005).

From the correlation analysis shown in Table 14, it can be seen that there was a significant correlation between family size and income ($r = 0.053$), age and family size ($r = 0.128$), and gender and family size ($r = -0.071$).

The size of the family affects the degree of benefit or disadvantage that an individual or family will experience. Smaller families may improve in terms of economic life, education, income, and health. Through time, larger families will result in lower levels of income, education, health, welfare, and economic position (Kormos and Kiddle, 2013).

Children who grow up in large families will become thin, but children who grow up by themselves will become thick. Additionally, the family's income will affect how much weight they acquire and lose. Children from low-income families will experience weight loss, whereas those from high-or middle-income families will experience weight growth.

Table 14 The correlation analysis between family size, age, income and gender.

	Gender	Family size	Income	Age
Gender	1	-0.071	-.213*	-.232**
Family size	-0.071	1	0.053	0.128
Income	-.213*	0.053	1	0.035
Age	-.232**	0.128	0.035	1

***.** Correlation is significant at the 0.05 level (2-tailed).

****.** Correlation is significant at the 0.01 level (2-tailed).

Chapter five

5. Conclusions and Recommendations

5.1 Conclusion

Students spend the majority of their time in the classroom. The muscles, ligaments, and most crucially the brain are put under a great deal of stress by prolonged durations of static posture. Correct sitting position is vital for preventing disorders and increasing student efficiency by encouraging and inspiring them to do better. According to recent study, bad sitting position is becoming more of a health hazard.

The cause of discomfort among three selected primary school pupils are un- adjustability of classroom furniture, lack of ergonomics and anthropometry. Majority of students are not aware of the meaning, significance, and role of ergonomics, anthropometry, and classroom chairs and desks in school. The classroom chairs and desks in the three studied schools were found not to be anthropometrically and ergonomically designed and fitted, which accounted for over 70% of the reasons for pain among the primary school pupils.

The descriptive statistics of the anthropometric dimensions of primary school pupils (293 male and female) are shown in Tables 11 and 12. This table shows that the mean stature 117.36 for males the age ranges of 5 to 6 and 120.44 for the age ranges of 7 to 8. And also for female 117.72 age ranges of 5 to 6 and 120.99 for the age ranges of 7 to 8. SH for males at the 5^{th} percentile is 57.85 cm and for females it is 58.42 cm. sitting elbow height (SEH) of the males is on average 2.04 cm higher than that of females for both age ranges. Similarly, sitting height SH is on average 3.27 cm, elbow height (EH) is on average 0.03 cm, knee height (KH) is on average 4.16 cm, shoulder height (SShH) is on average 2.06 cm, and buttock popliteal length (BPL) is on average 3.04 cm. The average 1.64 cm higher for females than for males. However, the hip width HW of the females is on average 2.02 cm higher than that of the males. Therefore, it is clear that, the anthropometric measurements of female students in both age categories are somewhat greater than those of male students except HW. And the other parts of body dimensions are nearly the same for both 5-6 and 7-8 age ranges.

The optimal relationship between body size and ergonomic and anthropometric measurements of school desk and chairs were showed in table 11 and 12. As a result, there is mismatch between body size and school desk/ chairs dimensions.

Adjustable and ergonomic chairs can also help students prevent musculoskeletal disorders. The research results additionally indicated that the need for building and creating two age-dependent different size categories of school desk/combination chair for primary school pupils, namely 5–6 and 7-8 years, so as to reduce discomfort, pain, and the occurrence of musculoskeletal conditions. All must be done in agreement with the primary school student's anthropometry.

5.2. Recommendations

The results of this study revealed that there was a high mismatch between the body dimensions of three selected primary school pupils and the classroom desks and chairs. This study resulted in the creation of an anthropometric database for pupils at Dire Dawa Primary School. Anthropometric measurements are currently considered to be one of the most significant aspects of product design. These dimensions are primarily influenced by age and gender, but they also have an impact on geographic areas. Thus, these variables must be considered when creating anthropometric datasets. Several anthropometric characteristics were significantly different across ages, genders, and locations. When designing products like classroom chairs and desks, these disparities must be taken into consideration. As children grow, ergonomic furniture conforms to their height and proportions. All school desks may be adjusted to their current height and proportions, making them ergonomic at all times. It's just as important to be able to adjust the backrest and seat depth as it is to adjust the school desk height. In order to satisfy the comfort of the student classroom chairs; their seating height should be adjustable and seat back should be adjustable and comfortable. And also, at least three techniques exist to tailor a product to a diverse range of consumers across several dimensions: Tailor the product to a specific consumer; Make it adaptable and Produce many sizes of the same product.

According to Molenbroek *et al.* (2003*),* the latter is the most popular choice for Dire Dawa's school chairs and desks, as it strikes a compromise between cost and anthropometric fitness.

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APPENDIX 1

QUESTIONNAIRES

Part one: - Questionnaire for primary school Teachers:

First and foremost, I'd like to express my gratitude for your willingness to participate in this survey. This is about the importance of classroom furnishings to primary school in terms of educational attainment and learning. The goal of this questionnaire is to gather data on the impact of classroom furniture on primary school achievement and learning. All of your responses are kept private and anonymous.

Direction 1

Please attempt all of the items by placing an "**X**" mark in the appropriate box that corresponds to your choice or by writing the information needed in Brief whenever necessary.

Section 1: - Background Information

1. Name of the school _____
2. Woreda _____
3. Gender: - Male ☐ Female ☐
4. Age - 18-25 ☐ 26-30 ☐ 31-35 ☐ 36-40 ☐ 46-50 ☐ more than 50 ☐
5. Educational qualification
   - Diploma ☐ Degree ☐ Master ☐ Others ☐
6. Family status 1-3 ☐ 4-6 ☐ more than 7 ☐
7. Income low ☐ middle ☐ high ☐
8. During your training at your university or institution, what subjects did you apply?
   - Developmental psychology ☐
   - primary school education ☐
   - Social science ☐
   - Natural Science ☐
   - Others ☐

Part 2. Questionnaire that related with Ergonomics, Anthropometry and classroom furniture

Direction. Select the appropriate answer

1	Are you aware of the significance of ergonomics in classroom chair and desks?	1. yes 2. no
2	Do you comprehend the Anthropometric measurements and fitness of classroom chair and desks?	1.yes 2. no
3	What is your opinion on the reasons of discomfort among primary school students?	1. Classroom chairs 2. The climate of classroom 3. Body size of student 4.Nutrition of food
4	Do you suppose primary school students will find the classroom chair and desks comfortable?	1. yes 2. no
5	Do you think that dietary nutrition only impacts the body size and classroom comfort of primary school students?	1. yes 2. no
6	Do you know the role of ergonomics and Anthropometric fitness in classroom chair and desks/school?	1. yes 2. no
7	Do you assume that the classroom chairs/furniture that most primary schools use for student seats are ergonomically suited and anthropometrically measured?	1. yes 2. no
8	Do you believe students will be affected by the lack of ergonomic and anthropometric measurements on classroom chair and desks?	1. yes 2. no
9	Do you think the room's chairs/classroom furnishings fulfill ergonomic and anthropometric requirements?	1. yes 2. no
10	Do you believe that students' discomfort in the classroom is related to their weight gain or loss?	1. yes 2. no

Part 3. Some Questionnaire that concerned with primary school students

Direction. Select the appropriate answer

1	Do you feel comfortable when sitting at school desk in classroom?	1. yes 2. no	
2	Do you feel tired when sitting on a chair in classroom?	1. yes 2. no	
3	Do you feel comfortable on your back when sitting at school desk in classroom?	1. yes 2. no	
4	**Have you ever had pain or discomfort in your-**	**Yes**	**No**
	Neck		
	Upper back		
	Lower back		
	Shoulders		
	Elbows		
	Wrists/hands		
	Hips/Thighs		
	Knees		
	Ankles/Feet		
5	**When did you first notice the pain or discomfort-**	**Yes**	**No**
	Recently?		
	Months ago?		
6	Have you had this pain or discomfort in the last 7 days?		
7	Do you think pains are related to the school furniture design?		
8	Do you feel pain on your knee when sitting at school desk in classroom?	1. yes 2. no	
9	Do you feel comfortable on your sore joints when sitting at chair in classroom?	1. yes 2. no	

10	Do you feel fatigue during class work?	1. yes 2. no
11	Are your legs being at right angles while sitting?	1. yes 2. no
12	Does your sitting position when working in classroom disrupt your concentration and attention in class?	1. yes 2. no
13	Is your back straight and supported by the chair-back when sitting in classroom?	1. yes 2. no
14	Are your shoulders relaxed when sitting on a chair in classroom?	1. yes 2.no
15	Have you ever complained to the teacher about the discomfort of the furniture you use in the classroom?	1. yes 2. no
16	Have you ever complained to the classmate about the discomfort of the chairs and desks you use in classroom?	1. yes 2. no

Section two: - Information on a student's academic performance and behavior.

1. Place your pick in the appropriate box. Please try each thing at least once.
    1. Very few
    2. Less than half
    3. Half
    4. More than half
    5. Almost all

No	Item	1	2	3	4	5
1.	How many of your students pay enough attention to the class?					
2.	How many of your students put out sufficient effort to comprehend your explanation?					
3.	How many of your students are well disciplined in the class room?					
4.	How many of your students regularly participate in class?					
5.	How many of your students complete their homework on a regular basis?					
6.	What is the percentage of students who participate actively in class?					
7.	During the teaching-learning process, how many students ask more questions?					
8	How often do your students report of being tired or sick in class?					
9	How many of your students are able to sit comfortably in classroom while you are teaching?					
10	How many of your students, in your opinion, are seated comfortably in the classroom?					

- **Part 4: -Primary school Parent Questionnaire**

Direction 1- Select the appropriate answer

Put the appropriate box that corresponds to your choice. Please attempt all the items

No	Items	Response
1	How many hours does your child sleep at night?	_____Pm to____Am
2	How long does a student sleep during the day?	1.one hour 2.two hour 3.more than three hours
3	Do your children feel special pain when they are at home?	1.yes 2. no
4	Which part of the body do they feel pain in?	1. knee joint 2. shoulder 3. elbow 4. others
5	What do you think is the cause of this pain?	1. nutrition of food 2. classroom chairs 3. climate of classroom 4. others
6	What do you think is the solution of this pain?	1. Adjust their diet/nutrition 2. Adjusting school seats/classroom chairs 3. Physical activity 4. Treatment 5. Other

7	How often has your child experienced physical pain or discomfort?	1. Most of the time 2. Some of the time 3. not sure
8	What level of satisfaction do you feel your child has had with his or her family relationships?	1. Very few 2. Less than half 3. Half 4. More than half 5. Almost all
9	How often does your child participate in physical activities?	1. Most of the time 2. Some of the time 3. not sure
10	What was the level of emotional anxiety or concern for each of their body's physical health?	1. Most of the time 2. Some of the time 3. not sure
11	Do you assume the discomfort of the classroom furniture/school desk is the source of this emotional reaction?	1. Yes 2. No
12	How often do you believe your child is cheerful after class?	1. Most of the time 2. Some of the time 3. not sure
13	How often does the child become ill, and has there been any diagnosis for at least three years?	1. Most of the time 2. Some of the time 3. not sure
14	How much time does your child have for schoolwork or social activities?	1. Most of the time 2. Some of the time 3. not sure

- **Part 5: Questionnaire on Eating Habits and Dietary Information**

Direction: 1 Select the appropriate answer

No	Items	Select one answers
1	How many times do you eat on a daily basis?	1. Less than one meal a day 2. One meal a day 3. Two meal a day 4. Three meal a day 5. Greater than three meals
2	How often do you eat Breakfast?	1. Daily 2. Sometimes 3. Never
3	How often do you eat Lunch?	1. Daily 2. Sometimes 3. Never
4	How often do you eat Snack?	1. Daily 2. Sometimes 3. Never
5	How often do you eat Dinner?	1. Daily 2. Sometimes 3. Never
6	How often do you eat Fast foods?	1. Daily 2. Sometimes 3. Never
7	Hours spent with sleeping?	1. Less than six hours a day 2. Six to nine hours a day 3. Greater than nine hours a day

Data collection table for Anthropometric measurement of students. (Unit/cm)

No	Name of school	Grade	Age	sex	Stature	Sitting height	Sitting elbow height	Sitting shoulder height	Thigh clearance	Knee height	Popliteal height	Buttock-popliteal length	Hip width	Eye height	Buttock knee length	Forearm hand length	
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Data collection table for classroom chairs and desks

No	School desk/combination chair dimension	Unit /cm		
		School 1	School 2	School 3
1	Desk height			
2	Desk depth			
3	Desk length			
4	Desk slope			
5	Bench height			
6	Bench length			
7	Bench depth			
8	Footrest height			
9	Distance between desk and bench			
10	Thickness			

Images during data collection

Goro

Kidist Tereza

Sabian No 1

Interview with students

Measuring the Anthropometric dimension of students

Arranging Anthropometric data of students on paper

APPENDIX 2

An anthropometric body measurement of three selected primary schools with age ranges (5 to 8).

No	Age	Gender	S	SH	SHE	SSHH	TC	KH	PH	BPL	HW	EH	BKL	FAHL
1	5	M	108	54	39	42	7	32	25	26	20	50	34	26
2	5	M	116	55	40	42	6	35	24	28	22	48	35	28
3	5	M	117	54	39	45	7	38	28	30	24	53	40	27
4	5	M	118	56	39	46	8	40	25	34	20	48	40	29
5	5	M	119	55	60	46	9	42	32	30	22	55	45	32
6	5	M	120	68	65	55	6	40	30	35	21	50	46	30
7	5	M	116	57	45	52	9	45	32	28	23	58	43	29
8	5	M	108	54	40	43	9.5	35	25	28	22	48	35	27
9	5	M	117	55	45	45	7	38	28	26	22	50	35	26
10	5	M	116	54	39	42	7	32	25	28	22	50	34	26
11	5	M	117	56	40	46	9	40	30	30	21	53	35	28
12	5	M	117	58	60	55	9.5	42	33	36	24	55	40	30
13	5	M	116	57	60	52	7	40	32	34	23	53	40	29
14	5	M	117	56	55	46	8	41	30	35	24	50	40	29
15	5	M	120	54	40	43	9	38	28	28	21	50	35	28
16	5	M	118	55	45	45	7	38	25	30	22	48	34	29
17	5	M	120	56	50	45	8	41	30	30	23	53	35	30
18	5	M	117	57	55	52	8	42	32	35	23	55	40	32
19	5	M	119	58	55	52	9	43	33	37	20	58	43	30
20	5	M	118	59	60	55	8	45	34	38	21	59	45	32
21	5	M	119	58	55	52	7	41	32	35	24	58	42	29
22	5	M	120	57	50	45	6	40	30	30	25	55	40	27
23	5	M	119	56	50	45	9.5	42	32	34	20	53	35	29
24	5	M	122	55	45	46	9	43	32	36	23	58	43	30
25	5	M	117	57	55	45	8	41	32	35	22	55	42	29
26	5	M	118	57	55	46	9	42	30	30	22	50	40	28
27	5	M	108	55	45	45	8	41	30	35	23	55	42	29
28	5	M	117	54	40	43	9	42	32	36	20	58	43	30
29	5	M	121	56	50	46	8	40	28	34	21	58	42	29
30	5	M	117	57	55	46	9	41	30	35	24	55	42	30
31	5	M	117	55	45	45	7	40	28	28	24	53	40	29
32	6	M	117	57	55	52	9.5	43	32	36	22	58	42	30
33	6	M	117	58	60	46	9	41	30	35	22	58	42	29

34	6	M	116	59	65	52	9.5	40	28	34	22	55	43	28
35	6	M	120	67	70	55	9.5	43	33	37	24	58	40	30
36	6	M	118	68	65	58	8	45	34	36	24	60	43	29
37	6	M	118	56	50	46	9	38	25	30	23	50	42	30
38	6	M	119	57	55	52	9.5	40	28	28	21	50	40	29
39	6	M	117	58	60	45	8	41	30	35	20	55	40	29
40	6	M	117	59	65	52	9	42	32	36	22	58	42	32
41	6	M	122	67	70	55	9.5	42	30	34	23	55	43	29
42	6	M	116	55	45	42	6	35	28	30	22	53	43	32
43	6	M	118	56	50	43	7	38	25	34	22	55	42	29
44	6	M	119	57	55	45	8	40	28	34	22	58	40	34
45	6	M	118	58	60	46	9	41	30	35	22	55	43	35
46	6	M	117	58	65	52	9.5	42	32	34	22	59	43	32
47	6	M	117	59	65	52	9.5	42	32	35	23	58	43	30
48	6	M	108	56	50	43	7	40	28	34	20	59	42	29
49	6	M	119	57	55	45	8	41	30	34	23	58	43	32
50	6	M	119	58	60	46	9	41	30	35	24	55	42	34
51	6	M	121	59	63	52	9	41	30	34	26	58	40	30
52	6	M	116	68	65	52	9.5	42	32	35	22	53	43	32
53	6	M	116	67	70	55	9	40	28	34	20	55	42	34
54	6	M	117	59	65	52	8	42	32	36	23	58	43	30
55	6	M	108	58	60	46	8	40	28	34	22	59	43	29
56	6	M	117	57	55	45	8	40	28	35	24	60	46	32
57	6	M	118	56	50	43	7	40	28	30	22	58	45	34
58	6	M	118	55	45	43	7	38	25	30	23	55	43	30
59	6	M	120	54	40	43	7	41	30	34	20	55	42	30
60	6	M	118	68	65	52	9	42	32	35	25	58	43	29
61	6	M	120	67	60	46	9	41	30	34	26	55	42	35
62	6	M	118	59	65	52	9	40	28	34	22	59	45	34
63	6	M	116	58	60	46	9	42	32	36	22	59	43	32
64	6	M	122	57	55	45	8	42	32	35	23	58	42	30
65	6	M	122	56	50	43	7	41	30	35	23	55	42	30
66	6	M	118	55	45	42	6	38	25	28	24	53	43	29
67	5	F	121	56	40	43	6	35	24	30	20	50	40	30
68	5	F	119	55	39	42	6	35	24	28	21	53	42	32
69	5	F	120	57	45	42	6	35	24	28	23	53	40	32
70	5	F	117	58	50	43	7	38	25	30	21	50	35	30
71	5	F	118	59	55	45	8	40	28	30	24	53	40	29
72	5	F	121	67	65	52	9	42	32	34	22	53	40	30

73	5	F	118	57	50	43	7	38	25	30	22	55	42	30
74	5	F	116	58	50	43	7	38	25	34	23	58	43	30
75	5	F	116	55	45	42	6	35	24	30	24	55	42	29
76	5	F	117	56	45	42	6	35	24	30	24	53	43	32
77	5	F	118	57	45	42	6	35	24	28	24	55	42	30
78	5	F	116	56	40	43	7	38	25	28	20	53	40	29
79	5	F	117	58	50	45	8	40	28	30	26	55	42	34
80	5	F	117	59	55	45	8	40	28	34	22	58	43	32
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82	5	F	117	59	55	45	8	40	28	30	23	53	40	32
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84	5	F	117	58	45	43	7	38	25	30	23	53	40	30
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94	5	F	117	57	50	43	7	40	32	34	20	53	42	26
95	5	F	117	57	60	46	9	41	33	35	22	55	42	29
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97	5	F	118	57	45	43	7	38	30	35	23	53	42	32
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102	6	F	117	57	50	43	7	38	25	30	25	55	42	27
103	6	F	118	57	55	45	8	40	28	34	24	53	40	29
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105	6	F	119	59	55	45	8	40	28	28	24	53	40	32
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108	6	F	116	55	39	42	6	35	24	30	23	53	42	27
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112	6	F	118	58	50	43	7	38	25	30	26	50	42	27
113	6	F	120	59	45	42	6	35	24	30	24	55	43	27
114	6	F	121	67	60	46	9	41	30	34	25	58	42	29
115	6	F	120	59	55	45	8	40	28	30	23	53	43	28
116	6	F	122	62	65	52	9	42	32	34	23	58	42	28
117	6	F	117	57	45	43	7	38	25	30	25	55	40	29
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119	6	F	119	58	55	45	8	40	28	28	22	55	42	29
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121	6	F	117	57	45	45	8	40	28	30	22	53	42	30
122	6	F	119	59	50	43	7	38	28	28	22	53	42	30
123	6	F	119	58	40	45	8	40	28	28	20	55	42	27
124	6	F	119	67	45	43	7	38	25	26	22	53	42	28
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127	6	F	118	56	45	42	7	38	25	30	22	53	42	27
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129	6	F	118	58	45	42	6	35	25	28	23	55	40	28
130	6	F	119	59	50	43	7	35	25	34	22	58	40	29
131	6	F	121	67	45	42	7	35	24	28	24	53	43	28
132	6	F	122	68	65	52	9	42	32	34	21	58	42	29
133	6	F	119	57	45	42	6	35	25	30	21	55	40	30
134	6	F	119	56	40	39	7	38	25	28	22	53	42	29
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138	6	F	119	59	50	43	7	38	25	34	24	55	43	30
139	6	F	118	57	45	42	6	35	25	35	23	59	42	29
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141	6	F	120	58	50	45	8	40	28	30	22	58	45	32
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143	6	F	118	59	55	45	8	40	28	28	22	53	42	32
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145	6	F	118	68	65	55	9.5	43	33	37	24	65	46	35
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148	6	F	118	56	55	45	9	41	30	35	23	59	45	34
149	6	F	117	57	50	43	7	38	28	30	25	58	45	34
150	7	M	118	55	55	46	7	40	31	33	29	55	39	29

151	7	M	120	60	56	47	8	42	32	34	29	58	38	30
152	7	M	120	62	60	46	9	45	31	35	30	59	41	29
153	7	M	119	55	56	46	7	40	31	34	28	58	39	29
154	7	M	120	62	60	47	8	42	32	35	29	60	41	30
155	7	M	119	62	60	46	7	45	33	35	28	59	43	28
156	7	M	121	68	63	48	8	47	34	37	28	61	45	32
157	7	M	119	65	62	47	7	45	33	36	31	59	41	30
158	7	M	120	70	62	48	8	48	35	38	28	62	45	33
159	7	M	118	68	60	48	9	47	32	36	28	60	43	29
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161	7	M	122	55	55	45	7	40	30	33	29	55	38	29
162	7	M	123	60	56	46	8	40	32	34	28	58	40	29
163	7	M	121	70	60	46	10	42	30	35	29	65	46	32
164	7	M	118	68	56	45	8	40	30	34	31	55	44	29
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166	7	M	121	62	56	45	9	42	32	34	30	58	40	28
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170	7	M	120	68	62	46	7	40	30	33	30	55	43	32
171	7	M	120	70	63	50	9.5	45	32	34	30	60	41	33
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174	7	M	120	62	56	48	9	42	32	34	31	60	44	32
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177	7	M	121	62	56	46	9	45	33	35	29	58	44	29
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179	7	M	120	68	62	47	8	42	31	34	30	61	44	32
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187	8	M	121	62	56	45	8	40	32	34	30	58	44	32
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190	8	M	122	68	62	46	8	40	31	33	31	61	44	29
191	8	M	123	65	60	46	9	42	32	34	30	60	45	32
192	8	M	125	62	56	47	8	45	32	34	28	62	46	29
193	8	M	122	60	56	46	7	42	31	33	29	60	43	29
194	8	M	119	60	55	45	7	40	30	33	30	59	43	32
195	8	M	125	62	56	46	8	40	31	33	31	58	41	29
196	8	M	121	65	60	45	9	42	32	34	29	61	44	33
197	8	M	122	68	62	46	9.5	45	33	35	30	60	41	30
198	8	M	118	68	63	47	9	42	31	33	30	62	40	32
199	8	M	119	68	62	48	8	40	31	33	32	65	44	29
200	8	M	118	65	60	48	7	38	32	34	32	63	45	28
201	8	M	118	62	56	46	9	42	31	33	29	61	44	32
202	8	M	119	62	56	46	8	40	31	33	31	60	43	30
203	8	M	120	60	56	45	9.5	45	31	33	33	62	45	29
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207	8	M	119	68	62	47	9.5	45	32	34	30	60	43	34
208	8	M	120	65	60	47	9	42	31	33	30	59	41	33
209	8	M	119	68	62	46	9.5	45	32	34	30	61	45	30
210	8	M	121	70	63	45	9	42	31	33	29	60	43	29
211	8	M	120	65	62	46	8	40	31	33	28	59	41	29
212	8	M	121	62	60	45	7	40	32	34	29	58	45	32
213	8	M	119	60	60	47	9	42	33	35	33	60	43	29
214	8	M	120	55	56	46	7	38	31	34	30	62	41	32
215	8	M	122	60	60	48	7	42	31	34	29	62	40	30
216	8	M	120	62	56	47	9	42	31	33	30	60	44	29
217	8	M	120	65	60	46	8	40	31	33	29	59	43	33
218	8	M	121	68	62	45	7	38	31	33	29	59	41	30
219	8	M	123	65	60	45	7	40	31	34	28	58	44	29
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222	8	M	120	65	60	46	9.5	45	32	34	29	59	41	29
223	8	M	122	68	62	46	9	42	32	34	29	59	41	34
224	8	M	120	70	63	47	8	40	30	34	31	58	44	34
225	7	F	122	68	62	48	9.5	45	31	35	29	61	41	33
226	7	F	121	65	62	47	9	47	32	35	29	60	43	33
227	7	F	119	62	60	46	9.5	45	32	35	31	59	40	30
228	7	F	121	60	56	45	9	42	32	34	30	58	41	32

229	7	F	118	68	62	47	10	45	34	36	31	60	43	32
230	7	F	120	70	65	50	9	48	34	37	29	62	44	29
231	7	F	122	55	56	43	7	42	32	33	28	55	38	28
232	7	F	119	62	60	46	8	45	33	35	30	58	38	29
233	7	F	120	68	65	48	9.5	47	34	36	31	60	40	30
234	7	F	121	70	63	47	9.5	45	34	36	30	59	40	30
235	7	F	122	70	63	47	10	47	35	37	30	59	40	32
236	7	F	120	70	63	48	9	42	33	35	29	60	43	33
237	7	F	119	68	62	47	9.5	45	34	36	29	61	43	30
238	7	F	121	65	60	47	10	47	33	35	30	61	43	30
239	7	F	119	68	62	47	9.5	48	35	37	31	62	41	32
240	7	F	122	62	56	46	9	47	35	36	30	60	40	30
241	7	F	121	65	60	46	9.5	48	34	37	29	59	40	33
242	7	F	122	62	56	46	9.5	47	35	38	31	62	43	30
243	7	F	122	68	62	45	9	48	35	37	32	61	41	32
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245	7	F	121	65	60	47	9.5	50	34	35	30	62	43	29
246	7	F	123	68	62	46	9.5	47	33	35	31	61	41	32
247	7	F	124	65	60	45	9.5	45	34	36	31	60	43	33
248	7	F	118	62	56	47	9	45	35	36	30	60	41	32
249	7	F	119	62	56	46	8	47	34	37	28	59	41	33
250	7	F	119	65	60	47	9.5	45	33	36	29	59	43	33
251	7	F	123	60	55	46	9	42	33	36	28	60	41	34
252	7	F	122	55	56	45	9.5	47	34	35	29	61	40	32
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254	7	F	122	65	60	46	9.5	45	34	36	28	59	39	30
255	8	F	120	68	62	47	9	42	35	37	30	60	41	30
256	8	F	122	70	63	47	10	45	34	36	30	61	43	29
257	8	F	122	70	63	48	10	47	35	37	28	60	41	32
258	8	F	118	68	62	47	9.5	45	34	36	29	59	40	30
259	8	F	118	65	60	46	9	45	33	35	31	61	43	33
260	8	F	119	65	60	48	9.5	45	32	34	28	60	41	33
261	8	F	120	68	62	48	9.5	47	34	36	28	59	40	30
262	8	F	120	65	60	47	9.5	45	32	35	30	60	43	33
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264	8	F	122	62	56	45	10	45	35	37	28	61	44	32
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266	8	F	123	60	55	47	9.5	47	33	36	30	59	41	30
267	8	F	119	65	60	46	9	42	32	35	29	60	40	29

268	8	F	121	68	62	48	8	42	34	36	29	59	43	32
269	8	F	124	70	63	47	8	42	35	37	28	59	41	35
270	8	F	124	68	62	47	7	42	33	35	29	60	40	34
271	8	F	125	65	60	48	6	40	32	34	30	59	43	32
272	8	F	121	62	56	47	8	42	33	35	29	58	41	30
273	8	F	122	60	55	46	8	45	32	34	28	59	40	33
274	8	F	120	60	55	48	9	42	34	36	29	59	43	30
275	8	F	122	62	56	48	9.5	45	33	35	30	58	41	30
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277	8	F	121	68	62	46	9.5	45	34	36	31	60	43	30
278	8	F	121	68	62	45	9	42	33	35	28	59	41	32
279	8	F	118	65	60	45	8	42	32	34	29	55	40	33
280	8	F	125	62	60	46	9.5	45	33	35	30	58	40	32
281	8	F	125	68	62	45	8	40	32	34	30	59	41	30
282	8	F	120	62	56	47	9	47	33	35	29	61	43	29
283	8	F	121	62	56	48	9	45	34	36	28	60	41	33
284	8	F	123	60	55	45	9.5	45	35	37	29	60	40	34
285	8	F	121	65	60	47	9	45	34	36	31	61	43	33
286	8	F	119	68	62	48	9.5	45	33	35	28	60	40	35
287	8	F	119	70	63	48	10	47	32	34	29	59	43	34
288	8	F	119	68	62	47	9	45	32	34	29	59	40	33
289	8	F	120	65	60	47	9	45	34	36	28	58	40	32
290	8	F	120	62	56	46	9.5	42	32	34	28	61	43	32
291	8	F	123	60	56	46	9	47	32	34	28	55	39	29
292	8	F	119	62	56	46	9	47	33	35	30	60	41	29
293	8	F	119	60	56	46	9	47	32	35	29	59	43	29

Dimensions of currently in use school furniture (school bench/combination chair) in three selected primary schools

Classroom furniture	Parts of Classroom furniture dimensions	The existing furniture dimensions in selected primary schools (in CM)		
		Private schools	Government	
		Kedest Tereza	Sabian No 1	Goro
School desk/ combination chair	Desk height	74	75	75
	Desk depth	28	29	29
	Desk length	110	110.5	110.3
	Desk slope			
	Bench height	70	70.4	70.5
	Bench length	119	120	120
	Bench depth	24	24.5	24.5
	Footrest height	2.5	3	3
	Distance b/n desk and bench	22.5	23	23
	Thickness	2.5	2.5	2.5

Currently use classroom furniture/school bench