KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

FACULTY OF RENEWABLE NATURAL RESOURCES

DEPARTMENT OF WOOD SCIENCE AND TECHNOLOGY

ASSESSING THE ERGONOMIC IMPACT OF FURNITURE DESIGN ON THE HEALTH OF STUDENTS

CASE STUDY: AGONA SENIOR HIGH TECHNICAL SCHOOL

By

Ernest Boampong.

November, 2012

ASSESSING THE ERGONOMIC IMPACT OF FURNITURE DESIGN ON THE HEALTH OF STUDENTS

CASE STUDY: AGONA SENIOR HIGH TECHNICAL SCHOOL

By

Ernest Boampong, B.Ed. (Hons.)

A Thesis submitted to the Department of Wood Science and Technology, Kwame Nkrumah University of Science and Technology in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Faculty of Renewable Natural Resources,
College of Agriculture and Natural Resources

November, 2012

Declaration

I hereby declare that this submission is my own work towards the MSc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

Ernest Boampong (PG 2155808) ……………………

Student Name & ID Signature Date 13-3-13

Certified by:

Prof. Nana Kwasi Frimpong Mensah …………………… 14.3.13

Supervisor(s) Name Signature Date

Certified by:

Mr. Jonny Osei Kofi …………………… 14th March 2012

Supervisor(s) Name Signature Date

Certified by:

Dr. Charles Antwi Boasiako ……………………

Head of Dept. Name Signature Date

Abstract

This study has implications for designers because classroom furniture is an important facility that helps to provide a conducive, comfortable and functional classroom environment for students in educational institutions. The comfort and functional utility of classroom furniture depends on its physical design in relation to the physical structure and biomechanics of human body. An observation and evaluation study was conducted to explore the type of furniture used by students in classroom environment and their opinions were drawn on the design. The study also investigated back pain experienced by 17-22 years old students as they were exposed to the ill-designed classroom furniture which was a physical factor in schools. Students selected were given questionnaire to obtain information on their background, back pain, discomfort/complaints and satisfaction with classroom furniture. A digital weighing scale was used to measure the weight of students. Graduation scales in centimeters to measure the heights of students were indicated on the cardboard and pasted on the wall in the classrooms where the study was conducted. The students were barefooted when measuring their heights. The outcome of the study revealed that one type of furniture, (mono-desk) to seat one student at a time was found in use and the design features and its dimensions were the same. The features like seat width, and height, backrest height, thigh clearance, footrest and lamber support were found to be incompatible to the users. The prevalence rate of neck pain according to class, age, sex, weight, height experienced by students were in high percentages as follows; class - 57.4 to 93.2%: age - 66.7 to 91.6%: sex - 61.7 to 91.7%: weight - 70.4 to 100% and height - 69.9 to 85%. The study found significant association between flexed postures and upper back pain. Static postures neck pain and low back pain were also associated. In using correlation and regression analysis in the study, there was significant association of the backrest shape as a cause of upper back pain at 0.182** (5%). There was also a significant association between students feeling neck pain when sitting on mono-desk at 0.344*** (10%). Finally, the study has implication on students related to musculoskeletal disorders.

Acknowledgements

I wish to express my profound gratitude to my supervisor Nana Professor Kwesi Frimpong-Mensah and Mr. Jonny Osei Kofi for their friendly criticisms and encouragements. My very special tribute goes to Rosina, my wife, my children, Kwasi Owusu Boampong, Kofi Boamah Boampong and Yaw Baafi Boampong as well as my family for their love and continual encouragement and support for my studies. Thanks also goes to the Headmaster, staff and students of Agona Senior High Technical School for kindly provided information from their school and allowing me to record the posture of their students. I also wish to record my thanks and debts of gratitude for the help, prayer and support received from my mother Madam Akua Boamah.

Finally, I have attempted to give references for sources of work by other writers but apologize to any concerned if acknowledgement has inadvertently not been recorded.

TABLE OF CONTENTS

Chapter	Page
Declaration	iii
Abstract	iv
Acknowledgement	v
Table of contents	vi
List of Tables	ix
List of Figures	x
List of Plates	xi
1.0 INTRODUCTION	1
2.0 LITERATURE REVIEW	7
2.1. Ergonomics	7
2.1.1 Meaning of ergonomics	7
2.1.2 Benefits of ergonomics	8
2.1.3 History	9
2.1.4 Ergonomics and maintainability	11
2.1.5 Ergonomics simulation	12
2.1.6 Ergonomics task chair fundamentals	13
2.1.7 Meaning of back pain and classification	15
2.2. Posture in chair	16
2.2.1 Bad posture	16
2.2.2 Bad posture the cause of back pain	16
2.2.3 Perfect posture	18
2.2.4 Good posture	19
2.3. Seating ergonomics	20
2.4. Design innovations	21
2.4.1 The dynamic chair	21

2.4.2 Dynamics of sitting 22

2.4.3 Classroom furniture and postural alignment 24

2.4.4 Classroom sitting posture and neck pain 25

2.5 The origin of desk 26

3.0 MATERIALS AND METHODS **27**

3.1 Materials 27

3.2 Methods 27

3.2.1 Choice of study sites 27

3.2.2 Sample and study design 28

3.2.3 Observation method 29

3.3 Measurement of body dimensions of students 31

3.3.1 Popliteal height 31

3.3.2 Buttock-popliteal length 32

4.0 RESULTS **33**

4.1 Socio-demographic information 33

4.2 Design features of MONO-DESK and its compatibility to users needs 33

4.3 The design of mono-desk 35

4.4 Pictorial drawing 38

4.5 Response to questionnaire 39

5.0 DISCUSSION **46**

5.1 The compatibility of furniture to the user needs 46

5.2 Measurement of body dimensions of students 47

5.3 The prevalence of back pain according to sex 48

5.4 The prevalence of back pains 49

5.5 Regression Analysis 50

5.5.1 Regression analysis of the causes of back pain 50

5.5.2 Regression analysis of the student's satisfaction with furniture 50

5.5.3 Regression analysis of students on the complaints of back pain 51

5.5.4 Classroom sitting

6.0 CONCLUSION AND RECCOMMENDATIONS 52

6.1 Conclusion 52

6.2 Recommendations 53

LITERATURE CITED 54

LIST OF PLATES 57

APPENDICES 62

LIST OF TABLES

Table		Page
4.1	Comparison between popliteal height, buttock-popliteal length and clearance.	36
4.2	Furniture (mono-desk) parts with dimensions.	37
4.3	Prevalence of neck pain, upper back pain and low back pain according to age, sex, weight, height, class, as a result of using the mono-desk.	39
4.4	Satisfaction of furniture characteristics according to age, sex, weight, height and class.	40
4.5	Correlation and regression analysis of students satisfaction and their demographic characteristics	41
4.6	Correlation and regression of the causes of back pain and students demographic characteristics.	42
4.7	Causes of back pain according to age, sex, weight, height and class.	43
4.8	Correlation and regression of student's complaints of back pain and their demographic characteristics.	44

LIST OF FIGURES

Figure		Page
2.1	Bad sitting posture	17
2.2	Perfect sitting posture	18
2.3	Good sitting posture	19
3.1	Classroom plan	30
3.2	Posture showing popliteal height AB	31
3.3	Posture showing buttock popliteal length	32
4.1	Mono-desk used by students at Agona Senior High Technical School.	34
4.2	Exploded view of mono-desk furniture used by students of Agona Senior School.	35

LIST OF PLATES

Plate		Page
1	Student with the neck flexed.	57
2	Student with trunk unsupported.	58
3	Plump student sitting in mono-desk	59
4	Student with neck rotated.	60
5	Student with trunk rotated.	61

CHAPTER ONE

1.0: INTRODUCTION

Ergonomics issues among students are not documented widely compared to other issues such as air pollution, water pollution, H1N1 influenza and other hazards in schools (Chakrabarti, 1997). School furniture is among several factors that may contribute to musculoskeletal pain among students in Senior High Schools in Ghana. In the classroom, students often sit in poor posture with trunk, back and neck flexed or rotated even for longer period of time.

According to Webster's Medical Dictionary (2003) ergonomics, as an Applied Science is concerned with the characteristics of people that need to be considered in designing things that they use in order that people and things will interact most effectively and safely. Taking ergonomics as an Applied Science to its natural conclusion, ergonomically classroom chairs would refer to classroom chairs that enable students to sit in a manner that eliminates (or at least relieves) musculoskeletal stress and therefore help them to learn more effectively. This might sound simple but it is most definitely not. Each and every student has different needs; some have longer legs and others have shorter legs. So in order for classroom chairs to be really and truly ergonomic, they would have to be ergonomically designed in terms of shape, but also completely adjustable height, seat tilt, back tilt, and armrests.

Such chairs do exist of course. We see them all the time in office settings. Secretaries, receptionists, computer technicians and even CEO's use them as a matter of course. It has been obvious for a long time now that people in these capacities, who have to sit for long period of time much of it in front of a computer, absolutely must have chairs that will provide proper musculoskeletal support. If not, they might suffer from chronic back pain, headaches, stiff neck, shoulder pain and host of other problems.

No comprehensive study or research has been done in ergonomics in Ghana which develops interest in technology of furniture design based on the biomechanics of the human body and furniture related problems among students in Senior High Schools. Wayside designers are not applying principles for the design and construction of classroom chairs and tables in Senior High School because the furniture designed do not fit all students. Almost all the furniture designed and used in schools do not conform to standard due to lack of knowledge in ergonomics during designing and construction (Chakrabarti, 1997). We may assume that the problem exists at workplaces only but the problem also exists in Senior High Schools in the Sekyere South District in Ghana. Students will be at special risk for suffering negative effects from badly designed and ill-fitting furniture owing to the prolonged period spent seated during school.

The classroom is a formal environment for learning. A conducive and comfortable classroom environment motivates the students to perform better and encourage the learning process. A study conducted by Chakrabarti (1997) found that the seating furniture adapted to body dimensions increase the learning effectiveness. Care should be taken to see that the furniture is designed appropriately to suit the student's anthropometries. It should permit space for flexible movements of the body, provide place for all the educational activities. The students of Senior High Schools spend considerable time of their daily life (about 5-8 hours per day) in school. They spend 80% of the time in the classroom performing various activities such as reading, writing, drawing and other related activities which require them to sit continuously for long hours (Savanur *et al.,* 2004). Also students sit in classroom chairs for close to 80% of their time Chakrabarti (1997). Much of that time is spent reading and writing as well as in front of computers. In addition, it is the school where students acquire permanent habit of sitting (Troussier *et al.,* 1994).

Students aged 18 and even lower are more susceptible to chronic musculoskeletal disorders than adults, since their bones are still in the development stage (Legg *et al.,* 2003). Also students complain of pains around their neck, low back and upper back and concentration of impairments are all negative effects which result from prolonged sitting (Savanur *et al., 2004*). These pains also have substantial negative impact on their education and health. Chakrabarti (1997) reported that 29% of 8-17 year olds had back pain often and (Troussier *et al.,* 1994) reported 51% cumulative prevalence of back pain by the age of 20. As a result, a large portion of adult sufferers report a first onset of back pain in their early teenage years or in their 20's (Murphy *et al.,* 2002). However, in the school where the study was conducted, all the furniture were designed by the manufacturers without considering the anthropometric dimensions of the users (students) of different age groups. As an outcome of the study, mono-desk became unsuitable for students, compelling them to adopt awkward posture while attending their classes. Flaws in the furniture used by the students contribute to discomfort and inconvenience, adversely affecting classroom learning activity (Chakrabarti, 1997).

It is against this background that sitting postures in classrooms are being discussed with extent of neck pain, upper back pain and lower back pain experienced by students aged 17-22 years. In order to reduce neck pain, lower back pain and upper back pain among students, the school needs to provide each student with classroom furniture that is 100% ergonomically. Sitting postures performed by students in school can contribute to the development of back pain among them. When postures of the students are compromised with awkward body position then sitting can introduce harm and danger to students' musculoskeletal system (Murphy *et al.*, 2002).

The school would have to pay a lot of money for good quality standard classroom chairs and the school simply cannot afford to invest in classroom chairs that are completely ergonomically. It is difficult to hold students concentration while they are sitting in standard classroom chairs with all these mechanisms, up and down, back and forth tilting, tilting backwards-levers for height, armrests, seat tilt, and back angle, all rest on castors. This will make discipline tough enough for students' concentration while sitting in standard chair.

The first thing the school can do is to supply classroom chairs of varying height for each grade. There is evidence that a large percentage of students are sitting in chairs that are either too high or too low for their height. This leads to feet dangling in the air which increases back pressure or on the other hand, to a crunching of the knee area which enforces bad postures as well as constricting of the leg muscles. If a school has classroom chairs available in number of different heights, then a major problem of student chair mismatch will be solved to minimize back pains on students as a result of bad posture in classroom (Parcells and Stommel, 1999). According to (Legg *et al.,* 2003) mismatch occurs among the students where their furniture in classrooms do not match with their body dimensions and thus, the complained on their buttocks and back pains. The second factor of ergonomic stresses in school environment among students in school is the bad horizontal and vertical movements on their school furniture in class session. Many factors can increase the risk of developing low back pain after exposure to the ergonomics hazards. For the students, str ucturally they are not small and need chairs designed for them to sit for a long period of time without experiencing any back injury (Chaudhary, 2004). Generally, in normal school environment, many factors can influence students sitting postures; these include the anthropometric dimensions of students, the measurements and design features of school furniture (Legg *et al.,* 2003). The idea of total classroom ergonomic might still be out of reach, there are ergonomic features school can look for when purchasing standard classroom chairs while they may not seem significant, these features can make a big difference in helping students to sit in a healthy way as possible.

These features are:

- Waterfall-front seats. These are seats that slope downwards at the edges of seat (like the shape of waterfall) under the knee.
- Lumbar support, or lower back support, an important feature in ergonomic seating. This usually represents itself as a curve in the back of the chair, just above the point where the back and seat come together.
- Flexible back. Look for chairs that have some "give" in the back. This enables students to lean back a bit when they feel the need, alleviating leg and back pressure.

The main objective of the study was:

- To assess the ergonomic impact of furniture on students health.

The specific objectives include.

- To look and measure at the design features of mono-desk and its compatibility to the user's needs.
- To access the complaints from students aged between 17-22 years after sitting on the furniture over specified period of time.

CHAPTER TWO

2.0: LITERATURE REVIEW

2.1: Ergonomics

2.1.1: Meaning of ergonomics

The term ergonomics is derived from two Greek words "ergon" meaning work and "nomoi" meaning natural laws (Wojciech, 1957). Ergonomics study human capabilities in relationship to work demand. Ergonomics is another name for bioengineering. The scientists or engineers who work in the field are called ergonomist or bioengineers.

Ergonomics is the study of the design of objects, systems and environments for their safe and efficient use by people (Garratt, 1995). Ergonomics talks about the science of designing the job, equipment, and workplace to fit the workers. Proper ergonomic design is necessary to prevent repetitive strain injuries, which can develop over time and can lead to long term disability (Chaffiin and Anderson, 1999). The International Ergonomics Association (IEA) defines ergonomics as the scientific discipline concerned with understanding of interactions among human 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. Ergonomics is employed to fulfill the two goals of health and productivity. It is relevant in the design of such things as safe furniture and easy to use interfaces to machines.

2.1.2: Benefits of ergonomic chairs

Ergonomic chairs are chairs that have been specially designed to give the user maximum comfort and convenience. According to Phesant (1986), the following are benefits of ergonomically constructed chairs in classroom to promote conducive learning.

- Ergonomic chairs consider the physical and mental capabilities and limits of the students as they interact with it.
- Ergonomic chairs seek to fit the classroom to the student, not the student to the classroom.
- Many people believe that it is relaxing to sit. But it is actually not so, sitting really exerts great stress on the back because it transfers the full weight of the upper body onto the buttocks and thighs. Sitting, especially, for long period of time, can also cause increase pressure on the intervertebral discs-the springy, shock- absorbing parts of the spine. It's also hard on the lower extremities since gravity pools blood on the legs and feet and creates a sluggish return of blood to the heart. Ergonomic chairs relieve the user of all these symptoms.
- Traditional chairs were not designed with body mechanisms in mind. They therefore produce a lot of discomfort for the body leading to back pain, neck pain, eye strain, abdominal pain, and leg pain and movement disorder. It is for these reasons that we need ergonomic chairs.
- Ergonomic chairs have been manufactured to provide maximum comfort and convenience for the user. They are manufactured after years of research into body movements, skeletal stress and postures that lead to pain and ache. The overall result is improved health and higher productivity.

- Sitting in a static posture will even increase the stress in the back, neck, arm and legs, and add a great amount of pressure to the back muscles and spinal disc. Proper seating in a well-constructed chair can help reduce fatigue and discomfort, increase blood flow, reduce the risk of injury and increase productivity (Bendix, 1984).

The productivity of individual and the quality of their performance can be improved by examining the environment in which they operate and by improving the facilities and support they offer to the user's task. This is what the ergonomics is about. Sitting should be enjoyed; it should not be endured (Bendix and Winkel, 1985). Ergonomic chairs make everyday sitting as an enjoyable activity (Bendix, and Winkel, 1985).

2.1.3: History

The foundation of the science of ergonomics appears to have been laid within the context of the culture of Ancient Greece. A good deal of evidence indicates that Hellenic civilization in the 5th century BC used ergonomic principles in the design of their tools, jobs and workplaces. One outstanding example of this can be found in the description Hippocrates gave of how a surgeon's workplace should be designed (Marmaras *et al.*, 1999). The term ergonomics first entered the modern lexicon (Wojciech, 1957) Jastrzebowski used the word in their 1857 article (The Outline of Ergonomics, Science of Work, and Based on the Truths Taken from the Natural Science). (Marmaras *et al.*, 1999). Later, in the 19th century, Fredrick Winslow Taylor pioneered the "Scientific" Management method, which proposed a way to find the optimum method for carrying out a given task (Wojciech, 1957). Taylor found that he could, for example, triple the amount of coal that workers were shoveling by incrementally reducing the size and weight of coal shovels until the fastest shoveling rate was reached. Frank and Lillian Gilbreth expanded Taylor's methods in the early 1900s to develop "Time and Motion studies". They aimed to improve efficiency by eliminating unnecessary steps and actions (Wojciech, 1957). By applying this approach, then Gilbreth reduced the number of motions in brick laying from 8 to 4.5 allowing bricklayers to increase their productivity from 120 to 350 bricks per hour (Wojciech, 1957).

World War II marked the development of new and complex machines and weaponry, and these made new demands on operations' cognition. The decision-making, attention, situational awareness and hand-eye coordination of the machine's operator become key in the success or failure of a task. It was observed that fully functional air craft, flown by the best-trained pilots, still crashed. In 1943, Alphonse Chaplains, a lieutenant in the U.S Army showed that this so-called "pilot error" could be greatly reduced when more logical and differentiable controls replaced confusing designs in airplanes cockpits (Marmaras *et al.,* 1999).

In the decades since the war, ergonomics has continued to flourish and diversity. The space Age created new human factors issues such as weightlessness and extreme g-forces. The dawn of the Information Age has resulted in the new ergonomics field of human-computer interaction (HCI). Likewise, the growing demand for and competition among consumer goods and electronics has resulted in more companies including human factors (ergonomics) in product design. At home, work, school or play new problems and questions on ergonomic products must be resolved constantly (Marmaras *et al.*, 1999). People come in all different shapes and sizes, and with different capabilities and limitations in strength, speed, judgment, and skills. All these factors need to be considered in the design function. To solve design problems, physiology and psychology must be included with an engineering approach.

2.1.4: Ergonomics and maintainability

Ergonomics specifies as the scientific study of the relationship between man and his working environment. This covers the ambient environment, tools, equipment, methods and organization of work, and in design generally it concerns ease of use with product or an environment for maximum comfort. Ergonomics is also called 'human factors' in the United States and is represented by for example, user friendly computers, chairs and tables in workplaces and schools (Phesant, 1986) .

An indication of a good ergonomic design is often a product when used is obvious to the consumer who will know instinctively how to operate it. This may be due to compatibility with existing standards or just custom and practice. An example could be an increase shown on a dial or indicator being from left to right or rotating clockwise. Another may be the position in which users are to operate. If designing for an international market, cultural stereotypes must to known and incorporated. For example, for electronic light switches in Britain the switch is down for the 'on' position. The reverse is true in the United States and several European countries. These cultural stereotypes could become important in an emergency, when operators may revert to the expected normal operators of a mechanism. An old book, but still the bible of ergonomics is (Wojciech, 1957), which considers all aspects of this important area of design. (Phesant, 1996). An ergonomics relies a great deal on user familiarity it is often more important with static product. However, even with dynamic designs the man or machine interface should be included in the design process. An innovative design that is unfamiliar to users will be more readily accepted if it is obvious how it should be operated (i.e. good ergonomic design) (Phesant, 1986).

Ergonomics and maintainability have been linked, since product that needs maintenance should be designed so that this is as easy as possible. For example, parts that may require placement during the life time of a product should be positioned near the surface of the product and designed for quick and easy access and installation. The design team should consider not only the product but also the user, who needs to perform efficiently and safety at all times. Ergonomic and maintainability can help to provide a competitive edge over companies producing similar products and, therefore, these two disciplines should be considered early in the design of static product. (Phesant, 1986).

2.1.5: Ergonomic simulation

The functioning of a product depends not only as the product itself, but also on the manner in which the user employs it. Designers, therefore, want to know what kind of user behaviour their design provokes for that they can improve their design, if necessary.

As designers never have at their disposal the whole population for which the product is intended, a model of the design is tested on a man model (Zacharkow, 1988). Model is a representation or imitation of ergonomically relevant features of a population. The most important man models used in anthropometric ergonomics are;

- Tables and layout drawings (of work spaces)
- Two- dimensional,
- Computer models of human beings;
- Test subjects

A product models plus a man model provide a behavior model of the ergonomic functioning of the product (Patel and Ogle, 2007). The first three types of models can especially tells us what humans in more or less extreme circumstances can and cannot do, but do (or to a lesser extent) what humans actually do in normal conditions of use, which user faults they make.

2.1.6: Ergonomic task chair fundamentals

There are many basic principles involved in the design of an ergonomic task chair, most of which are very easy to understand. A good chair is important because nowadays most of students spend a good portion of every day working on their tables and chairs or using it for writing (Troussier, 1994). It is hard to ignore that almost everywhere you go you see people sitting in chairs that look cheap, old, flimsy and just plain inadequate for daily use. Investing in the right ergonomic chair will reward students with increase comfort at the classroom and a decreased risk of developing any serious condition in the future (Phesant, 1996).

A high quality task chair will always be available in custom configuration, because we spend huge sums of money on a new chair it is better be customized to your specific body size and shape. The one-size-fits all approach only applies to the less expensive chairs (Parcells and Stommel, 1999). There are few decent manufacturers producing good chairs in varied price. However, one needs to make sure that take some measurements are taken of a users current chair so that it is you know whether or not a larger or smaller need to go with a new one. This refers to the actual dimensions of the seat cushion and the back backrest (or sometimes called the back support).

The materials of the chair are not very important in terms of ergonomics but the firmness of the cushions is sometimes to consider. Sitting on the hardest surface you can handle when you are going to be seated for long periods of time-sometimes referring to a wooden bench as a better alternative than a good ergonomic chair, they cannot always be taken literally but are kept behind the idea is true. It is actually better for your back to sit on a firm surface rather than a really cushy one. Extremely soft chairs may be good for lounging but if you are going to be doing work you need a nice firm seat cushion to help strengthen your back and prevent it from going out of alignment (Zacharkow, 1988). Having arm rests on the chair are almost always optional and it is purely up to your personal preference. However, if you do choose a chair with adjustable arms just be conscious of how often you are resting your forearms on the pads, because too much leaning will cause problem to arise in your neck and shoulders (Bendix *et al.,* 1985).

2.1.7: Meaning of back pain and classification

Back pain is pain felt in the back that usually originates from the muscles, nerves, bones, joints or other structure in the spine (Bendix, 1984). The pain can often be divided into neck pain, upper back pain, lower back pain or tailbone pain. It may have a sudden onset or can be a chronic pain, it can be constant or intermittent, stay in one place or radiate to other areas. It may be a dull ache, or a sharp or piercing or burning sensation. The pain may radiate into the arm and hand, in the upper back, or in the low back, (and might radiate into the leg or foot), and may include symptoms other than pain, such as weakness, numbness or tingling. Back pain is one of humanity's most frequent complaints (Mandal, 1994). The acute low back pain is also called lumbago in U.S, is the sixth most common reason for physician visits. About nine out of ten adults experience back pain at some point in their life, and five out of ten working adult have back pain every year (Patel and Ogle, 2007).

The spine is a complex interconnecting network of nerves, joints, muscles, tendons and ligaments and all are capable of producing pain. Large nerves that originate in the spine and go to the legs and arms can make pain radiate to the extremities. Back pain can be divided anatomically: neck pain, upper back pain, lower back pain or tailbone pain. By its duration: acute (less than 4 weeks), sub acute (4-12 weeks), chronic (greater than 12 weeks).When a person leans into the chair back, there is both a backward and a downward force. The downward force pushes the bottom of the pelvis. Eventually, the sitter finds himself sitting on his tailbone at the edge of the chair with the spine as a whole transformed into a C-shape slouch. Of course the next step is to pick oneself up and lean back into the chair again (Mandal, 1994).

2.2: Posture in chair

2.2.1: Bad posture

2.2.2: Bad posture the cause of back pain

Most back pain is caused by bad posture while sitting. Even though bad posture may not cause any discomfort, continual poor posture will in the long term cause back pain (Back Care by Health Education Bureau, USA). Most population in the world adopts "C" position when seated at a desk (Galen, 1998). Sitting in the "C" position put tremendous pressure on the spine. This is due to basic engineering principles which states that bending something stiff creates stress in the object being bent. The more the object is bent out of position the greater the stress.

Diverse evidence from many cultures show that sitting has been associated with numerous problems: back pain of all sorts, fatigue, varicose veins, stress and problems with the diaphragm, circulation digestion, elimination, and general body development. Ergonomic researchers believe if they could only invent the perfect chair, all this would be solved. According to Grieco (1998), no amount of ergonomic thinkering can correct the classic right-angle seated posture which is intrinsic in chairs. The problem with chairs, according to Grieco, 1998 and other radical 'somatic' practitioners who practice new ergonomics is that we have been forced into a table and chair culture, where many activities take place in a right-angled seated position. This position forces the body into a C-shape slump and this places uneven pressure on the vertebral disks of the lower back. With time, the spine can become deformed and erode disks. When a person leans into the chair back, there is both a backward and a downward force. The downward force pushes the bottom of the pelvis. Eventually, the sitter finds himself sitting on his tailbone at the edge of the chair with the spine as a whole transformed into a C-shape slouch. Of course the next step is to pick oneself up and lean back into the chair again.

Figure 2.1: Bad posture in a chair.

2.2.3: Perfect posture

Perfect posture is that position of the seated spine when the pressure on the intervetebral disc is least. Every spine has its own unique shape. When this shape is preserved the posture is perfect. However, the human spine was not designed to be seated, and perfect posture is nearly impossible to attain for long periods (Well and Reaney, 1997). It must be supported. In engineering terms the spine is a vertical flexible column that becomes flawed when seated (Legg *et al.*, 2003). It needs correct support, and this is precisely what spinal system – S provides.

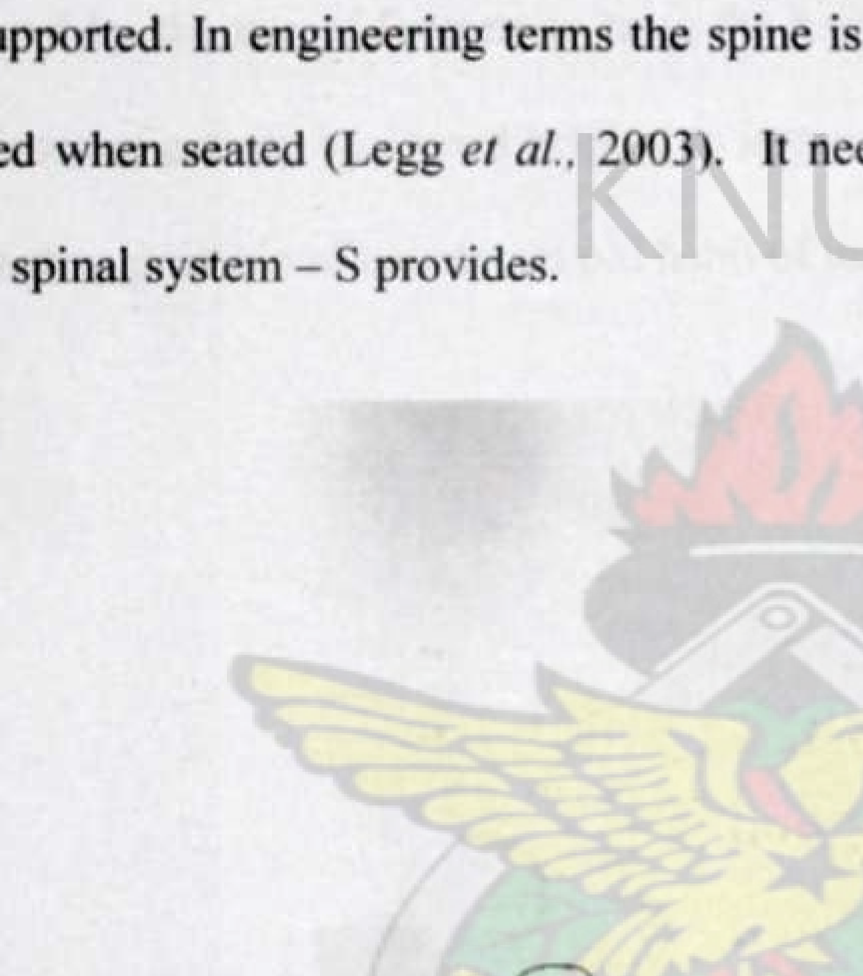


Figure 2.2: Perfect posture.

Source: Chaffin, D and Anderson, G (1999)

2.2.4: Good posture

According to Back Care by Health Education Bureau in U.S.A, to get relief or prevent damaging your spine, you must take immediate steps to reduce your spinal pressure by sitting correctly with your spine in its natural curved "S" position. Good Posture is the most important way of preventing back pain (Legg *et al.*, 2003). This is systematically achieved by the use of footrest to raise the height of the knees and effectively changes the centre of gravity backward helping to improve the sitting posture. Also sit as close to the desk as possible to counteract old habit of bending forward over the desk.

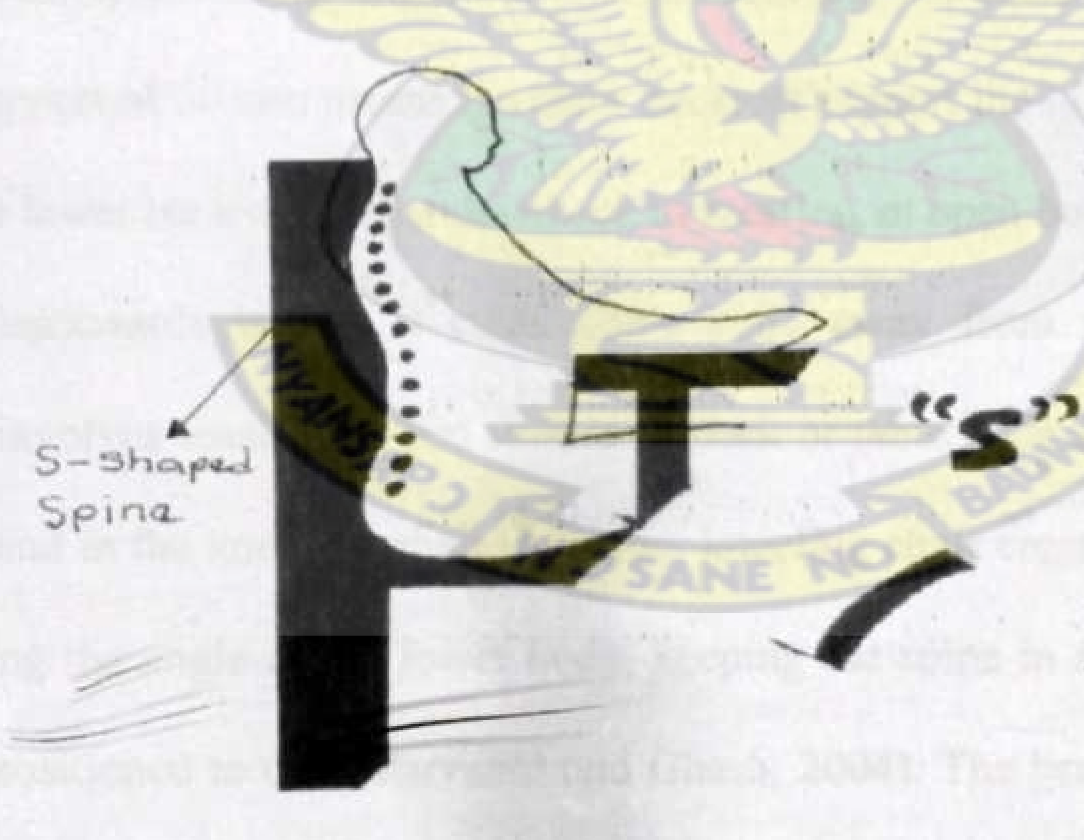


Figure 2.3: Good posture

Source: Chaffin, D and Anderson, G (1999).

2.3: Seating ergonomics

According to Taimela *et al.,* (1997), the best way to reduce pressure in the back is to be in standing position. However, there are times when you need to sit. When sitting the main part of the body weight is transferred to the seat. Some weight is also transferred to the floor, back rest, and arm rests. Where the weight is transferred is the key to a good seat design. If the proper areas are not supported, sitting in a seat all day can put unwanted pressure on the back causing pain. The lumber (bottom five vertebrate in the spine) needs to be supported to decrease disc pressure. Providing both a seat back that inclined backwards and has a lumber support is critical to prevent excessive low back pressure (Kansi and Knight, 1977). The combination which minimizes pressure on the lower back is having a backrest inclination of 120° and a lumber support of 50 mm. The 120° inclination means the angle between the seat and the backrest should be 120°. The lumber support of 50 mm means the chair backrest support the lumber by sticking out 50 mm in the lower back area. One drawback to creating an open body angle by moving the backrest backwards is that it takes one's body away from taking position, which typically involves leaning inward towards a desk or table. One solution to this problem can be found in the kneeling chair. A proper kneeling chair creates the open body angle by lowering the angle of the lower body, keeping the spine in alignment and the sitter properly positioned to task (Parvanur and Ghash, 2004). The benefits of this position is that if one leans inward, the body angle remains 90° (degrees) or wider. One misperception regarding kneeling chairs is that the body's weight bears on the knees, cannot use the chair. This misperception has led to a generation of kneeling chairs that attempt to correct this by providing a horizontal seating surface with an ancillary knee pad. This design wholly defeats the purpose of the chair. In a proper kneeling chair, some of the weight bears on the shins, not the knee, but the primary function of the shin rests (knee rests) are kept one from falling forward out of the chair. Most of the weight remains on the buttocks. Another way to keep the body from falling forward is with saddle seat. This type of seat is generally seen in some sit stand stools, which seek to emulate the riding or saddle position of a horseback rider, the first "job" involving extended periods of sitting.

Another key to reducing lumber disc pressure is the use of armrest. They help by putting the force of your body not entirely on the seat and backrest, but putting some of this pressure on the armrest. Armrest needs to be adjustable in height to assure shoulders are not overstressed.

2.4: Design innovation

2.4.1: The dynamic chair

Murphy *et al.,* (2004) highlighted the predominant postures assumed by students while working at their desks. Kane *et al.,* (1998) interpreted that fixed position chair would meet less than 30% of the postural support requirements of students. The design would need to allow for the backwards tilt on the backrest part of the chair when students are leaning back (reading the board, watching the teacher) while still providing support when sitting up straight and that allowed the seat surface to tilt forward to support the student leaning whilst forward working at the desk. Existing school chairs that attempt to meet these needs generally comprise a pivoting shell with seat and backrest in one piece. In the reclining position these create upward pressure under the thigh, equivalent to having a seat too high, which causes discomfort leading to inattentiveness among students. The proposed solution was to have seat and back pivot separately, enabling genuine relief of pressure on the legs in both reclining and forwarded seat position (Zacharkow, 1988). This will allow the user to move seamlessly from one position to another without making it necessary to move the chair itself. Briethecker *et al.,* (1999), provided analysis of the physiological and pedagogical benefits of furniture that moves or can be adjusted to meet different postural requirement of students working within a classroom. In October, 2003 at an education conference in Hobart, Tasmania, Dr. Dieter Briethecker delivered a presentation on his work Posture and Movement, Wiesbaden, in Germany (Briethecker *et al.,* 1999). His studies found physiological and educational benefits of movement during class time compared to the 'static' classroom pattern that predominates internationally. He affirms that when students are forced to maintain a fixed posture as with conventional education furniture the need to be uneasy and move constantly to be comfortable in the furniture. This presentation confirmed the validity of the design concept. This challenge was then to provide a method of flexion for both seat and back surface that was functional, robust and cost effective.

2.4.2: Dynamics of sitting

The harmful effects of improper classroom furniture on the spine have been known for long time (Zacharkow, 1988). In order to understand the dynamics of sitting, the study of the mechanics of the relevant body parts and the external support must be involved.

For instance, 75% of the total body weight is supported by only (260 mm^2) of the surface when sitting (Parcells and Stommel, 1999) .This small area is under the ischial tuberosites of the pelvis. The heavy load concentrated in this area result in high compressive stresses estimated at 85-100 pounds per square inch (psi) (Tichauer, 1978). The tuberosites form only a two-point support system which is not stable since the centre of gravity of a seated person's body above the seat may not be directly over tuberosites (Braton, 1989). In view of this, the seat alone cannot stabilize the seated person, hence, the use of the legs, feet and back in contact with other surfaces, as well as muscular forces necessary to produce equilibrium (Braton, 1989). Leg support is critical to distribute and reduce buttock and thigh load. Feet need to rest firmly on the floor or foot support so that the lower leg weight is not supported by the front part of the thighs resting on the seat (Chaffin and Anderson, 1999).

If the major weight is placed on the ischial tuberosities and the proximal half of the posterior thighs, seat support should occur under and anterior to the ischial tuberosities (Babbs, 1979). To maintain the weight bearing over the anterior to the ischial tuberosities, sacral and pelvis support are needed to prevent backward rotation of the pelvis and posterior curve (lumbar kyphosis). Lumbar lordosis, the normal anterior curve of the lumbar vertebrae helps to transfer some of the weight (as much as 25%) over the posterior thighs (Zacharkow, 1988). Since flattening of the lamber curve and posterior rotation of the pelvis occur when hips flex and the trunk-thigh angle narrows. Keegan (1973) recommended that chairs with a rearward sloping backrest as a means of achieving a minimum trunk-thing angle of 105°. Studies of sitting posture which evaluate postural accommodation of seats with forward slope angles have found that with increasing forward slope, the spine moves toward lumbar lordosis (Bridge *et al.*, 1989). Bendix, (1984) noted that the body's adaptation takes place in the spine and two thirds in the hip joints on the forward inclined seat

2.4.3: Classroom furniture and postural alignment

Classroom furniture from manufacturers is not typically designed to accommodate the dimensions of the individual user. 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 (Personal communication, 2009). Instead, a one-size-fits philosophy has been adopted in the industry, because such furniture is less costly to manufacture and easier to sell at a lower price. Manufacturers of furniture for schools were asked what research they based on for their furniture designs. The responses were that they did not rely on any. Instead, they based their designs on their own specification. The only things they considered were the seat width and belly room. These manufacturers main concern was to sell furniture not to safety of customers. Existing designs have basically been unaltered for years (Mandal, 1994).

There are costs involved in products that do not reflect designs based on properly selected anthropometric data and ergonomics. Improper designs will make sitting to require greater muscular force and control to maintain stability and equilibrium. This in turn, results in greater fatigue and discomfort and likely to lead to poor postural habits as well as neck and back complaints. Most important for students, musculoskeletal stress resulting from efforts to maintain stability comfort seating may make for a restless individual a condition not conducive to focused learning. Good posture facilitates lung expansion and reduces organ crowding and strain and soft bones, tendons and muscles (Chaffin and Anderson, 1979). Schools and health care providers at times implement health care education programmes in an effort to introduce young people to health-promoting and health protecting behaviours, proper seating rarely gets the attention it deserves.

2.4.4: Classroom sitting posture and neck pain

Students spend long hours of sitting while reading, writing and looking on the chalkboard in the classroom (Phesant, 1986). They often study in prolonged hours in awkward and static postures in the classroom. Students often sit in poorly designed and awkward desk arrangements. Awkward desk arrangements and prolonged sitting in classroom may cause muscles and other soft tissues to become stretched or shortened compared to normal (Mandal, 1994). Muscles may be overworked or become constantly contracted. Blood and lymph flow may be constricted. Soft tissue may become inflamed. Nerves may even get irritated. Pain from poor or prolonged postures may present headaches, neck and low back pain, upper back pain and pain in shoulder. Neck pain from poor posture in classroom is due to neck flexion and neck rotation in the classroom due to the students position in the classroom when watching the chalkboard (Mandal, 1994). Once the head is flexed forward or rotated, when watching the chalkboard, the vertebrae do not support the weight of the head as muck Bendix, (1984).

2.5: The origin of desk

The desk was first appeared in William and Mary show room from 1689 to 1702, furniture in England along with distinctive serpentine stretcher (Walton, 1974). This revolution in desk design resulted from the use of walnut in place of oak (the William and Mary is sometimes referred to ("The Age OF Walnut") in the construction of their designs including desk. Walnut was first used to construct desk because it was much easier than oak to work with hand tools. Another name for the desk was writing desk. It was popular pastime and several types' writing desks were made. It was first design in the form of writing box mounted on a stand (sometimes four legs), the hinged slant top opened out to form writing surfaces (Walton, 1974). According to oral history it was brought to Ghana by various missionaries, who established schools in Ghana. Initially, the desk was constructed differently from the chair, but couples of years ago; due to the extinction timber the country forest designers combined the desk and the chair together to seat 1 to three students/pupils in schools (Walton, 1974).

CHAPTER THREE

3.0: MATERIALS AND METHODS

3.1: Materials

The materials and equipment which were used for the study were digital weighting scale, mono-desk, and tape measure. The weighing scale was used to measure the weights of students to determine the average weight of the target population of students. The tape measure was used to measure the dimensions of the mono-desks to know the different sizes of mono-desks in the school. The mono-desks were used by students to observe the different sitting postures in the classroom.

3.2: Methods

3.2.1: Choice of study sites

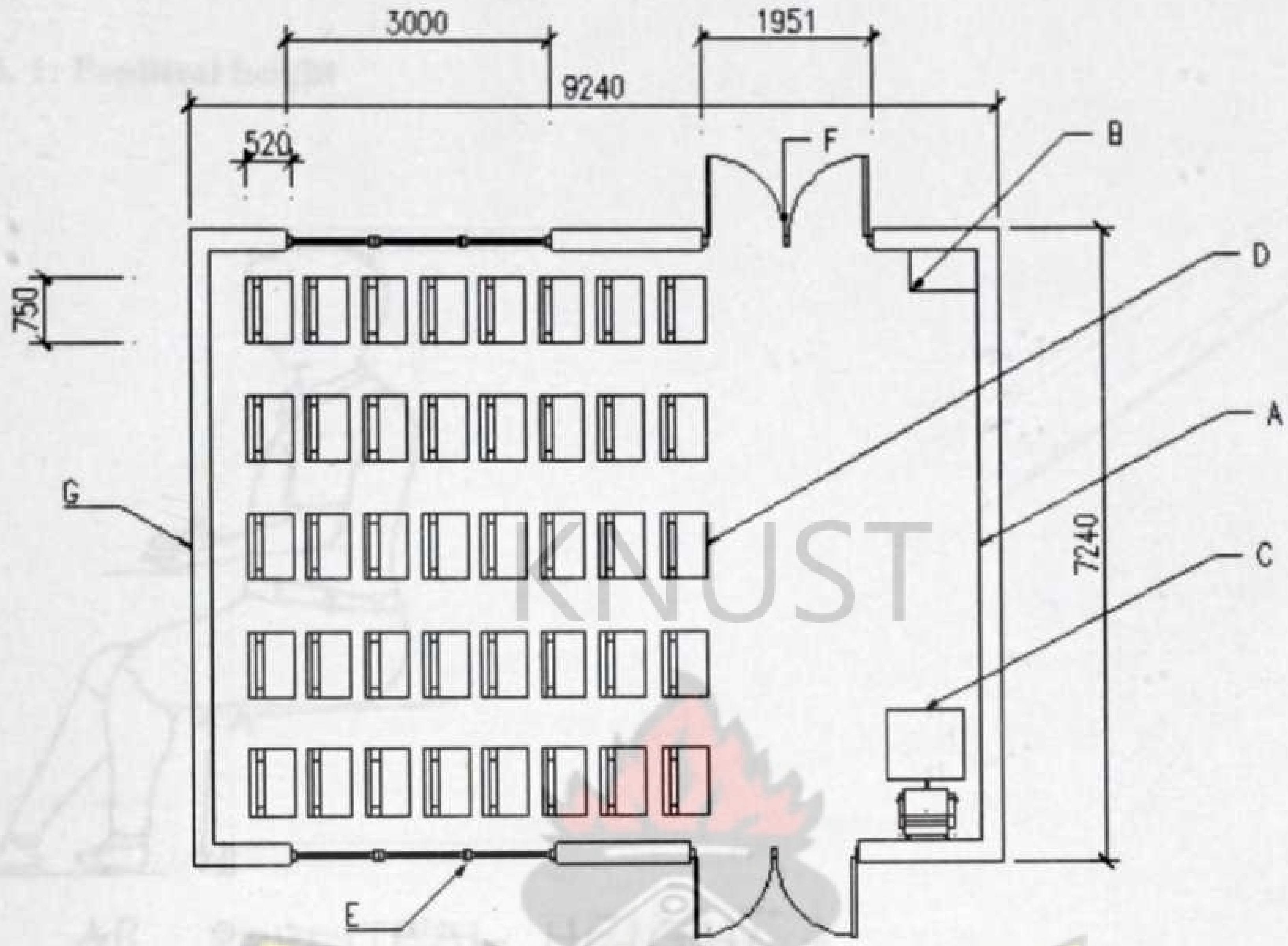
The study was carried out at Agona Senior High Technical School in Sekyere South of Ashanti Region in Ghana. The school was selected because it assembles mono-desks for students to use in classrooms Permission to conduct the study was granted by the school authority. Feasibility studies were carried out at the school to indicate the availability and type of furniture used by students. Students were briefed about the research with the option to withdraw at any stage. The lottery method was used to select various classes for the study. In this, names all classes in SSS 2 and SSS 3 were written on pieces of paper, put in a bowl thoroughly mixed and picked by students one after the other. In SSS 2, four classes were selected by students namely Visual 2, Technical 2, Agric 2 and 2 Arts 1. In SSS 3 four classes were also selected 3 Arts I, Agric 3, Visual 3 and 3 Arts 2. A systematic random sampling method was used to choose the target population of 120 students. If the population can be accurately listed (finite population); the systematic sampling method is used to select a random sampling (Agyedu *et al.*, 2007). The study selected 120 students from a population of 482 students. The sample interval was 2. The first person selected corresponded to the student numbered 1 on the class lists not written in alphabetical order, and then every second student in each interval of one student was thereafter selected. The classes which were used for the study were SSS 2 and SSS 3. Averagely, 15 students were sampled from each class.

3.2.2: Sample and study design

The age of the students was between 17 and 22 years of age. For this purpose 120 students were selected at random (n = 120). The subjective evaluation of the health problem of the students was made by questionnaire technique. Students sat on mono-desks and their pictures were taken to obtain plates for the study. Postural analysis of the students during normal classrooms lessons were made by video-photographic method as well as direct observation methods. The postural patterns of the students in relation to the school furniture were studied while they attended classes by video photographic method. The video records were then transferred to computer, and the postural changes were analyzed after superimposing time on it. Careful and repeated observations were made for minimizing errors.

3.2.3: Observation method

The main features of 150 mono-desks were observed and measured to determine the variations/differences in the sizes of the furniture. Direct observation of students in the classroom was considered the most suitable methods to use in school to record posture (Murphy *et al.,* 2004.A detailed health and lifestyle questionnaire was distributed and measurement of height and weight was recorded. The questionnaire was distributed after the observation was complete. The questionnaire was based on the Standard Nordic Questionnaire (SNQ) (Kourinka *et al.,* 1987). The questionnaire included a diagram of a body part divided into neck, upper back and lower back so as to assist students in identifying the right body map when answering the questions. Also all the students participated in the measuring of their weights and heights during Physical Education lessons. The main features of 120 mono-desks were measured to determine the variation differences in the sizes of the furniture.



All dimensions in millimeters

Scale, 1:50

Figure 3.1: Classroom plan

KEYS

A-Chalkboard
B-Cupboard
C-Teacher's table and desk
D- Mono-desk
E-Window
F-Double door
G- Back wall

3. 3: Measurement of body dimensions of students

3. 3. 1: Popliteal height

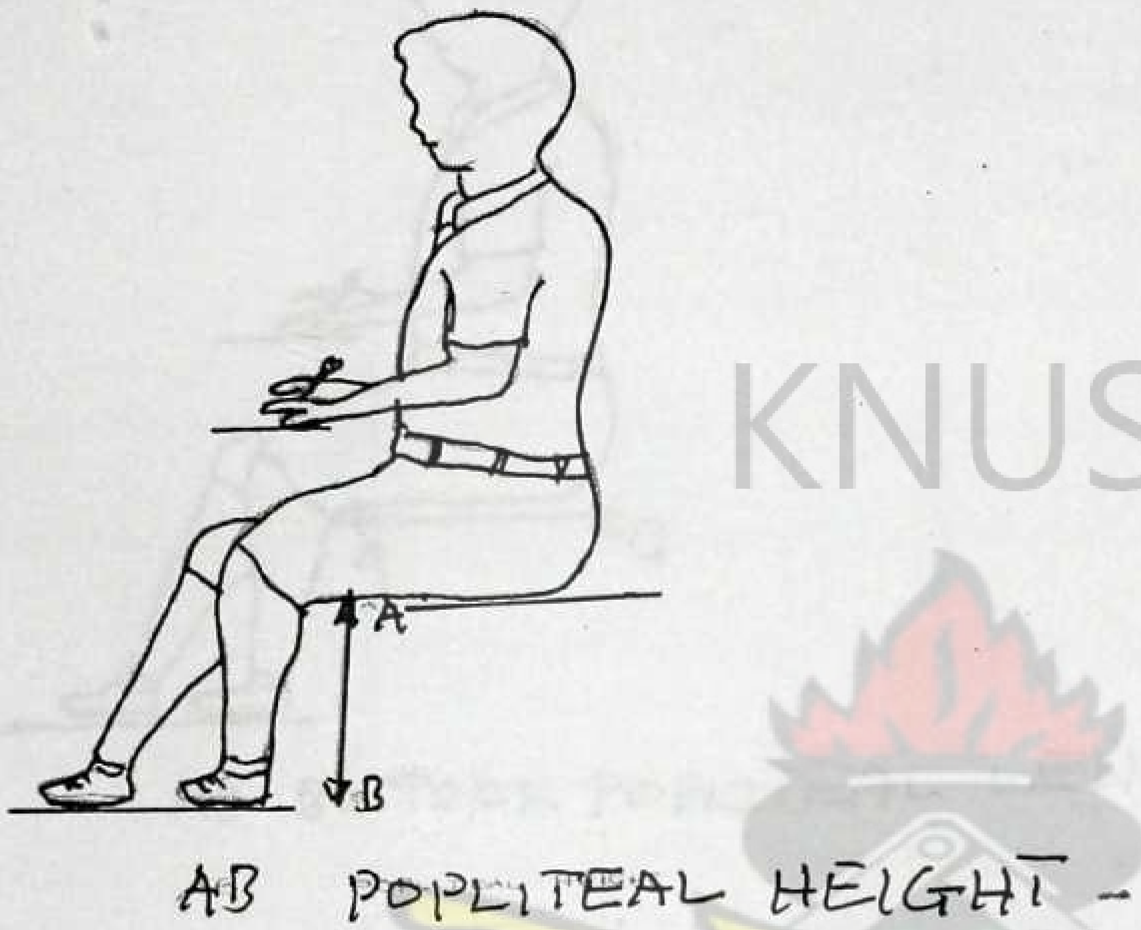


Figure 3.2: A student posture showing popliteal height AB.

Popliteal height is the distance, taken vertically with 90° knee flexion, from the foot resting surface to the posterior surface of the knee or popliteal space. Students sat erect on a seat, feet on the floor, knees were flexed 90° and the thighs parallel. The vertical distance from the floor to ~~the lateral~~ underside of the left thigh at a point contiguous to where the tendon of the biceps femoris muscle joins the lower leg was measured.

3. 3. 2: Buttock popliteal length

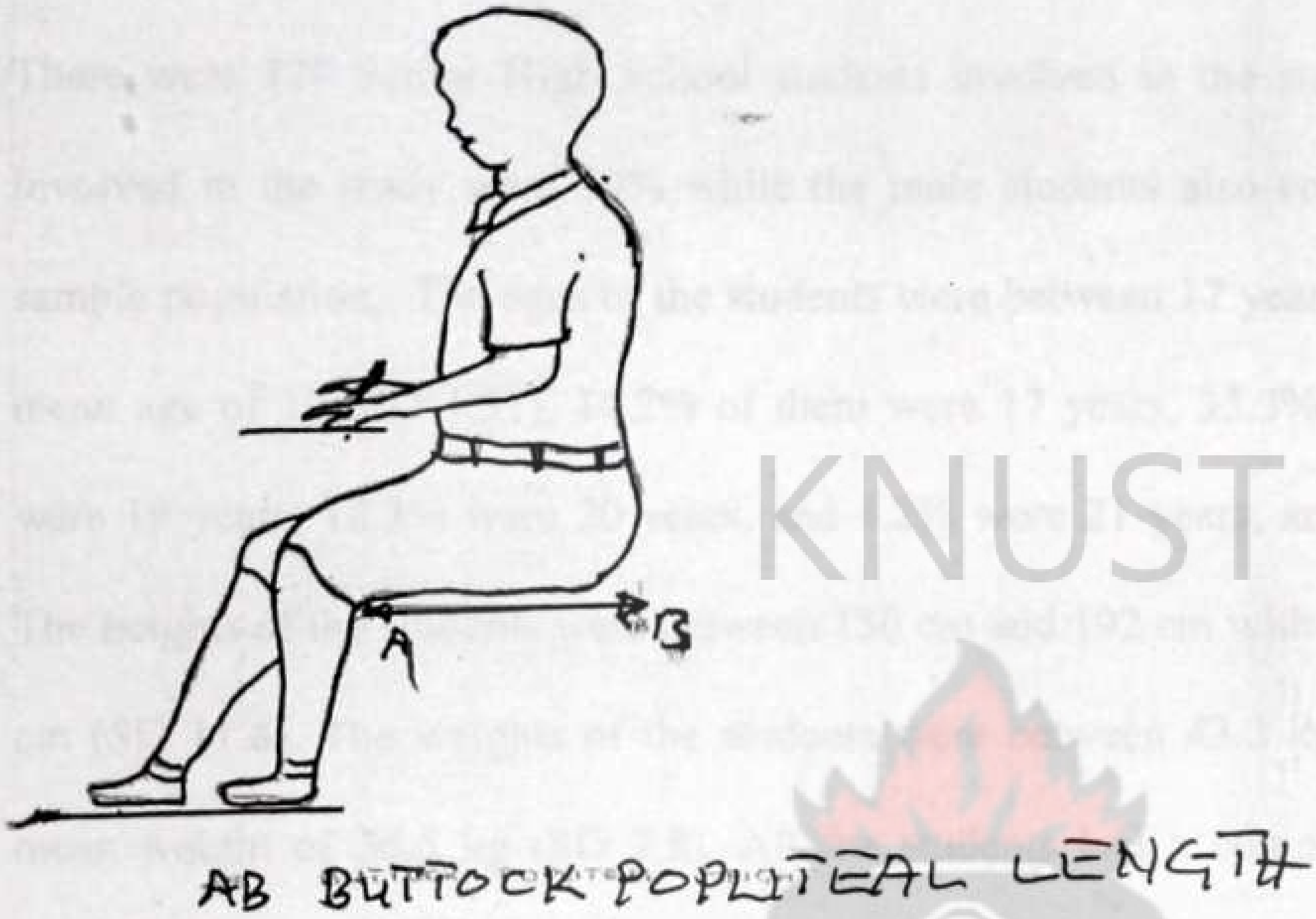


Figure 3.3: A student posture showing buttock popliteal length AB.

Buttock-popliteal length is the horizontal distance from the posterior surface of the buttock to the posterior surface of the knee or popliteal space. Students were told to sit erect on the mono-desk with kneel flexed at 90° and thighs parallel. The horizontal distance from the most posterior aspect of the left buttock to the posterior surface of the knee was measured with tape measure with tape measure.

4.0 RESULTS

4.1: Socio-demographic information

There were 120 Senior High School students involved in the study. Female students involved in the study were 50% while the male students also constituted 50% of the sample population. The ages of the students were between 17 years and 22 years with a mean age of 19 (SD 1.31). 14.2% of them were 17 years, 33.3% were 18 years, 25% were 19 years, 18.3% were 20 years, and 4.2% were 21 years, and 5% were 22 years. The heights of the students were between 150 cm and 192 cm with a mean height of 169 cm (SD 11.8). The weights of the students were between 43.3 kg and 92.1 kg with a mean weight of 56.6 kg (SD 7.8). All the students had a complete data set with no missing values, thus response rate was 100%. From the observation in the school, it was found that mono- desks made of table and chair combinations were used in the school.

4.2: Design features of mono-desk and its compatibility to users' needs.

After measuring the sizes of the furniture, it was determined that there were no variations in sizes of the furniture. The chair cum desk was a combined unit to seat one student. The desk had 15° inclination instead of 10° which was not facilitating writing and the chair had a backrest with an angle of 95° instead of 100° to 120° which was not also facilitating relaxed sitting. The height of the backrest was low to relax students. The pictorial drawing illustration of the mono-desk found in the study is shown in Figure 4.1.

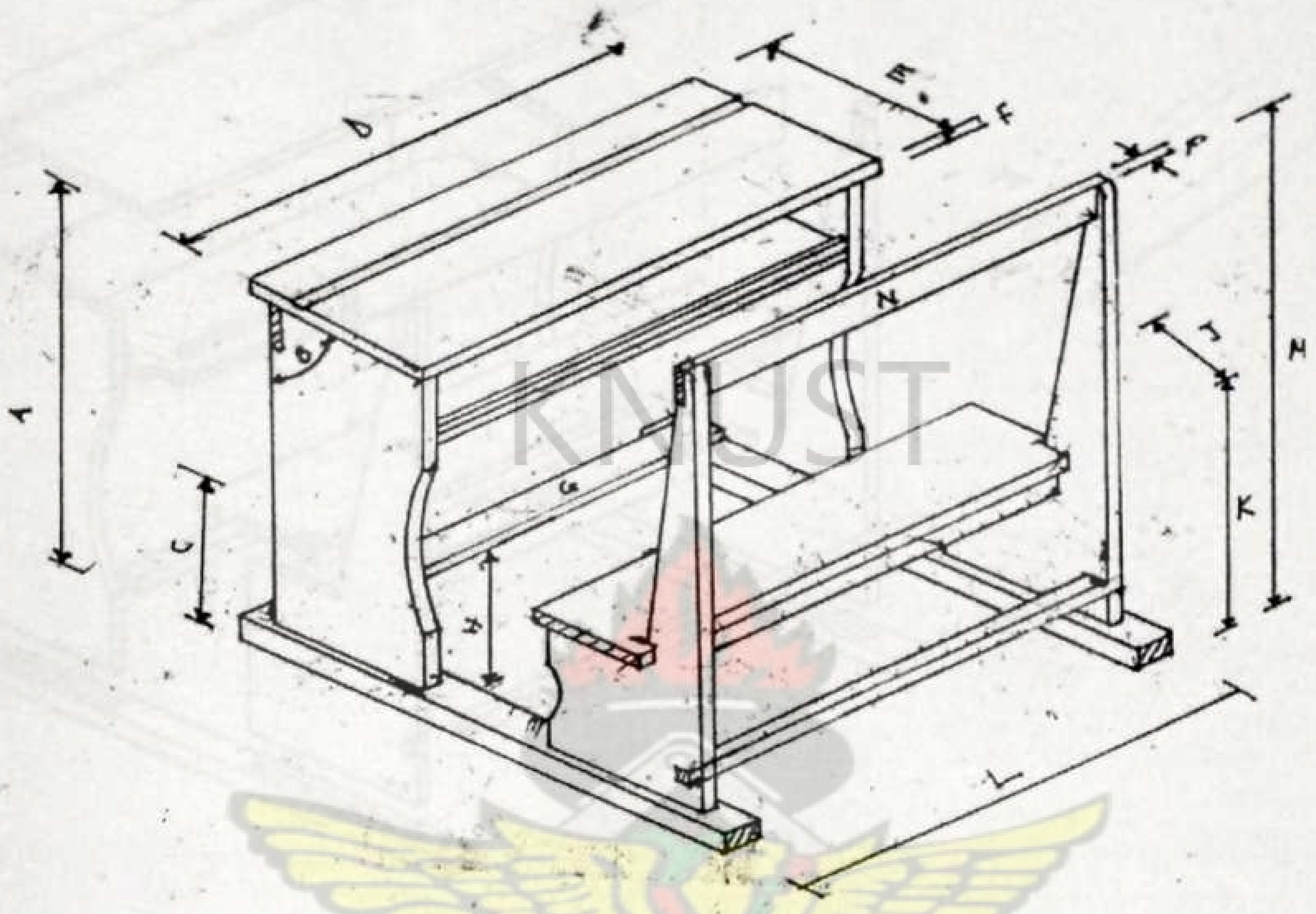


Figure 4.1: The mono-desk used by students of Agona Secondary Technical School.

Desk dimensions

A...Height of desk
B...Inclination of top and side
C... Desk Clearance
D...Width of desk
E...Depth of desk
F...Thickness of desk
G...Footrest
H...Height of footrest

Chair dimensions

K...Height of seat
L… Width of chair
M...Height of chair
N...Backrest
P...Pan Thickness
J...Depth of seat

4.3: The design of mono-desk

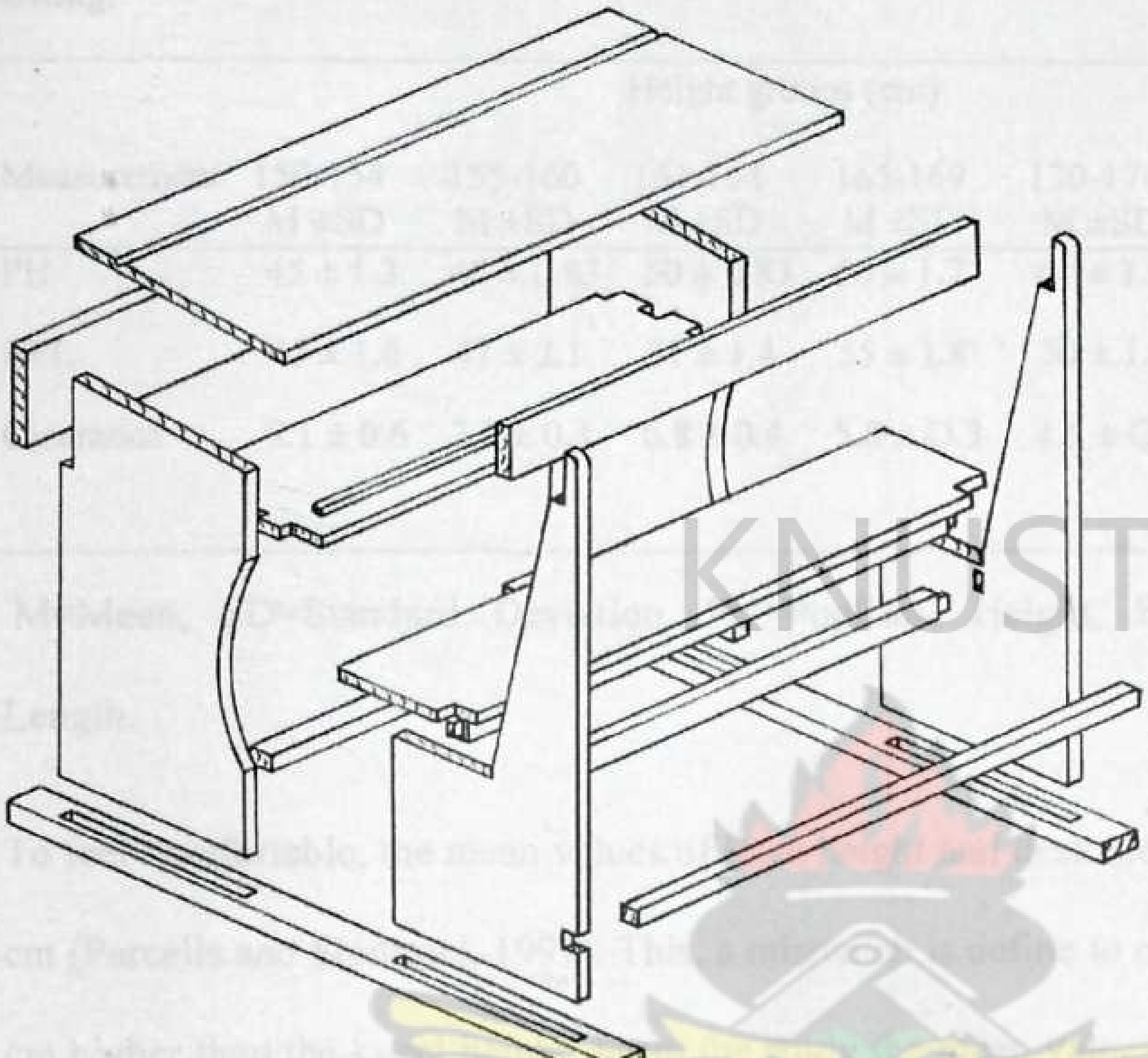


Figure 4.2: An exploded view of furniture used by students of Agona Secondary Technical School.

4.1: Comparison between Popliteal height, buttock popliteal length and clearance for sitting.

	Height groups (cm)						
Measurement	150-154 M ±SD	155-160 M ±SD	161-164 M ±SD	165-169 M ±SD	170-174 M ±SD	175-179 M ±SD	180-181 M ±SD
PH	45 ± 1.3	48 ± 0.83	50 ± 0.83	56 ± 1.7	61 ± 1.3	62 ± 2.1	62 ± 2.5
BPL	45 ± 1.6	47 ± 2.1	51 ± 1.4	55 ± 1.8	50 ± 1.8	61 ± 1.3	61 ± 0.4
Clearance	9.1 ± 0.6	7.8 ± 0.3	6.8 ± 0.4	5.8 ± O.3	4.5 ± O.3	3 ± 0.5	2.3 ± 0.2

M=Mean, SD=Standard Deviation, PH=Popliteal Height, BPL=Buttock Popliteal Length.

To feel comfortable, the mean values of knee height and desk clearance should exceed 2 cm (Parcells and Stommel, 1999). This, a mismatch is define to occur when a desk is < 2 cm higher than the kneel height. From the study the mean values of clearance for sitting on the desk exceeded 2 cm for all height groups. The mean values of the clearance dimensions of the students are found to increase from the tallest height of 181 cm to the shortest height of 150 cm of the study. The mean value for the shortest height clearance was 2.3 cm and increased to 9.1 cm for the shortest height.

Table 4.2: Furniture (mono-desk) parts with dimensions

Furniture parts	Dimensions (mm)
Chair height	470
Chair depth	210
Backrest height	300
Desk height	785
Desk depth	320-330
Desk top slope	15°

The information given on Table 4.1 on furniture dimensions that emerged out of physical observation showed no variations in dimensions. With regard to the opinions of students it can be noticed that in case of chair height that was above 470 mm, 70% expressed it as uncomfortable as it was not able to facilitate the foot to rest on the floor while sitting straight. Regarding the chair width 500 mm-530 mm, 60%-70% of students expressed, it was wide for complete body support of all users. A majority (70%) felt it was to be very uncomfortable with seat depth of 210 mm as the seat supports only part their buttock. Regarding the desk, majority of students who used the desks with height of 785 mm felt it was very uncomfortable. With the depth of the desk 320 mm-330 mm and the width between 530 mm-550 mm expressed comfortable because it was convenient to reach and spread reading and writing materials. The desk had a provision to keep books and among the students, 80% expressed it to be comfortable. 90% of students expressed comfortable with the smooth surfaces, edges and round corners. All the desks had footrest above 50 mm from the ground and a majority felt it was very high and 80% opined it as uncomfortable when the foot rest on it so they preferred to rest their foot on the ground.

4.4: Pictorial drawing

In addition to the working drawings an isometric drawing is made (using instruments) of the article. The pictorial drawing shows enough of the front, one side and the top of the article to indicate how the shapes or parts are related and fitted together. An exploded isometric drawing of the article is useful; the construction of the mono-desk can be seen immediately, the members being shown in their relative positions are ready for assembling. Exploded views are frequently used to illustrate the details of joints.

4.5: Response to questionnaire.

Table 4.3: Prevalence of neck pain, upper back pain and low back pain according to age, sex, weight, height and class as a result of using the mono-desk

	Neck pain		Upper back pain		Low back pain	
	Yes	No	Yes	No	Yes	No
Age						
17-20	13(12%)	95(88%)	6(9.8%)	15(13.9%)	55(92.2%)	6(9.8%)
> 20	8(66.7)	4(33.3%)	11(91.6%)	1(8.3%)	1(8.3%)	11(91.1%)
Sex						
Male	37(61. %)	23(38.3%)	50(83.3%)	10(16.7%)	47(78.3%)	13(21.7%)
Female	54(90%)	6(10%)	55(91.7%)	6(8.3%)	52(86.7%)	8(13.3%)
Weight (kg)						
40-59	37(61.7%)	21(29.6%)	62(87.3%)	9(26.7%)	58(81.7%)	13(18.3%)
60-69	27(75%))	12(25%)	23(79.3%)	6(20.07%)	33(86.6%)	6(15.4%)
>70	10(100%)	0(0%)	9(90%)	(0%)	10(100%)	0(0%)
Height (cm)						
100-160	22(81.5%)	5(18.5%)	22(81.5%)	5(18.5%)	23(85.2%)	4(14.8%)
> 160	65(69.9%)	28(30.1%)	82(88.2%)	11(11.8%)	78(83.9%)	15(16.1%)
Class						
SSS 2	35(57.4%)	26(42.6%)	49(80.3%)	12(19.7)	54(88.5%)	7(11.5)
SSS 3	52(88.1%)	7(11.9%)	55(93.2%)	4(6.8%)	47(79.7%)	12(20.3%)

From Table 4.3, neck pain, upper back and low back pain recorded high prevalent rate among students aged between 17 years and 20 years. In the students aged above 20 years also recorded 91.6% for upper back pain and 91.1% for low back pain while neck pain recorded 66.7% prevalent rate. In sex, female students recorded 91.7% prevalent rate of upper back pain followed by 90% and 86.7% of neck pain and low back pain respectively, while male students had low prevalent rates as compared to female students. In weight, students who weighed between 40-59 kgrecorded prevalent rate of 61.7% for neck pain, while 87.3% and 81.7% were the prevalent rates for upper back pain and low back pain respectively. Also students who weighed between 60-69 kghad a prevalent rate as high as 84.6% low back pain. The prevalent rates of 75% and 79.3% were recorded for neck pain and upper back pain respectively.

Table 4.4: Satisfaction with furniture characteristics according age, sex, weight, height and class.

	Backrest shape		Height of mono-desk		Classroom furniture	
	Yes	No	Yes	No	Yes	No
Age						
17-20	13(12%)	95(88%)	6(9.8%)	15(13.9%)	55(92.2%)	6(9.8%)
> 20	8(66.7)	4(33.3%)	11(91.6%)	1(8.3%)	1(8.3%)	11(91.1%)
Sex						
Male	5(8.3%)	55(91.7%)	3(5%)	57(95%)	3(5%)	57(95%)
Female	18(13.3%)	52(86.7%)	12(20%)	48(80%)	4(6.7%)	56(93.3%)
Weight (kg)						
40-59	9(12.7%)	62(87.3%)	12(16.9%)	59(83.1%)	4(5.6%)	67(94.4%)
60-69	4(10.3%))	35(89.7%)	3(7.7%)	36(92.3%)	3(7.7%)	36(92.3%)
>70	(0%)	10(100%)	(0%)	10(100%)	(0%)	10(100%)
Height (cm)						
100-160	4(14.8%)	23(85.2%)	4(14.8%)	23(85.2%)	1(3.7%)	26(96.3%)
> 160	9(9.7%)	84(90.3%)	11(11.8%)	82(88.2%)	6(6.5%)	87(93.5%)
Class						
SSS 2	5(8.2%)	56(91.8%)	6(9.8%)	55(90.2)	6(9.8%)	55(90.2)
SSS 3	8(13.6%)	51(86.4%)	9(15.3%)	50(84.7%)	1(1.7%)	58(98.3%)

From Table 4.5, it indicates whether students are satisfied with the characteristic of furniture used in the classroom. It was noted that a high percentage of students generally expressed dissatisfaction with the backrest shape and the height of the table. From the table, students expressed total dissatisfaction of the mono-desk used in the school.

Table 4.5: Correlation and Regression analysis of students satisfaction and their demographic characteristics

Variables	Correlation coefficient (Pearson´s R)
Are you satisfied with the backrest shape?	
(All the students)	0.86 NS
Are you satisfied with backrest shape?	
(The height of students)	0.069 NS
Are you satisfied with the height of the mono-desk?	
(The weight of students)	0.038 NS
Are you satisfied with the height of mono-desk?	
(The height of students)	-0.168*
Are you feeling comfortable with classroom furniture?	
(All the classes)	-0.173*
Are you feeling comfortable with classroom furniture?	
(The height of students)	0.049 NS

[The level of significance of the correlation coefficient values are as follows:

*=significance at 0.1, (1%) and NS = not significant]

The results in Table 4.5 indicated a strong negative correlation of students satisfaction with the backrest shape according to the height of students was negative significance (i.e.-0. 069). There was also strong negative correlation of students dissatisfaction with the height of mono-desk according to students heights in classes was negative significance at (i.e. -0.168*). This implies that there was a strong dissatisfaction with the height of the mono-desk. Also there was a strong disapproval of students not feeling comfortable with classroom furniture was negative significance at (i.e. - 0.173). The correlation of students satisfaction with backrest shape of mono-desk according to students in the classes, students satisfaction with backrest shape of mono-desk according to the weight of students and students comfortability with furniture according to students height were positive but not significant with values 0.86, 0.038 and 0.049 respectively.

Table 4.6: Correlation and Regression analysis of causes of back pain and students demographic characteristics

Variables	Correlation coefficient (Pearson's R)
Backrest shape causes upper back pain? (All the classes)	0.109 NS
Backrest shape causes upper back pain? (The height of students)	0.128 NS
Backrest shape causes upper back pain? (The weight of students)	0.182**
Lesson length causes low back pain? (All the classes	-054NS
Lesson length causes low back pain? (The height of students)	-0.029 NS

[The level of significance of the correlation coefficient values are as follows: ** = significance at 0.05 (5%) and NS = not significant]

From Table 4.7, the correlation coefficient obtained of the causes of back pain and students demographic characteristics indicated, backrest the cause of upper back according to the weight of students had a significant value (i.e. 0.182). However, the backrest shape, the cause of upper back pain according to the height of students was negatively insignificant (i.e. - 0.128) but backrest shape the cause of upper back pain to students in the classes had the positively not significant (i.e. 0.109). There were negative insignificant values of lesson length causing low back pain to students in all the classes and lesson length causing low back pain according to the heights of students had values (i.e.-0.054 and -0.029), respectively.

4.7: Causes of back pain according to age, sex, weight, height and class

	Backrest causes upper back pain				Lesson length causes lower back				Trunk flexion > 20° is the cause neck pain				Height of mono-desk is the cause of lower back pain			
	SA	A	D	SD	SA	A	D	SD	SA	A	D	SD	SA	A	D	SD
Age																
17 to 20	79	23	4	4	86	15	4	3	73	25	6	4	65	27	9	7
> 20	9	3	0	0	12	0	0	0	9	3	0	0	7	3	1	1
Sex																
Male	37	18	2	3	45	1	1	3	34	1	5	2	34	16	3	7
Female	51	5	2	1	53	4	3	0	48	9	1	2	38	14	7	1
Weight (kg)																
40 to 59	54	12	3	1	55	12	3	1	45	19	5	2	42	19	7	3
60 to 69	26	10	1	2	33	3	1	2	29	8	0	2	22	9	3	5
>70	8	1	0	1	10	0	0	0	0	0	1	0	0	0	0	0
Height (cm)																
100 to160	22	3	1	0	22	2	2	1	20	5	0	2	18	3	3	3
≥160	66	20	3	4	76	13	2	2	62	23	6	2	54	27	7	5

[SA = Strongly Agree, A = Agree, D=Disagree, SD= Strongly Disagree.]

Table 4.8: Correlation and Regression analysis of students complaints and their demographic characteristics

Variables	Correlation coefficient (Pearson's)
Do you feel neck pain when sitting on a mono-desk?	
(All the classes)	0.344***
Do you feel neck pain when sitting on a mono-desk?	
(The height of student)	-0.008 NS
Do you feel neck pain when sitting on a mono-desk?	
(Sex of students)	0.243***
Do you feel upper back pain when sitting on the mono-desk?	
(All the classes)	0.190**
Do you feel upper back pain when sitting on the mono desk?	
(The height of students)	0.10NS
Do you feel low back pain when sitting on the mono-desk?	
(Sex of students)	0.160*
Do you feel low back pain when sitting on the mono-desk?	
(The height of students)	0.026 NS
Do you feel low back pain when sitting on the mono-desk?	
(All the classes)	-0.121 NS

[The level of significance of the correlation coefficient values are as follows: *** = significance at 0.01, (10%) **= significance at 0.05 (5%), * = significance at 0.1, (1%) and NS = not significant.]

The result in Table 4.8, showed correlation of complaints students made on pains associated with the use of mono-desks in classrooms. Students in all the classes, both male and female complained when they use the mono-desk and were significant at 10% (0.344 and 0.243),respectively. The correlation between upper back pain and mono-desk according to students in all classes was significant at 5% (i.e. 0.190) and correlation of complaints between low back pain and mono-desk according to both male and female students was significant at 1% i.e. (0.160). However, the correlation of complaints between low back pain and mono-desk according to students heights and the students in all the classes were negatively insignificant (i.e. 0.026 and 0.121), respectively. The correlation of complaints between upper back pain and mono-desk according to the height of students was positive but not significant (i.e. 0.109) and also the correlation of neck pain between and mono-desk according to height of students was negatively insignificant (i.e. -0.008)

5.0 DISCUSSION

5.1: The compatibility of furniture to the user needs.

The result of the study shows that the furniture were designed and constructed by local carpenters without the necessary consideration of the body dimensions requirements of the students, this may be due to their ignorance in the design principles of furniture. This makes the school furniture far from compatible with the anthropometric measurements of students. The mismatch of the student body dimensions and the school furniture may cause physical problems for the students using the furniture. Such mismatch may induce physical problems in those using the furniture (Parcells and Stommel, 1999).

Students usually attend classes for a long period of time about 5-7 hours per day in a sitting posture with ill-designed classroom furniture. Students spending long hours in school on incompatible furniture force the students to sit and do classroom activities in unnatural or bad posture like twisting, lateral and forward bends. For a long period, this causes physical and mental strain on the students. Fatigue which may cause by sitting will also set in on the furniture which does not match students body dimensions. Most students were sitting on classroom chairs with seat either too high or low. This was due to the students anthropometric dimensions which were not the same compared to furniture dimensions which were of the same dimensions. This made either the chair of the furniture in the classroom to be either too high or too low. Also students are using table in classrooms with height either too high or low. Studies have shown that any deviation of dimensions of furniture or artifacts from the anthropometric dimensions may cause physiological and biomechanical load on the musculoskeletal systems (Wells and Reaney, 1997). According to (Parcells and Stommel, 1999), most furniture in classrooms with fixed dimensions are unlikely going to accommodate majority of students. When students adopt stooping posture as a result of improper design of school furniture for a long time, it leads to the development of lower back pain (Wells and Reaney, 1997). The stooping posture may be the cause for greater prevalence of back problems among students in our schools. Again, improper construction of the backrest may intensify the problem of backache. The height of the backrest was too low with dimension of 300 mm instead of 400 mm and above. The angle of the backrest was 95° instead of 100° to 120°. This made the backrest too low for students to relax. The rail for the backrest was one instead of more than one rail at the top. The rail supports only the upper back of the students instead of supporting both the upper back and the middle part of the back of students.

5.2: Measurements of body dimensions of students

The school provided desk/chair combination to seat one student, majority of the students did find any appropriate chair cum table appropriate to sit on. Most students were sitting in mono-desks that were either too low or too high due to their anthropometric dimensions of students. The only positive thing for the research or finding was that knee height and desk clearance were not problem for majority of students. The heights from 185 cm t0 192 cm did not find the table clearance appropriate due their thigh clearances were above 2 cm stated by Parcell, 1999. The level of mismatch between desk height and elbow height becomes lower with increasing height of students. As the desk height is too high for short students, they are supposed to raise their shoulderswhen writing, which leads to the development of upper back pain. For the tallest students, the desk height becomes relatively shorter in respect of anthropometric measurements and therefore, the problem of upper back pain discomfort is less prevalent. The study found out that students were sitting on unsuitable furniture where they sat in prolonged flexed positions during class lessons. This was due to the mismatch between their body dimensions and furniture dimensions. Approximately 70% of the students in the study were not within or did not find furniture suitable to their body dimensions. This supports previous findings of Murphy *et al.,* (2004) who found that only 20% of students found acceptable table chair/desk combination.

5.3: The prevalence of back pain according to sex

From Table 4.3, female students experienced more back pain than male students. This may be due to gender differences as the physical, physiological and biomechanical features are not the same between male and female. Due to differences in muscles between males and females, males have higher muscle strength and females have lower muscle strength particularly in the upper limb as supported by Katzmarzyk *et al.,* (1998). Females also have greater body awareness and lower level of pain and they tend to complain more than male (Briethecker *et al.,* 2004). Results showed that 21 and 22 year-old students who were 5% in the study almost all made complaints or had higher incidence of spinal pain as compared to other year groups may be due to the strength and endurance of MS system of their ages.

5.4: The prevalence of back pains

Neck pain was the highest prevalence symptom experienced by students, followed by lower back pain and then upper back pain. The high prevalence of neck pain is due to high level of neck flexion at 20° as well as static and awkward posture during sitting as suggested in the literature by (Briethecker *et al.,* 2004). In the study taller students reported more neck pain and this could also be due to increased neck flexion while working at the desk. Students with the trunk flexed more than 20° also may increase the possibility of students reporting low back pain in the study. Students working at the desk always adopt flexed posture due to prolonged disc compression may also contribute to lower back pain. (Katzmarzyk *et al.,* 1998) and Bendix (1994) suggested that collagen-fibre elasticity may also contribute to low back pain. Students observed in the study, sitting static posture during lessons showed high level of increase in upper back pain. Murphy *et al.,* (2002) suggests that trunk flexion of more than 20° may also contribute to upper back pain.

5.5: Regression analysis

5.5.1: Regression analysis of the causes of back pain

From the regression analysis carried out on all the selected variables or causes of various back pains, it was found that backrest shape the cause of upper back pain was influenced by the height of the students. The pain could be contributed by sitting with awkward or static postures, as well as students not fitting into the furniture. This may be when students sit with the trunk flexed increases the spinal load, compared to standing and prolonged static sitting increases instradiscal pressure, resulting in decreased nutrition to the disc and also causing pain at the back of the body.

5.5.2: Regression analysis of students satisfaction with classroom furniture

From the regression analysis carried out to find the dissatisfaction with the height of classroom furniture according to the weight of students, showed the height of the mono-desk in the classroom had significant influence of students in their studies. This level of dissatisfaction with classroom furniture means that there is anthropometric mismatch between the dimensions of the furniture available and anthropometric characteristics of students as stated by Savanur, (2000). Also due to students variability in sizes that exist among them, they may be very unlikely that furniture of fixed dimension will fit the majority of students as suggested by Parcells and Stommel *et al.,* (1999). Thus there should be improvements in the design of the classroom furniture that are used by students. This is to ensure the wellbeing or confortability of the students usage of furniture during their schooling years and thus will determine their future body postures.

5.5.3: Regression analysis of students on the complaints of back pain

Students experiencing neck pain when they sit on the mono-desk was significantly associated with gender and class. This shows that students who sat on the mono-desk had a significant influenced in the incidence of neck pain. This may be due to the fact that students feel uncomfortable when they adopt flexed or static postures for prolonged periods of time, increasing muscular fatigue in the neck thus causing pain in the neck pain and back pains.

5.5.4: Classroom sitting and postural alignment

Students sitting close to the walls normally flex their necks when looking on the chalkboard to write. This affects the first three students on the front rows on the wall, but do not affect the rest of students sitting at the rows closed to the walls. This is due to the fact that these students either rotate or flex their neck when looking on the chalkboard in front of them. Students sitting in the three middle rows in the do not flex their necks because the chalkboard is in front of them, straight in the classroom.

6.0 CONCLUSION AND RECOMMENDATIONS

6.1: Conclusion

This study on ergonomic impact of furniture design on the health of students was necessitated by the need to look into the health problems posed to students by furniture used in the classroom, its compatibility to users and the number of movements students make in the furniture.

The study looked at the design features of mono-desk and its compatibility to the user needs. It was found out from the opinions of students the dimensions of furniture contributed to the feeling of discomfort and health problems because of incompatibility of interface between the bodies of students and school furniture dimensions.

In the case of the number of movements made in the mono-desk by students during classes, it was realized that many students endured seating arrangements in their classrooms that are not conducive to learning. Students furniture contributed to different postures of students in the classroom regardless of the furniture. This will array the fears in students that sitting is not a risk factor but certain types of furniture may contribute to postural discomfort which will eventually lead to pains at the back of students. Unconducive furniture in classroom also promotes greater frequency of posture changes which normally distract students attentions during lesson and also brings negative health implication to students.

Finally, an ergonomic intervention is required to redesign the classroom furniture for students at different age groups in order to reduce furniture related health problems. Appropriate designs of classrooms furniture with consideration of body dimensions of students and other ergonomic factors may be helpful for reducing health problems and improving the posture of students in the classroom.

6.2: Recommendations

Students realized the important features that contribute to good furniture design and recommended some valid suggestions with the researcher.

- Students preferred furniture with broad seat, clearance space for thighs and legs in order for them to feel comfortable in the classroom when they sit in the mono-desk.
- If local carpenters are going to continue to produce and sell traditional designed furniture, schools need to be encouraged to at least provide much variety in furniture sizes as possible to accommodate the variety of students sizes.
- Different types of furniture with variations in models should be used by students in classroom to minimize discomfort at the different parts of the spinal cord and also adopts S posture in the furniture.
- Though, the mono-desks designed and constructed use less timber products as compare to the construction of separate table from the chair. It recommended that the chair should be constructed separately from the table in order for them to adjust the distance between the table and chair for easy movements and to avoid students remaining static posture in the mono-desk.
- Provision for footrest, wide work surface, and wide books and bags storage, strong and durable wood should be incorporated in the design and construction of classroom furniture to avoid mismatch between students body dimensions and chairs.

LITERATURE CITED

Agyedu, G. O., Donkor, F. and Obeng, S. (2000). Teach yourself research methodology. University of Education Winneba, Kumasi Campus. (Unpublished).75-112 pp.

Babbs, F. (1979). A design layout method for relating seating to the occupant in vehicle. Philadelphia: Wiley Publishers. 227-234 pp

Bendix, T. (1984). Low back pain and seating. London: Taylor and Francis Publishers

Limited.147-155 pp.

Bendix, T., Winkel, J. and Jersen, F. (1985). Comparison of office chairs with fixed forwards a backwards inclining, or tiltable seats. Copenhagen: LaegeforeninggensForlap. 695-703 pp.

Bernard, B. P. (1997). Musculoskeletal disorder and workplace factors. Philadelphia: Wiley Publishers. 22-28 pp

Braton, P. (1989). Behaviour, body dynamic and discomfort. Cambridge: MIT Press. 16- 27 pp.

Briethecker, D. G., Cardon, G., Cardon, D., De Clercq, I. and Boudeaudhuij, D. (2004). Sitting habits in elementary schoolchildren: A traditional versus a moving school. 133-142 pp.

Bridge, R., Eisenhar-Rothe, C. and Henneberg, M. (1989). Effects of sear slope and hip flexion on spinal angles in sitting. New York: Watson- GuptillPulishers. 79-88 pp

Cardon, G. and Briethecker, D. G. (1999). Sitting habits in elementary school children. London: Taylor and Francis Ltd. 21-40 pp

Chaffin, D. and Anderson, G. (1999). Occupational biomechanic. New York: WileyPublishers.252-280 pp.

Chakrabarti, D. (1997). Indian anthropometrics dimensions. Ahmedabad: Natural Institute of Designs, India.96-101pp.

Chaudhary, N. (2004). Mismatch between classroom furniture and students anthropometrics characteristics. Mumbai: National Institute of Industrial Engineers. 167-171 pp.

Garratt, J. (1995). Design and Technology. London: Cambridge University Press 1-45pp.

Galen, C. (1998). The chair: Rethinking culture, body and design. London: Norton and Co. Publishers.45-77 pp.

Grieco, A. (1998). Sitting posture an old problem and a new one. Florida: CRC Press. 345-462 pp.

Kane, D, Pilcher, M .and Legg, J. (1998). Development of furniture system to matchstudents need in New Zealand Auckland: Macmillan Publishers.90-99 pp.

Kansi, P. and Knight, G. (1977). Collecting working postures in industry: A practical method for analysis. *Applied Ergonomics*. London: Macdonald and Evans Publishers. 223-237 pp.

Katzmarzyk, P. T.,Malina,R.M.,Song,T.M and Bouchard, C. (1998) Television viewing, physical activity and health- related fitness for youth. Quebec:MaGraw Publishers. 56-60 pp.

Keegan, J. (1973) Alteration of the lumber curve related to posture and seating. Ohio: MaGraw Publishers. 23-66 pp.

Kourinka, I., Jansson, B., Kilbom, A., Vinterberg, H., Sorensen, F.B., Anderson,G.O. and Jorgensen, K. (1987). Standardized Nordic questionnaire for the analysis of musculoskeletal symptom. New York: Willey Publications. 78-89 pp.

Jorgensen, K. (1987). Standardized Nordic questionnaire for the analysis of musculoskeletal symptoms. Applied Ergonomics.23-27 pp.

Legg, S.J., Pajo, K., Sullman, M. and Marfell-Jone, M. (2003). Mismatch between classroom furniture dimensions and students anthropometrics characteristics. Cambridge University Press.34-50 pp.

Mandal A. C. (1994). The prevention of back pain in school children. London: Taylor and FrancisPublcations 269-277 pp.

Marmaras, N., Poulakakis, G. and Papakostopoulos, V. (1999). Ergonomics design in ancient Greece. *Applied Ergonomics,* 30 (4), 361-368 pp

Murphy, S., Buckle, P. and Stubbs, D. (2002). The use of Portable Ergonomic Observation Method (PEO) to monitor the sitting postures in school children. New York: Wiley Publishers.67-70 pp.

Murphy, S., Buckle, P. and Stubbs, D. (2004). Classroom posture and self-reported back and neck pain in school children. San Diego: CA Publishers. 35-56 pp.

Patel, A. T. and Ogle, A. A. (2007). Diagnosis and management of acute low back pain.

New York: Warner Books 10-32 pp

Parcells, D. and Stommel, M. (1999). Mismatch of classroom furniture dimensions and students body dimensions-empirical findings and health implications.Journal of Adolescent Health.1-30 pp.

Parvanur, C.S. and Ghash, S. (2004). An ergonomic study of comparison between school classroom students body anthropometrics. Mumbai Institute of Engineers 45-67 pp

Phesant, S. (1996). Anthropometry, ergonomics and the design of work. London: Taylorand Francis Publishers. 179 pp.

Phesant, S. (1986).Body space- anthropometry, Ergonomics and the design of work. London: Heinemann Educational Books. 85-91 pp.

Roebuck, J.A., Kroemer, H.E., Thomas, W.G., Engineering anthropometry methods.New York: Warner Books. 35-50 pp.

Savanur, S.S., Ghosh, S., Dhar,U. and De, A. (2004). An ergonomic study of comparison between school classroom furniture and student`s anthropometry. In: Proceeding of the National Conference on Humanizing work and the work environment, Mumbai: National Institute of Industrial Engineering. 22-25pp.

Tichauer, E. (1978). The biomechanical basis of ergonomics: Anatomy applied to the design of work situation. New York: Wiley Publishers. 31-35 pp.

Taimela, S., Kujala, U. M., Salainen, J. J. and Viljanen, T. (1997). The prevalence of low back pain among children and adolescents.

Troussier, B., Davoine, P., de Gaudemaris, J., Fauconnier, J. and Phelip, X. (1994).Back pain in school children. London: Tabs Books Inc.143-146 pp.

Troussier, B. (1997). Comparative study of two different kinds of school furniture among School children. London: Tabs Books Inc. pp 42.

Walton, J. H. (1974). Woodwork theory and practiceSydney: Australian Publishing Company Press Ltd. Australia.300-500 pp.

Watson, S. B. (1983). Are you sitting? Health safety work. New York: Wiley Publishers. 29-42 pp.

Weiner, J.S., (1969). Human biology, a guide to field methods, IBP Hand Book No.9.Oxford: Blackwell Book Inc.

Well, R. A. and Reaney, A. (1997). Chronic musculoskeletal injuries in the workplace Philadelphia: W. B. Saunders Books. 49-52 pp.

Wojciech, C.H., (1957).Ergonomic fundamentals. Oxford: Macmillan Education Ltd. U.K. 61-75 pp.

(Zacharkow, D. (1988). Posture: Sitting, chair design and exercise. Springfield, IL: CCThomas Publishers.45-60 pp.

List of plates

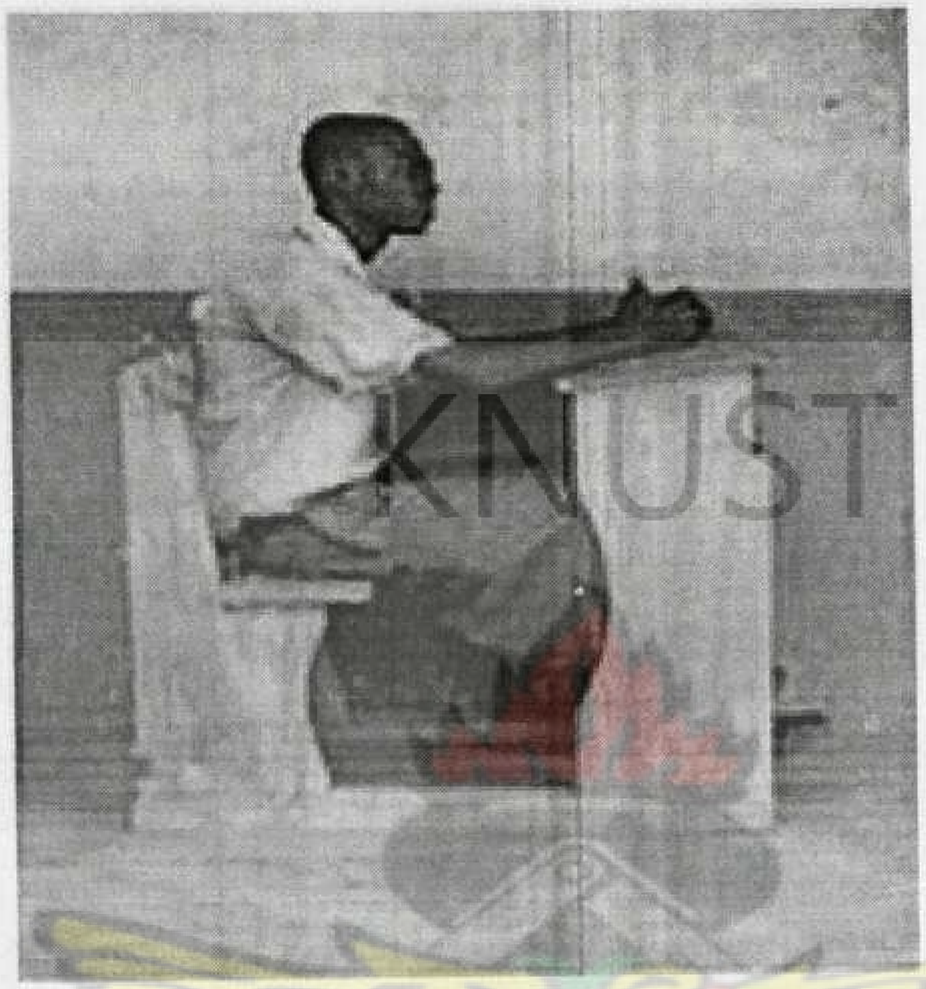


Plate 1: Student with the neck flexed.

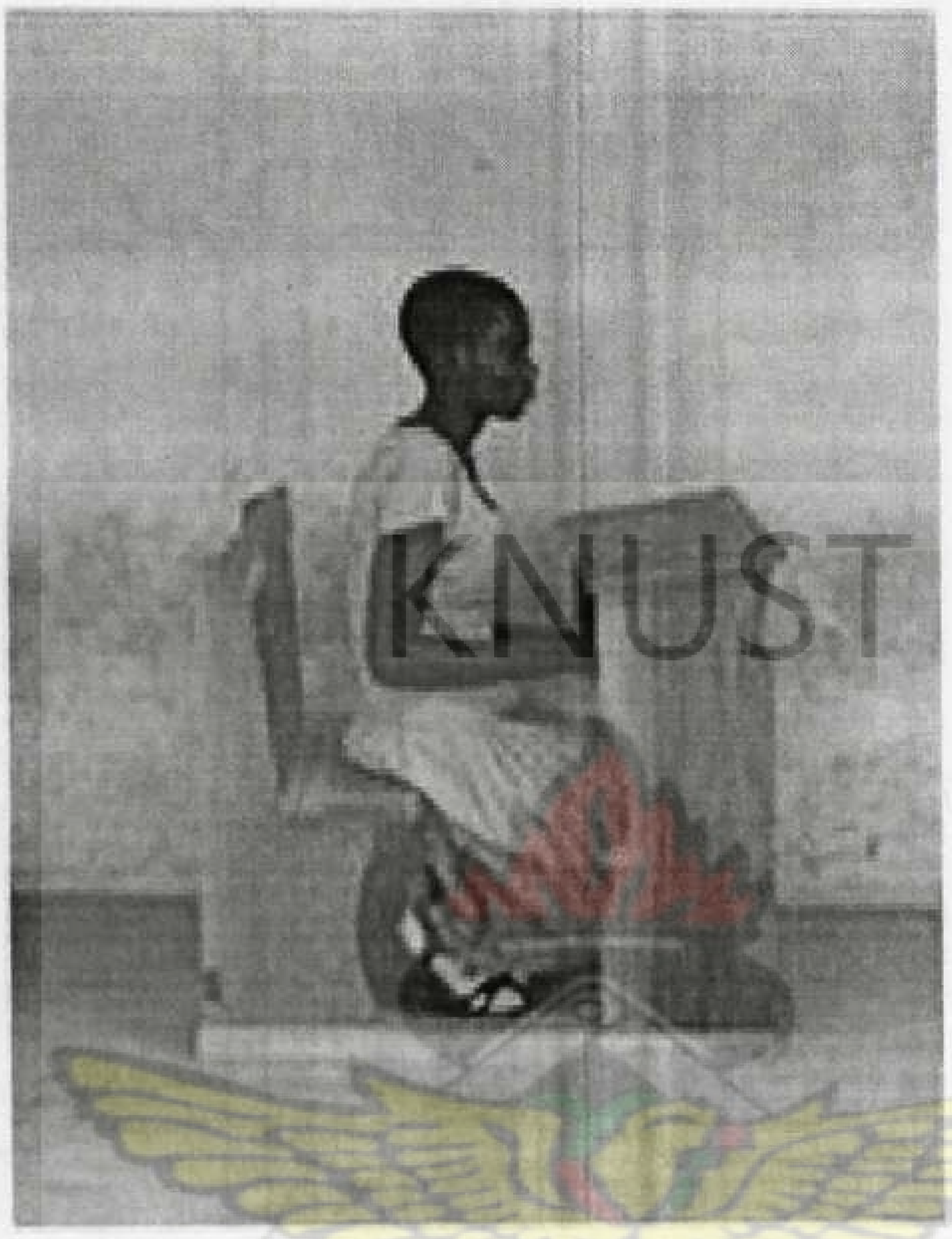


Plate 2: Student with trunk unsupported.

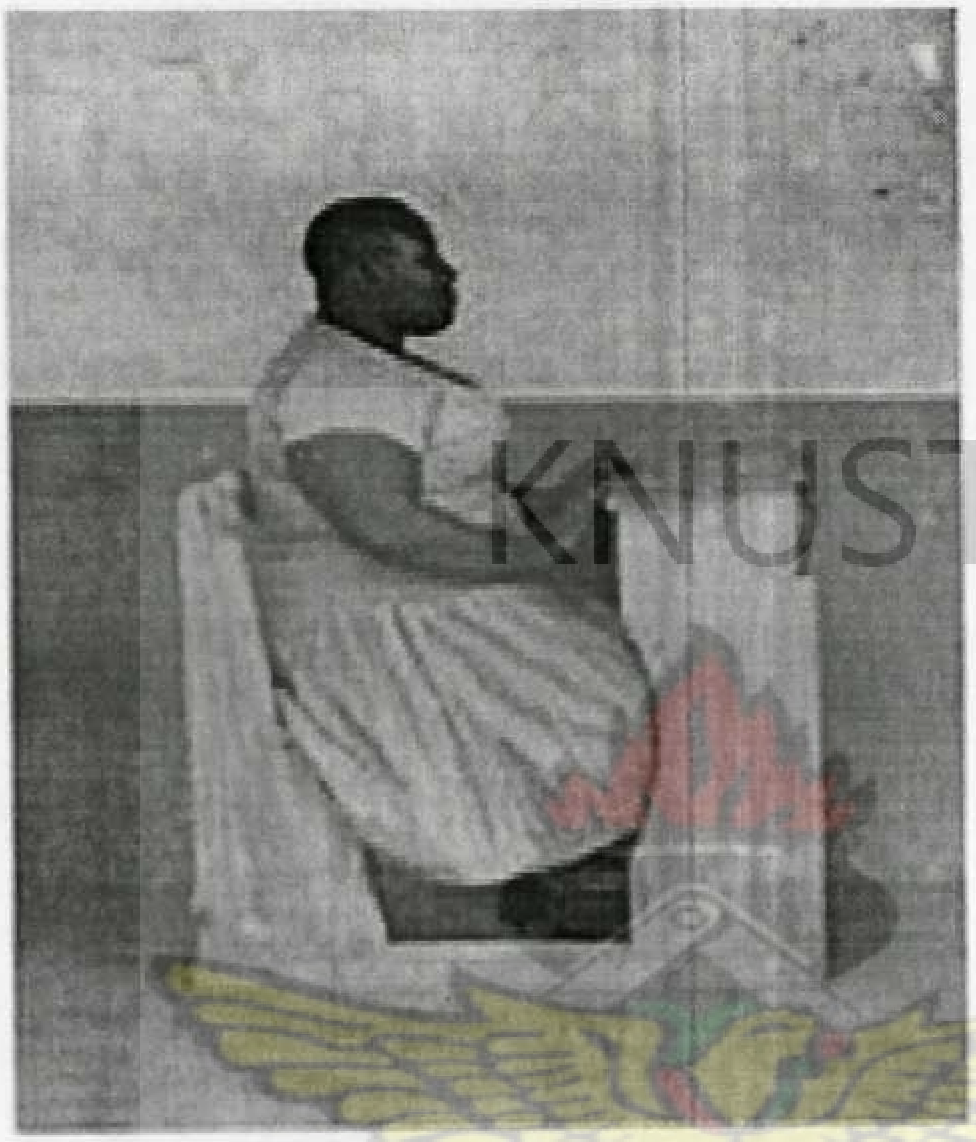


Plate 3: Plump student sitting in a mono-desk.

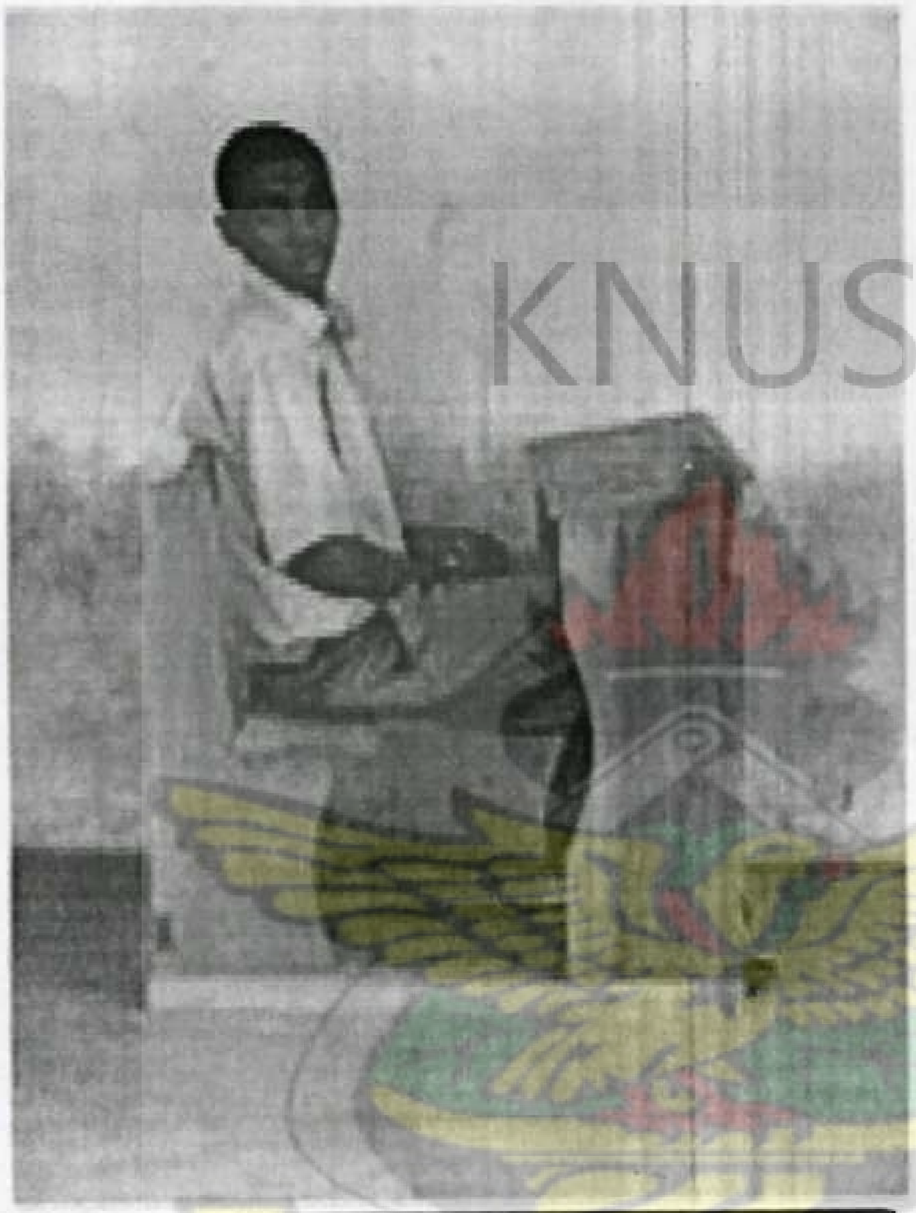


Plate 4: Student with neck rotated.

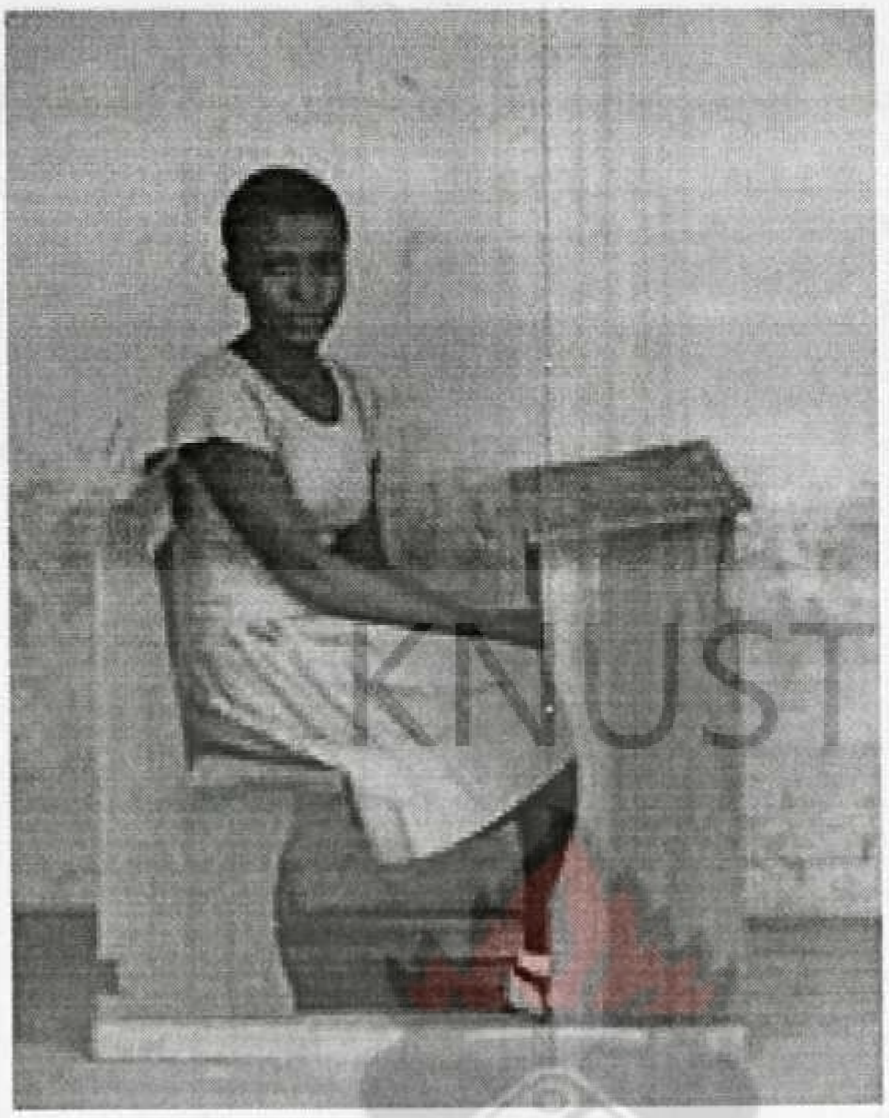


Plate 5: Student with trunk rotated.

Appendices

Appendix 1A: Trunk flexion causes neck pain

			Age of respondent (year)		
			17-20	>20	Total
Trunk flexion >20° is the causes of neck pain	Strongly agree	Count	73	9	82
		% within flexion >20° is the causes of neck pain	89.0%	11.0%	100%
	Agree	Count	25	3	28
		% within flexion >20° is the causes of neck pain	89.3%	10.7%	100%
	Disagree	Count	6	0	6
		% within flexion >20° is the causes of neck pain	100%	.0%	100%
	Strongly disagree	Count	4	0	4
		% within flexion >20° is the causes of neck pain	100%	.0%	100%
Total		Count	108	12	120

Appendix 1B: Lesson length causes low back pain (weight of respondent)

			weight of respondent (kg)			
			40-59	60-69	70 & above	Total
Lesson length causes low back pain	Strongly agree	Count	55	33	10	98
		% within Lesson length causes low back pain	56.1%	33.7%	10.2%	100%
	Agree	Count	12	3	0	15
		% within Lesson length causes low back pain	80%	20%	0%	100%
	Disagree	Count	3	1	0	4
		% within Lesson length causes low back pain	75%	25%	0%	100%
	Strongly disagree	Count	1	2	0	3
		% within Lesson length causes low back pain	33.3%	66.6%	0%	100%
Total		Count	71	39	10	120
			59.2%	32.5%	8.3%	100%

Appendix 1C: Lesson length causes low back pain (sex of respondent)

			Male	female	Total
Lesson length causes low back pain	Strongly agree	Count	45	53	98
		% within Lesson length causes low back pain	45.9%	54.1%	100%
	Agree	Count	11	4	15
		% within Lesson length causes low back pain	73.3%	26.7%	100%
	Disagree	Count	1	3	4
		% within Lesson length causes low back pain	25%	75%	100%
	Strongly disagree	Count	3	0	3
		% within Lesson length causes low back pain	100%	0%	100%
Total		Count	60	60	120
			50%	50%	100%

Appendix 1D: Lesson length causes low back pain (height of respondent)

			Height of respondent (cm)		
			100-160	>160	Total
Lesson length causes low back pain	Strongly agree	Count	22	76	98
		% within Lesson length causes low back pain	22.4%	77.6%	100%
	Agree	Count	2	13	15
		% within Lesson length causes low back pain	13.3%	86.7%	100%
	Disagree	Count	2	2	4
		% within Lesson length causes low back pain	50%	50%	100%
	Strongly disagree	Count	1	2	3
		% within Lesson length causes low back pain	33.3%	67.7%	100%
Total		Count	27	93	120
			22.5%	77.5%	100%

Appendix 1E: Trunk flexion >20° is the cause of neck pain (Sex of respondent)

<table>
<tr><td colspan="3" rowspan="2"></td><td colspan="2">Sex of respondent</td><td rowspan="2">Total</td></tr>
<tr><td>Male</td><td>Female</td></tr>
<tr><td rowspan="8">Trunk flexion >20° is the cause of neck pain</td><td rowspan="2">Strongly agree</td><td>Count</td><td>34</td><td>48</td><td>82</td></tr>
<tr><td>% within Trunk flexion >20° is the cause of neck pain</td><td>41.5%</td><td>58.5%</td><td>100%</td></tr>
<tr><td rowspan="2">Agree</td><td>Count</td><td>19</td><td>9</td><td>28</td></tr>
<tr><td>% within Trunk flexion >20° is the cause of neck pain</td><td>67.9%</td><td>32.1%</td><td>100%</td></tr>
<tr><td rowspan="2">Disagree</td><td>Count</td><td>5</td><td>1</td><td>6</td></tr>
<tr><td>% within Trunk flexion >20° is the cause of neck pain</td><td>83.3%</td><td>16.7%</td><td>100%</td></tr>
<tr><td rowspan="2">Strongly disagree</td><td>Count</td><td>2</td><td>2</td><td>4</td></tr>
<tr><td>% within Trunk flexion >20° is the cause of neck pain</td><td>50%</td><td>50%</td><td>100%</td></tr>
<tr><td colspan="2" rowspan="2">Total</td><td>Count</td><td>60</td><td>60</td><td>120</td></tr>
<tr><td></td><td>50%</td><td>50%</td><td>100%</td></tr>
</table>

Appendix 1F: Trunk flexion >20° is the cause of neck pain (Height of respondent)

			Height of respondent (cm)		Total
			100-160	>160	
Trunk flexion >20° is the cause of neck pain	Strongly agree	Count	20	62	82
		% within Trunk flexion >20° is the cause of neck pain	24.4%	75.6%	100%
	Agree	Count	5	23	28
		% within Trunk flexion >20° is the cause of neck pain	17.9%	82.1%	100%
	Disagree	Count	0	6	6
		% within Trunk flexion >20° is the cause of neck pain	0%	100%	100%
	Strongly disagree	Count	2	2	4
		% within Trunk flexion >20° is the cause of neck pain	50%	50%	100%
Total		Count	27	93	120
			22.5%	77.5%	100%

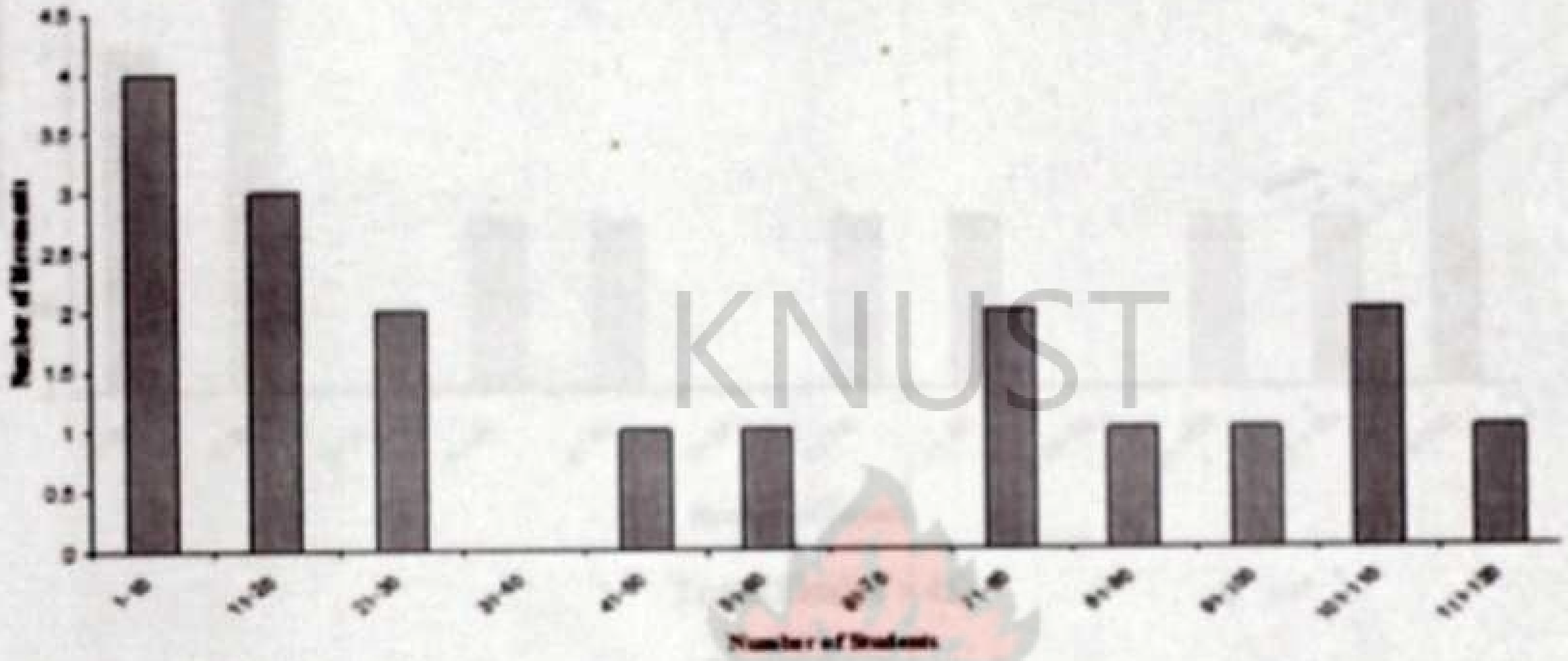
Appendix 1G: The height of the mono-desk is the cause of low back pain

			weight of respondent (kg)			Total
			40-59	60-69	70 & above	
The height of the mono-desk is the cause of low back pain	Strongly agree	Count	42	22	8	72
		% within the height of the mono-desk is the cause of low back pain	58.3%	30.6%	11.1%	100%
	Agree	Count	19	9	2	30
		% within the height of the mono-desk is the cause of low back pain	63.3%	30%	6.7%	100%
	Disagree	Count	7	3	0	10
		% within the height of the mono-desk is the cause of low back pain	70%	30%	0%	100%
	Strongly disagree	Count	3	5	0	8
		% within the height of the mono-desk is the cause of low back pain	37.5%	62.5%	0%	100%
Total		Count	71	39	10	120
			59.2%	32.5%	8.3%	100%

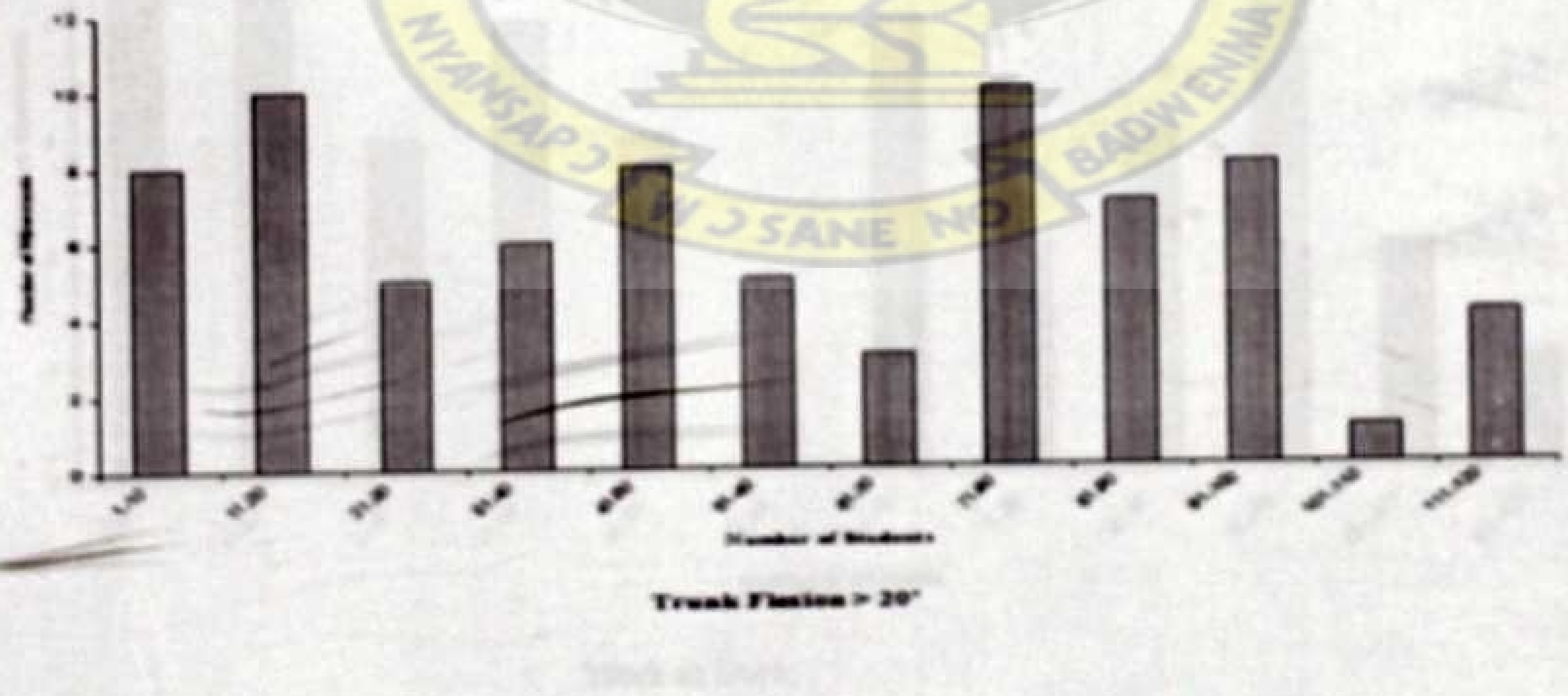
Appendix 1H: The height of the mono-desk is the cause of low back pain (Sex respondent)

			Sex of respondent		Total
			Male	Female	
The height of the mono-desk is the cause of low back pain	Strongly agree	Count	34	38	72
		% within the height of the mono-desk is the cause of low back pain	47.2%	52.8%	100%
	Agree	Count	16	14	30
		% within the height of the mono-desk is the cause of low back pain	53.3%	46.7%	100%
	Disagree	Count	3	7	10
		% within the height of the mono-desk is the cause of low back pain	30%	70%	100%
	Strongly disagree	Count	7	1	8
		% within the height of the mono-desk is the cause of low back pain	87.5%	12.5 %	100%
Total		Count	60	60	120
			50%	50%	100%

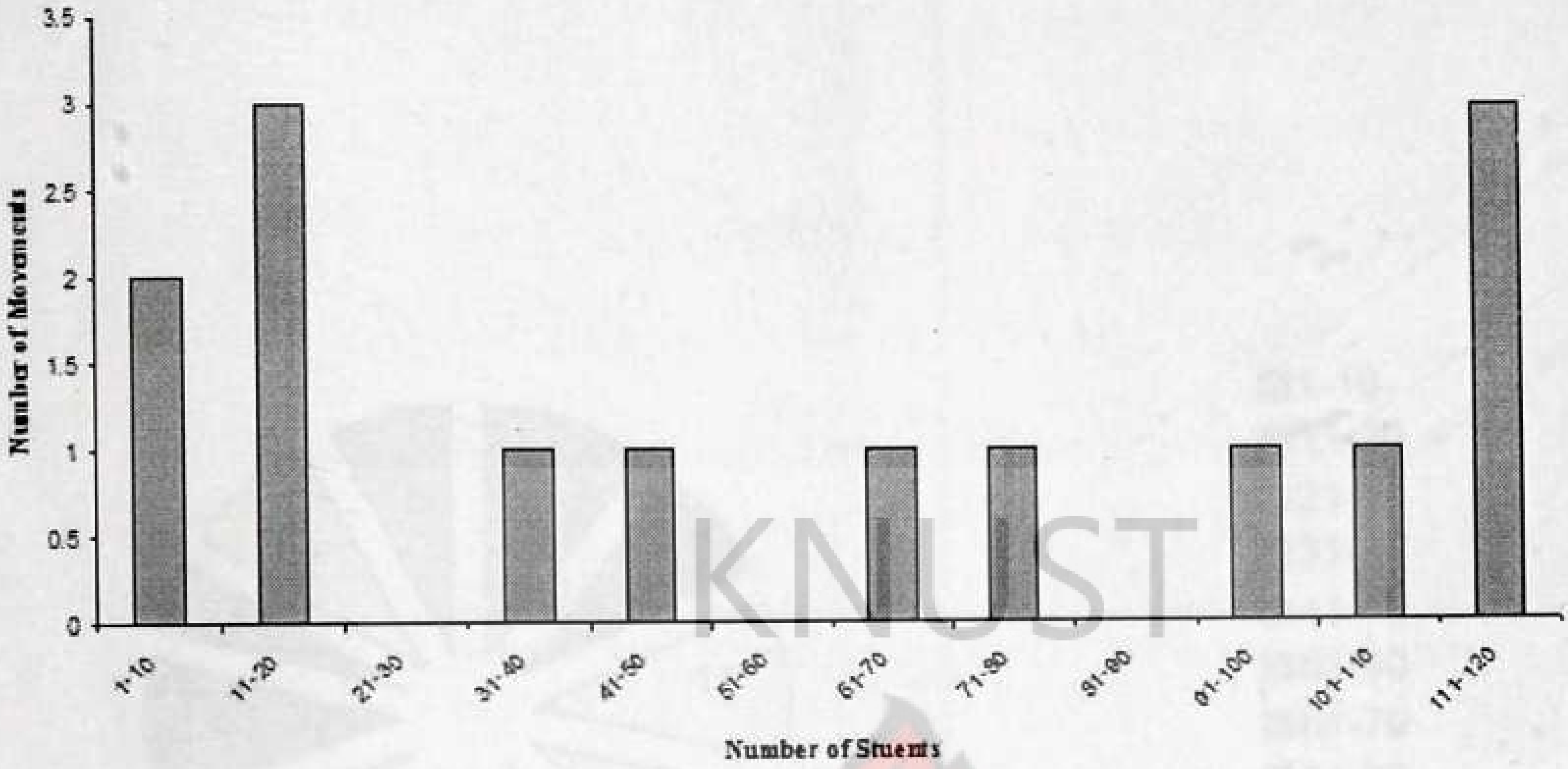
GRAPHS SHOWING NUMBER OF MOVEMENTS IN PORTABLE ERGONOMIC



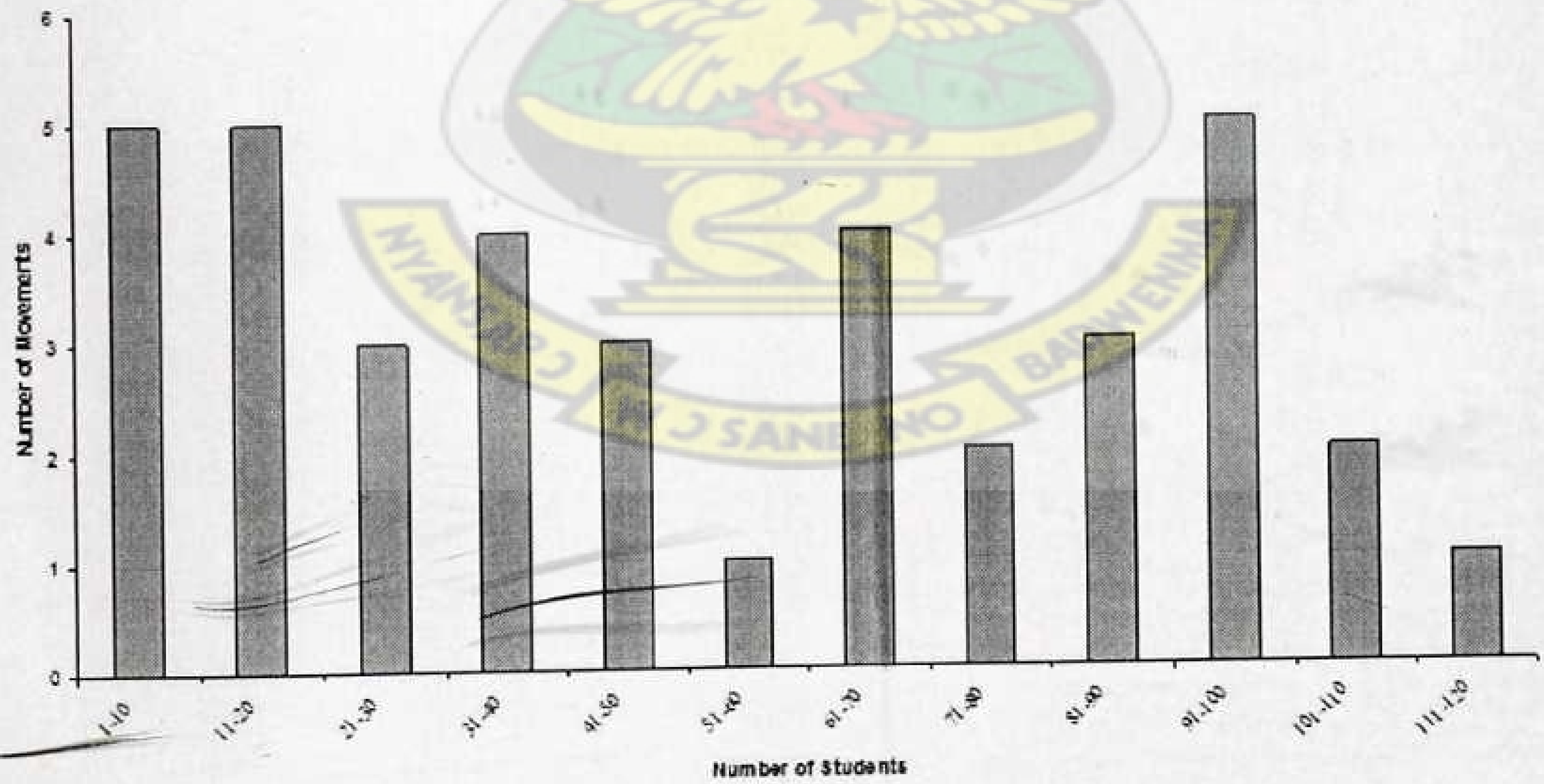
Trunk Unsupported



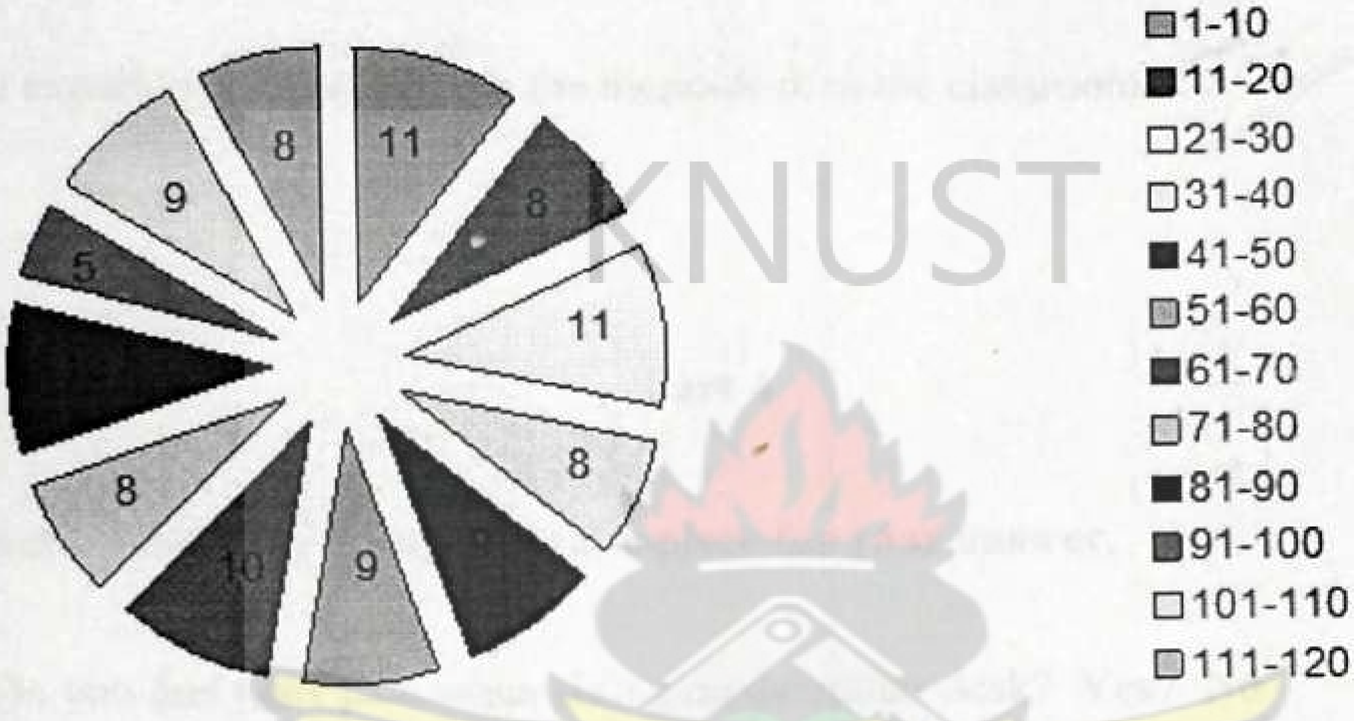
Trunk Flexion > 20°



Trunk Flexion > 45°



Work at Desk



Neck Flexion > 20˚

Questionnaire Preamble:

Furniture used by students in classrooms has negative impact on the health of students such as back pain as a result of poor posture whilst sitting. It is because of that I seek; the continual poor posture will affect students studies in classroom. I will therefore be grateful if you could answer this questionnaire to enable me to know the extent of back pain you experience when you use the mono-desk in the classroom.

Part A

Please put (o) mark in the appropriate place for your answer.

- Do you feel neck pain when sitting on the mono-desk? **Yes / No**
- Do you feel upper back pain when sitting on the mono –desk? **Yes / No**
- Do you feel low back pain when sitting on the mono-desk? **Yes / No**
- Do you feel fatigue during class work as a result of back pain? **Yes /**
- Are you satisfied with the backrest shape? **Yes / No**
- Are you satisfied with the height of mono-desk? Yes / No

7 Are you satisfied with classroom furniture? Yes / No

Part B

Please tick (√) the response that best reflects the extent to which you disagree or agree with each of the following statements.

STATEMENTS	RESPONSES			
	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
8. Backrest causes upper back pain.				
9. Lesson length causes low back pain				
10. Trunk flexion>20° is the cause of neck pain.				
. 11. The height of the mono-desk is the cause of low back pain.				